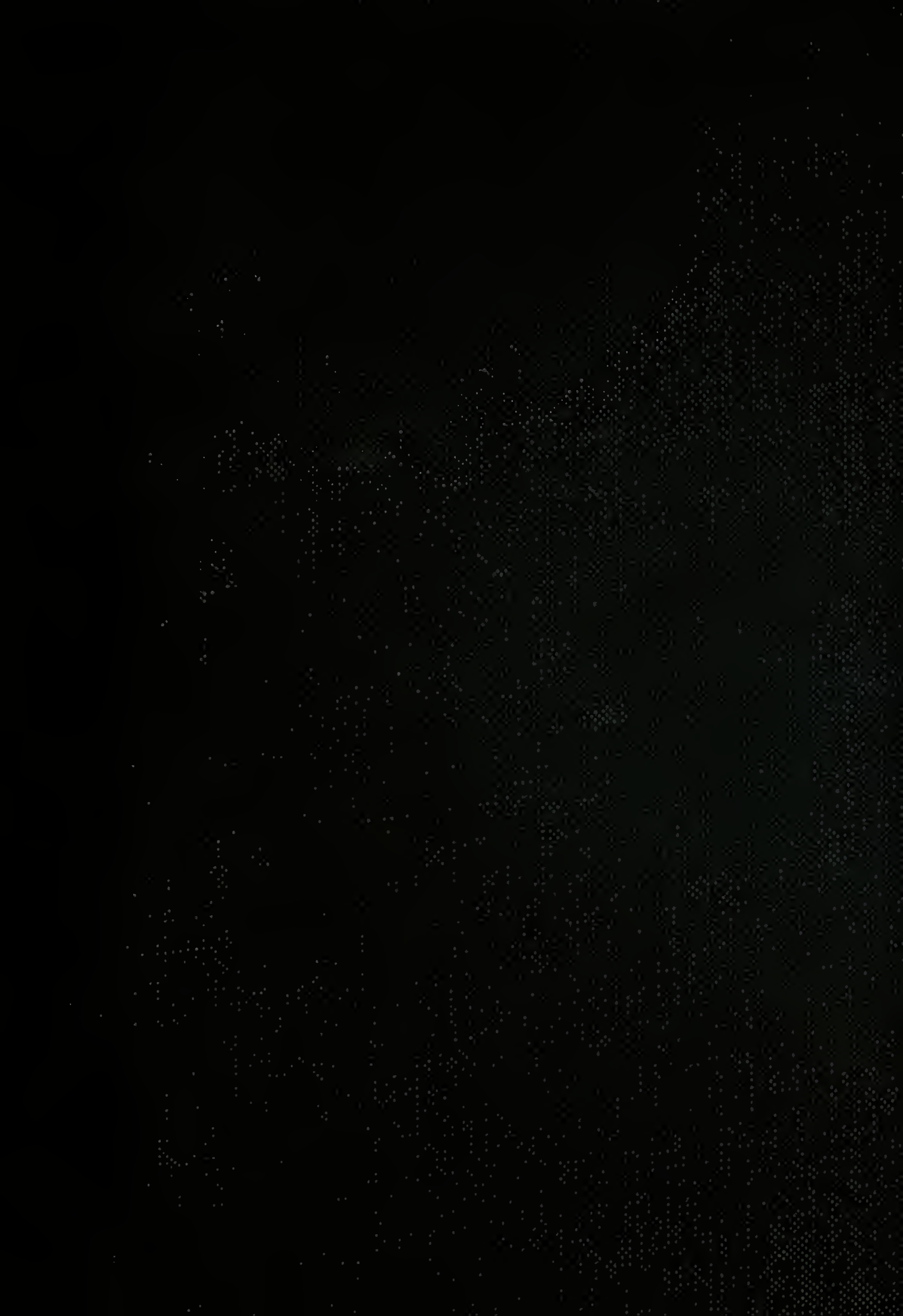


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RADIO BROADCAST

VOLUME XIV

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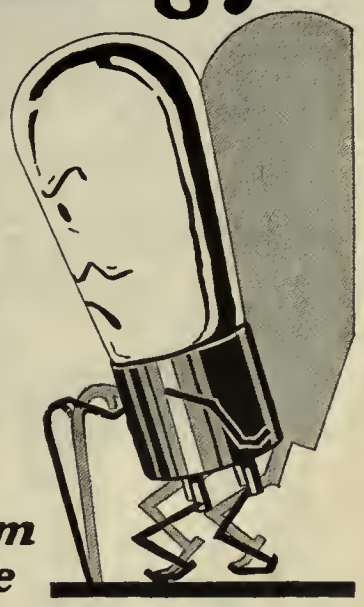


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Willis Kingsley Wing, Editor

NOVEMBER, 1928 — Keith Henney, Director of the Laboratory — Edgar H. Felix, Contributing Editor — Vol. ~~IX~~ 14. No. 1

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The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. . .

A FUNDAMENTAL part of the policy of this magazine is the careful scrutiny of everything appearing in its pages, from the smallest advertisement to the most intricate of technical articles. We have always felt that our first duty to the reader was to protect him from misleading statements and inaccuracies of whatever sort. This magazine is not, however, the expression of one man's opinion, nor even of the group responsible for editing and publishing it. We have frequently given space to articles on technical subjects in which the authors came to conclusions at variance with our own opinions. Almost invariably after the appearance of the magazine we would be deluged with letters and telephone calls demanding to know why we "said" this or that. The editorial expressions of this magazine, whether general or technical are always definitely identified. Articles from other sources are also indentified, and for the opinions expressed, the author is alone responsible. We welcome the opportunity of printing controversial articles.

TO JUDGE from reports which reach us, the motion-picture industry is in nearly as complete a turmoil as that in which radio found itself some years ago. The cause of the trouble is, of course, the application of synchronized and non-synchronized sound accompaniment to the "feature picture." This development is bringing into play practically all of the experience that broadcasters have so laboriously accumulated in the past few years, and is drawing into the movie field many broadcasters and other engineers who have developed apparatus and its uses for this work. In this connection, the pages of Carl Dreher's department, "As the Broadcaster Sees It," are well worth watching, for Mr. Dreher is including much first-hand and practical information on sound motion picture work. Much of this work is being done by expert radio service men.

A NEW ZEALAND radio distributor writes us he is interested in communicating with American radio manufacturers who wish New Zealand distribution for kits or complete sets, either a.c. or d.c. operated. Manufacturers who are interested may communicate with the editor.

FOR those to whom the news has not yet traveled, we repeat the announcement made in this column last month: the bound volume of Radio Broadcast Laboratory Information Sheets Nos. 1–190 is now available at $1. Order from your newsdealer or directly from the Circulation Department of Doubleday, Doran.

TO JUDGE from the comments in many letters, the Home Study Sheets are increasing in popularity. It may have escaped the attention of many who are following these Sheets that we are quite willing to examine the answers to the problems in each Study Sheet. These answers will be promptly examined and returned with our comments.

THE December issue will contain an interesting article on band-pass filters, an interesting and practical article on television, more good data for the service man and professional set builder, instructions on how to grind quartz crystals, a number of important constructional articles—and our regular departments.

—Willis Kingsley Wing.

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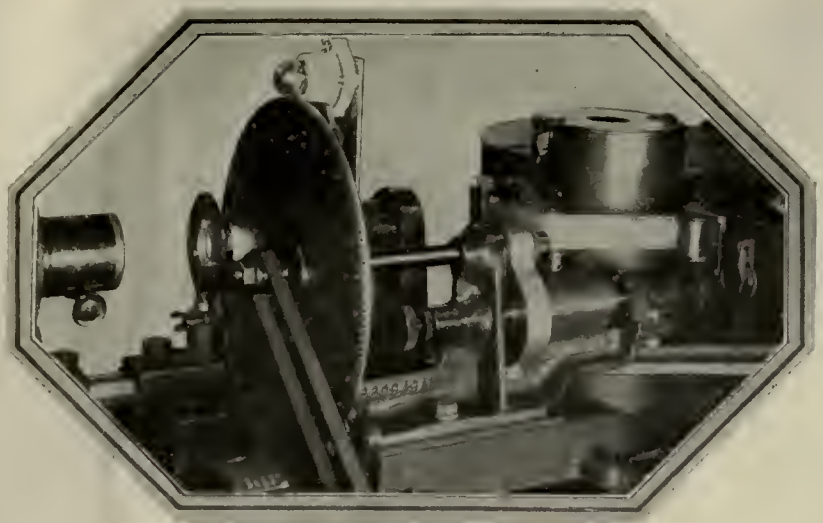
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Pictures Transmitted in One Minute at Radio World's Fair

This radio-photo receiver was demonstrated by the Westinghouse Electric and Manufacturing Company for the first time in the New Madison Square Garden, New York, during the week of the radio show. The apparatus is capable of converting electrical impulses into a complete photograph in less than one minute. Because of the difficulty in securing a wavelength assignment the demonstration was carried on with the use of wires. However, the engineers state that the equipment functions equally well by radio within the limits of fading and static. The chief advantage of this new apparatus is that it reduces the time required for the transmission of a photograph from five minutes to one minute. The size of the reproduced photograph is five by eight inches



NEW DEVICE PUTS MOVIES ON THE AIR

This apparatus is the heart of the television motion picture transmitter developed by Westinghouse. It is used at KDKA for the broadcasting of radio motion-picture programs

What Prospects of Television Abroad?

By LAWRENCE W. CORBETT

IN DISCUSSING the progress of television the technical press of the United States and Great Britain appears to take turn in deploring the lack of initiative of its own countrymen and in praising that of its rivals across the Atlantic. Yet, if we take the opinion of no less an authority than Sir Oliver Lodge, we must admit that the leading exponents of the art in both countries are equally up against a stone wall and that the limitation of the apparatus they are using at present will not permit further improvement.

But Sir Oliver Lodge, and other equally famous scientists whose opinions incline in his direction, are by no means pessimistic of the ultimate success of television. His criticism applies only to that apparatus now commonly used by many of those who claim recognition in the art. Mechanical contrivances, Sir Oliver believes, are limited by certain physical restrictions which it will be inordinately impossible to surmount. To use his own words:

Cathode rays or moving electrons are the only things likely to be sufficiently docile and controllable to be used as the agents for television. No material things are likely to be able to move quickly enough, but electrons respond so instantaneously that, if devices can be invented for utilizing them, the theoretical difficulties with the required rapidity of motion would begin to disappear both from the sender and the receiver, especially as photoelectric response is almost infinitely rapid.

A. Campbell Swinton, whose early apparatus was described in an article on television which appeared in RADIO BROADCAST for July, 1928, by R. P. Clarkson, appears to have realized the limitations that mechanical equipment would impose upon television, as far back as thirty years ago, and to have recommended the utilization of cathode rays. As stated in the July article, the proposed equipment originally devised by Mr. Swinton offered possibilities which many of our so-called "advanced" present-day systems do not.

At the time of writing this article (early in August and in London) much is being said about Baird's statement that he will market in September a home television receiver which will cost $125.00 The inventor has told the writer that he is already well in production with these receivers and that there will be no shortage when the instruments are released. In fact, the writer has already seen a finished model in the Baird laboratories. The cabinet houses both the television receiver and a electrodynamic loud speaker of American pattern. An eight-inch diameter circular glass screen is to the left of the cabinet, and through this screen, but on a smaller-sized square, is seen the actual imagine.

When questioned as the availability of service to purchasers of these sets (bearing in mind that the B. B. C. has refused to coöperate with Baird at the present time) the inventor informed the writer that he will transmit pictures from a 4-kw. (input) transmitter on the roof of his laboratories in the heart of London. These transmissions, it is planned at the time of writing, will take place on 200 meters (1500 kc.) Mr. Baird has no license for this transmitter, since, says he, one is not required for television transmissions.

Here is raised an interesting point. An English editor of a group of radio publications who has studied the British Telegraphy Act very thoroughly tells the writer that by no possible inter-

The British Situation

By NORMAN EDWARDS

Managing Editor, Popular Wireless and Modern Wireless

FOR months past the question of television has been agitating the minds of the British public, and day by day the Press in all parts of Great Britain has been persisting in dinning into the public ear that "television is here."

The Baird International Television Development Co., backed by British capital, invested for the development of television in England, now definitely has promised a television service by the end of the current year, despite the fact that the British Broadcasting Corporation, which has a monopoly on broadcasting in England, has refused to coöperate with Baird and his associates because, in the opinion of the Chief Engineer of the B. B. C., and his advisers, the Baird system is not developed sufficiently to warrant it being utilized as a public service: and the Chief Engineer and his associates in the British Post Office having investigated the Baird system believe it to be in a state of experimental infancy and unfitted for offering a means of service to the public.

Furthermore, the Wireless Telegraphy Act, which governs the use of radio in England, legally has been interpreted to cover television, and as the British Post Office refused to licence the Baird system as a public utility service, the question now arises in the public mind as to what Baird will do.

The Baird people definitely seem to believe that they can find a legal flaw in the Act of Parliament which governs the use of radio in Great Britain, and propose to start a service, without receiving the permission of the British Post Office. But it is believed that the Post Office will take steps to prevent Baird giving an unauthorized service. The position at the moment is complicated.

The reason why the British Post Office and the B. B. C. will not coöperate with Baird is not due to any prejudice but simply to the technical fact that the experts concerned do not consider Baird's system likely to be successful in satisfying the public demand for a television service. Baird still adheres to the mechanical system which experts have pointed out repeatedly—experts which include Sir Oliver Lodge; Dr. Lee de Forest; Captain Eckersley, the Chief Engineer of the B. B. C., and A. A. Campbell Swinton, F. R. S.—shows no likelihood of being developed in such a way as to provide a commercially possible television service, and in fact, not even a service which would warrant the authorities in England granting the Baird Company facilities for exploiting it to the public.

I can say in conclusion that Mr. Corbett's article sums up both technically and legally, with excellent succinctness, the television situation in Great Britain.

pretation of the law may Baird "televise," which in itself constitutes transmission of intelligence, unless he obtains a license. And he has been refused the necessary license! It has been prophesied that Baird will be enjoined by law from transmitting as soon as he commences to do so! Surely this attitude on the part of the authorities can be due to nothing more or less than lack of faith by the British Post Office engineers (under whose scrutiny radio is microscopically preserved) in Baird's present methods. Baird, it must be admitted, has made remarkable strides in the advancement of the art but now, it is felt, he has come to the end of his tether, and is being criticized severely for placing on the market apparatus representing a germ of an idea still in an embryonic stage of undevelopment.

It is argued that Marconi had no more to offer the public in those early days when he first fought to establish his ideas about wireless, but then, he appealed to a far more critical public (and then only to highly-trained engineers) than Baird is doing. Moreover, Baird, aided by colorful and exaggerated reports in a general press that knows nothing more about his invention than the fans who will be expected to invest in his televisors, is meeting with considerably less opposition than did Marconi.

COLOR TELEVISION

COLOR TELEVISION, the latest development of Baird, was described in the London daily papers in glowing terms. The writer was given a personal demonstration of this new child of television, by Baird, and was impressed only to the extent that is due to a radical development yet in its cradle days. A man's head, covered alternately with a blue or red cloth, afforded the subject to be transmitted in the demonstration. It was possible to see when the subject opened or closed his mouth, put out his tongue, and possibly when he rolled his eyes, and to see the different colors of the head coverings, but to say that the features were recognizable would highly exaggerate the matter. Monochrome (black and white) television, however, affords several times as much detail as color television.

The following explanation of the principles of color television was dictated by Mr. Baird especially for RADIO BROADCAST. Except for the changes outlined below, the equipment is similar to that used by Baird in his monochrome experiments and already described in this magazine on several occasions:

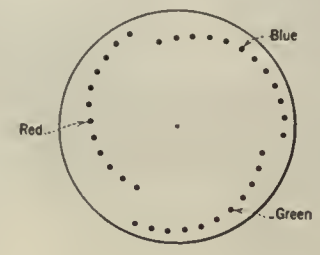


FIG. 1

BAIRD'S EXPLANATION

THE transmitting machine consists of a disc perforated with three sets of holes arranged in spirals and set round the periphery of the disc. See Fig. 1.

One spiral is covered with red filters, the second spiral is covered with green filters, and the third spiral with blue filters, so that each spiral lets through only light of one color. As the disc revolves, a spot of red light first traverses the object being transmitted, this red light being thrown back from the object and effecting a photo-electric cell. The red light, having completed this traversal of the object, the green spiral next comes into operation and traverses the object with a spot of green light. This is then followed by the traversal of the object with a spot of blue light from the spiral covered with blue filters. Thus, the object is traversed first by green, then by red, and then by blue illumination and three images are sent out to the receiver, the first image showing only the red parts of the object, the second image showing only the green parts, and the third image showing only the blue parts.

At the receiving station a similar disc to that of the transmitter revolves exactly in step with the transmitting disc, and behind this disc in line with the eye of the observer are two glow discharge lamps—a neon lamp, and a lamp filled with helium and mercury vapor. The neon lamp supplies the red constituents of the light and the helium and mercury vapor the blue and green. The eye of the observer sees first a red image, then a blue image, and then a green image, the images being presented so rapidly that persistence of vision causes them to blend and the observer to see a composite image made up of these three colors.

Now red, green, and blue constitute the three primary colors from which all other colors are made up: for example, purple is a combination of red and blue, yellow is a combination of green and red, and in the same way all other colors are made up of various proportions of these three primaries, red, green, and blue. The process used in color television is exactly similar to the three-color process used in color cinematography.

The application of color television will naturally be considerable, but it is not proposed by the Baird Television Company to put color machines on the market for some time, as this apparatus is still in the experimental stage. The first television machines to be marketed will be simply monochrome, showing one color, and these machines were exhibited at the Radio Exhibition held at Olympia, on September 22nd last, and will be placed on the market at a price of £25.

The image appears on a glass screen approximately eight inches in diameter and the televisor includes a loud speaker of the electrodynamic type. A special receiving device has been designed which enables both vision and speech to be received from the same aerial and at the same time.

As three separate images must be sent in color television the speed of transmission should be increased three times. In practice, however, it is found that this increase of speed is unnecessary as each of the three images contains in itself quite a large proportion of the visual image received and it is not necessary to transmit at more than twice the speed of normal television to obtain a satisfactory blend of the images and colors.

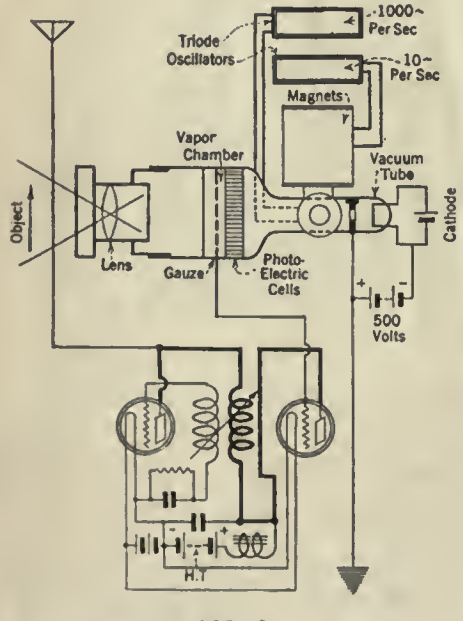


FIG. 2

CAMPBELL SWINTON'S EXPERIMENTS

THE favorable opinion tendered toward the suggestion of Oliver Lodge and others who suggest the utilization of electrons as a basis for experiment in the development of television leads one to expect that newer experimenters in the field will turn their attention to such systems as that avocated by Campbell Swinton. His experiments have been carried to a much farther stage than Mr. Clarkson explained in RADIO BROADCAST recently.

It was only shortly after Braun, in 1897, introduced the cathode-ray oscillograph that it occurred to Swinton to work on the cathode-ray principle in an endeavor to make practical some system of television. He found in experiments that the cathode-ray beam could be deflected both magnetically and electrostatically with remarkable precision. With two similar cathode-ray beams simultaneously controlled and deflected by electric or magnetic forces due to identical currents Swinton expected to obtain absolute synchronism in the motions of the beams with maximum accuracy, irrespective of the speed. He planned to use one of Braun's oscillographs at the transmitting end and another one at the receiving end, the beams to be synchronously and simultaneously deflected by the varying fields of two electromagnets placed at right angles to each other, and energized by the same two a. c. currents of widely different frequencies. In this manner the moving extremities of the two beams would sweep over the surfaces at the transmitting and receiving ends with remarkable rapidity and synchronism, so rapidly, in fact, as to take advantage of the well-known phenomenon of persistence of vision.

To produce the required picture at the receiving end it was only necessary that the rapidly scanning extremity of the cathode-ray beam he impinged on a sensitive fluorescent screen. The beam, of course, would be caused to vary in intensity by the varying signals from the transmitter, thus producing the necessary graduations of light and shade to produce a picture. Swinton's real difficulty lay in devising a system which would efficiently accomplish the variations in

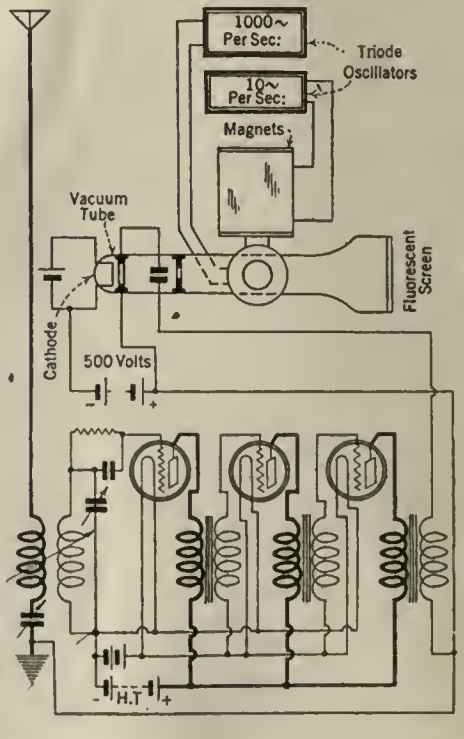


FIG. 3

the transmitted current, which, in turn, depended for its variations on the variations of the scanning cathode-ray beam at the transmitter. In these early experiments the use of a selenium cell was depended upon as the link responsible for the actual variations in transmitted current.

In 1911 Swinton first suggested the use of photo-electric cells as the basis for the transmitting screen—not a single cell, but a fine mosaic of them—and this idea survives in his latest equipment.

Some inventors use the combination of a mechanical arrangement at the transmitting end and the cathode-ray beam at the receiver. Naturally, then, the final result is governed by the speed of the mechanical parts, and the speeding up made possible by the use of electrons throughout is not possible.

As a further development, Swinton suggests the use of electrons by means of suitable three-electrode tubes to supply, from batteries or from the mains, the two a. c. currents of largely different frequencies required to actuate the deflecting magnetic or electrostatic systems at the receiving and transmitting ends, used for the purpose of causing the synchronous, combined oscillating and traversing movements of the beams. The exact synchronization of these latter could be maintained by special radio signals on a wavelength separate from that used for the transmission. Figs. 2 and 3 show the latest Swinton transmitter and receiver circuits, respectively. In these circuits it will be seen that all mechanical motion has been done away with, resulting in circuits hardly more complicated than those used at the present time for broadcasting reception.

In describing the operation of his apparatus, Swinton writes as follows:

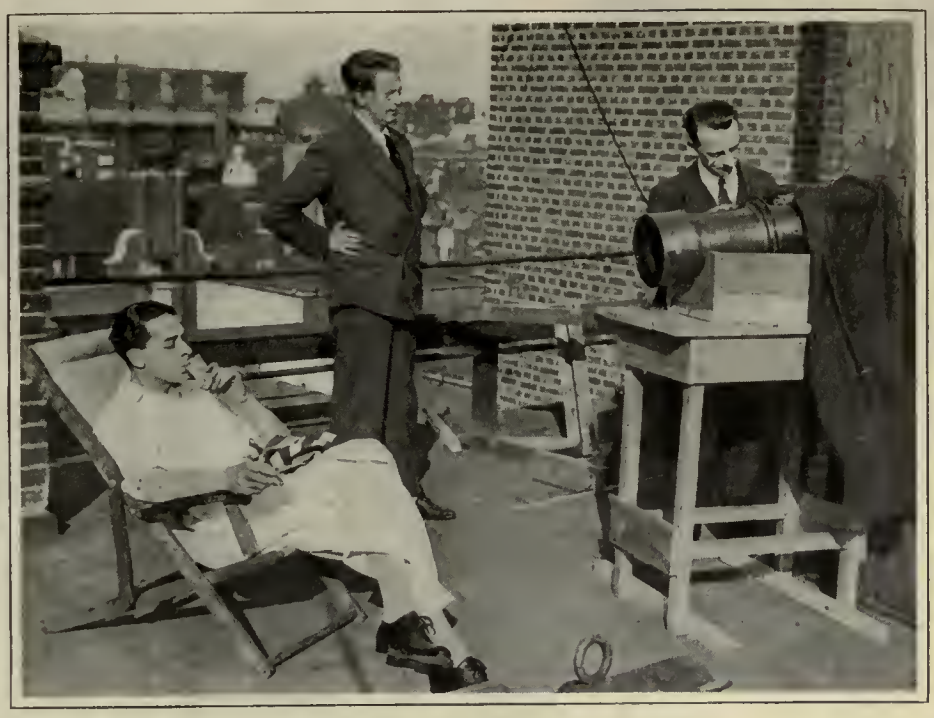
At both ends the two cathode-ray beams impinge on screens, which they are caused by the defecting systems to sweep rhythmically and in complete synchronization in parallel lines backwards and forwards from end to end. In the transmitter the screen is composed of a very large number of minute photo-electric cells each of which are activated more or less by the amount of illumination it receives from the image thrown upon the whole screen by the lens. The end of the transmitting cathode beam explores each of these cells in turn, and as to whether it finds it illuminated and thus activated or not, an electrical impulse of varying intensity, proportional to the amount of local illumination, is transmitted to the neighboring gauze grid. The varying electric current thus originated after amplification and conversion into wireless waves is transmitted to the receiver, where, after further amplification and detection, it varies the strength of the receiver cathode-ray beam, which, in turn affects the brightness of that particular portion of the fluorescent screen on which the end of the cathode beam is at that instant impinging. Thus, on the receiving fluorescent screen a replica of the picture thrown by the lens on the transmitting screen is reproduced.

Very probably with modern knowledge and arrangements the transmitting method in which selenium is used might be got to work, though perhaps it would be too sluggish for showing rapid movements in the picture transmitted.

A CRITICISM OF MODERN METHODS

COMMENTING in a paper on the advances made in television, whose mechanical devices formed the nucleus of the apparatus, Mr. Swinton has said:—

What has been effected mechanically, more especially in America, shows what can be done by vast expenditure, labor, and elaboration. As experimental shows they were no doubt magnificent, but having regard to the apparent impossibility of either improving or amplifying to any sufficient extent, one doubts whether they can lead to anything really worth having along their own lines. Surely it would be better policy if those who can afford the time and money would abandon mechanical devices and expend their labors on what appear likely to prove the ultimately more promising methods in which the only moving parts are imponderable electrons.



BAIRD DEMONSTRATES DAYLIGHT TELEVISION

In this picture Jack Buchanan, the popular musical comedy star, is shown sitting in front of the new Baird daylight television camera Mr. Baird is standing in the center, and his assistant is adjusting the lense of the television camera

In a letter which appeared in the *London Times* Mr. Swinton expressed other views on television. Excerpts from the letter follow:

To the Editor of the Times:—

The telegram on the progress of television in your July 14 issue leads me to think some comment should be made on the many very absurd prognostications that have appeared on this important subject.

It is well known that all methods of television are based on the same principle as is the reproduction of pictures in the Press, wherein the picture in each case is composed of a mosaic of minute dots so small and so closely packed together that the individual dots are not recognizable as such by the unaided human eye. Let us take as an illustration a well-reproduced newspaper half-tone 10 x 16 inches in size. This contains more than 250,000 dots.

Now on the same principle that requires that cinematograph film pictures have to succeed one another at the rate of 16 a second, so as to give the illusion of continuous motion, for the purpose of successful television each of the thousands of dots has to be registered in its proper place and with its proper strength no fewer than 16 times a second. Thus to transmit the picture referred to would require registering the dots at a rate of 4,000,000 a second.

Such achievements are obviously entirely beyond the possible capacity of any mechanism with material moving parts and this view, which I have personally been inculcating in scientific circles for many years, has recently been thoroughly endorsed by no less an authority than Sir Oliver Lodge, himself a notable pioneer inventor in wireless telegraphy, who has recently written two articles on the subject. In these he entirely agrees with my view that nothing of this order can ever be hoped for from material mechanism, and that the only way in which it can ever be accomplished is by doing away entirely with material moving parts and utilizing the vastly superior agency of electrons, those infinitesimal and imponderable unit particles of negative electricity which are the most mobile things known to science.

A. A. CAMPBELL SWINTON.

OTHER EUROPEAN INVENTORS

NOT a great deal is heard of the effort of European inventors on the Continent, although from time to time small items of intelligence do come through. In France, M. Bélin, in conjunction with M. Holweck, has succeeded in transmitting shadows. The apparatus of M. Bélin is unique in that the transmitter makes use of two mirrors vibrating at right angles to one another, the combined action of which enables the subject transmitted to be explored by a potassium photo-electric cell. At the receiving end there is a fluorescent screen traversed by a cathode ray. Thus we get a combination of the use of the mechanical and the electron!

Another Frenchman, M. Dauvillier, has also succeeded in transmitting shadows, but admits that an increase of one thousandfold in sensitivity will be necessary before his apparatus is perfect.

Other scientists who are bending their efforts in an endeavor to be first in the race are Mihàly, Korn, Nesper, and Muller. The latter has been experimenting for some time in an endeavor to produce metal foils of extreme thinness, and has produced some of gold a hundred times thinner than heretofore, so thin, in fact, that printed letters can be read through six layers. Varying intensities of light passing through these layers of foil have been found to alter a current of electricity passing through. The use of this discovery may lead to the production of a very cheap television equipment, it is hoped.

New Trends in *Radio Design* for 1929-30

By KEITH HENNEY

Director of the Laboratory



AT THE present writing (September) several distinct trends in the progress of radio may be observed by any one who gets about even a little bit. These trends are often first evidenced in home-made receivers and in the kit sets put out by wide-awake manufacturers and are later seen in the sets built by the large complete-set people. Sometimes, of course, the set manufacturer is in advance of the others, but in general the tendency has been for this branch of the industry to follow the leader. Whether this is due to lack of engineering initiative, or to hesitancy to adopt something new, or to patent arrangements, is difficult to say. It is true, however, that among the licensees of the R.C.A. there have been few major new ideas that have seen the light of the dealers' shelves. These people are still making t.r.f. sets or neutrodynes. Small improvements have been made, but they are in the nature of refinements of existing circuits and apparatus.

What are these new trends, and what do they mean to the future of the radio business—say the 1929–30 season?

THE DYNAMIC SPEAKER

WE HAVE already discussed in this magazine the moving-coil or dynamic speaker. After considerable effort to find an unbiased source of loud speaker information, we discovered Joseph Morgan of the International Resistance Company, who wrote the article "All About Loud Speakers" in the August RADIO BROADCAST.

There is no doubt that the present season is going to be a dynamic speaker season. Nearly every set manufacturer of note will have a model or two equipped with this newest milestone on the way toward more perfect reproduction. There are many such speakers now on the market; some of them are the Magnavox, Jensen, Peerless, Rola, Newcombe-Hawley, Marco, Radiola 105, Farrand, etc.

Why is the moving coil speaker superior to our present cone and horn types? Briefly, because it presents to the final power tube a nearly pure resistance rather than a complicated combination of inductance, capacity, and resistance whose frequency characteristic is anything but a straight line. The dynamic speaker has a moving system that can move through large distances, up to a quarter inch, which means that plenty of low-frequency power can be put into it with the certainty that sound energy will come out, and that there will be no clatter of armature against pole pieces. No other type of speaker has been tested in the Laboratory which reproduced fundamental tones below 100 cycles. They emit sound, to be sure, but it is not like the original.

Will 1929 See These New Developments in Everyday Use?

1. THE DYNAMIC SPEAKER
2. THE BAND SELECTOR
3. THE ONE-STAGE AUDIO
4. THE FIVE-ELEMENT TUBE

The dynamic speaker, then, is here, and in 1929 will take its place in the best commercial sets and in the homes of the most critical home set builders and engineers. It entails several hardships on the constructor. The filter in his power supply must be better than is necesaary with other speakers that do not reproduce tones below 100 cycles. He must put the speaker in the middle of a rather large and awkward and solid board not less than three feet square for best results. His amplifier, to utilize the advantages of this kind of speaker, must be very good. Because the speaker is more efficient—at least some of them are—he can get along with less power, but at present it is not safe to economize at this point. The constructor had better plan to use 171's or better in his final stage. The day of the 199 tube loud speaker is not yet here. On the other hand, we do not believe it necessary for the home listener to go to 250-type power output tubes, although the reserve power possible with such an amplifier as was described in the July RADIO BROADCAST (page 141), is something to strive for as the ultimate.

In the laboratory of Dr. John P. Minton, the well-known acoustical engineer, we heard a 10-inch Peerless dynamic speaker which was mounted in a three-foot baffle of not too solid construction. The speaker was operated from an amplifier employing a single 171-type tube in the output stage, and the results were very satisfactory. The signals were made louder than could be tolerated comfortably in a small apartment, and they were considerably "up" from the output of a W.E. 560 AW. Persons who invariably talk louder than the radio when the latter is turned on would have considerable trouble in preventing one enjoying a symphony concert from a local station with such a speaker connected in the output circuit.

At the present time the Laboratory staff is busy measuring the characteristics of a number of the newer speakers of this type and when the datum is available in its final form it will be published in RADIO BROADCAST.

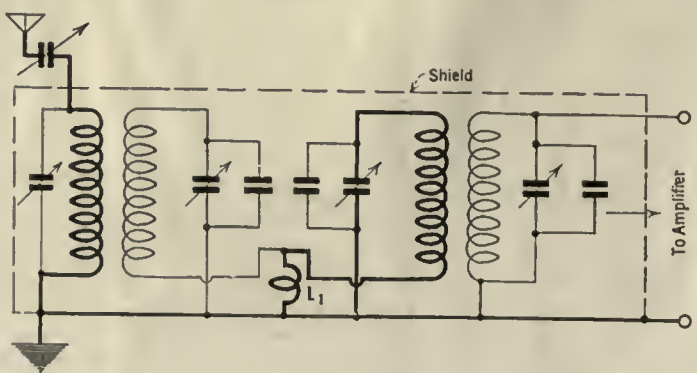


FIG. 1

There are no tubes in the Jones band selector which is shown in schematic form here. All the selecting is done by one set of apparatus, the amplifying by another. The tuned circuits are coupled together by the small inductance, L_1

THE BAND-PASS R.F.

ANOTHER very distinct trend is the band selector business. In December, 1927, Dr. F. K. Vreeland read a paper before the I. R. E. on his ideas of what a good radio-frequency amplifier should be. He had two suggestions. One was to stagger the three tuning condensers of a t.r.f. set slightly, that is, tune two of the condensers slightly above and below the exact resonance point. This, according to Dr. Vreeland, would tend to broaden the top of the response curve and to steepen its sides. This would make it possible to receive the high audio frequencies that are

so badly clipped at present, and yet to prevent cross-talk from adjacent radio channels.

Dr. Vreeland's other suggestion has occasioned a lot of discussion. It consists in using in the receiver a band selector composed of—this is our interpretation, not Dr. Vreeland's—two tuned circuits coupled closely enough so that the resonance curve of such a system has a flat top, a top with a dip in it, or a sharply peaked top depending upon the constants of the circuit. According to the discussion, this is not a new idea—we do not know that Dr. Vreeland said it was—but the fact is that in the old spark days, the bane of radio inspectors was the closely coupled antenna-transmitter system which emitted a broad wave.

The effects of staggering are two: (1) to broaden the top of the response curve and thereby to improve fidelity; and (2) to reduce the r.f. gain somewhat. With deliberate staggering it should be possible to use very highly selective circuits—"low loss," if you will. Then the gain per stage ought to be somewhat greater. The gain in fidelity, however, will not be noticeable on the average amplifier and loud speaker. On the other hand, with a flat audio amplifier, a good transmitting station, and a dynamic speaker, the higher frequencies as heard should be materially improved.

We must now record a visit to the Technidyne Laboratory, where we again had the pleasure of chatting with Mr. Joseph Jones who is business manager of this organization, of which Mr. Lester Jones is the engineer. This was not our first meeting or conversation, and only convinced us the more that this is an organization which will be heard from more and more in the next few years.

The Technidyne group has a band selector, too, but it differs in several respects. The Jones group has in addition a self-shielded coil, a loop of similar characteristics, and an untuned r.f. amplifier of considerable gain. How these work into a modern receiver will be indicated below. The coil has two windings, one inside the other. The high potential ends of the coil are inside, so that one can grasp hold of the coil, or wrap a short-circuited turn of heavy copper wire about it, without destroying signals or even detuning the set. In our opinion this is an extremely useful invention and has resulted in a very valuable patent. So long as coils are used in receivers, there must be means of keeping their respective fields from getting out of bounds. One method is to encase the coil in a metallic can—shielding it—and another is to use a self-shielded coil.

The Jones band selector will probably be used in several receivers, notably the Sparton. It works out as follows. A band selector is made up of several coils and condensers and encased in a container. This has but one wire coming from it, the connection to the following unit, the r.f. amplifier, which connects to the detector and the audio system. This amplifier is untuned, has five stages in it, with the gain varying from 3000 to 15,000 from the short to the long waves to offset the lack of coupling on these waves between set and antenna. When an antenna is attached to the amplifier input, the mix-up of signals is worse than anything the Radio Commission ever imagined.

This circuit has several obvious advantages. In manufacture there are three belts on which the selector, the r. f. amplifier, and the a.f. amplifier are placed for inspection. This is to be contrasted to factories in which the completed receiver is placed upon a single belt. If anything goes wrong with a selector unit, it is removed; the same thing happens with an r.f. or a.f. amplifier. When any good selector is attached to any good r.f. and a.f. amplifier units a good receiver results.

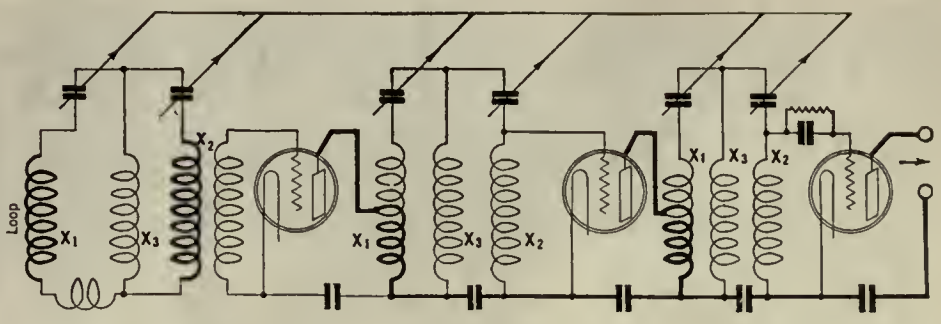


FIG. 2

The circuit diagram of the Vreeland band selector; note the inductance, X_3, which couples together the two tuned circuits composed of X_1 and X_2 and their associated tuning condensers

In service a similar occurrence takes place. The service man takes with him an extra selector and an r.f. amplifier. If the customer's selector is out of order, a new unit is slipped into place—the entire set is not placed out of commission.

The Hammarlund-Roberts engineers have incorporated the band selector idea in their 1929 Master receiver already described in this magazine (October, page 341). In this receiver both the primaries and the secondaries of the r.f. transformers are tuned, the two circuits being coupled together by the mutual inductance existing between the two coils. This is very loose mechanical coupling. The Vreeland and the Jones system use other types of coupling, it being possible, of course, to couple two tuned circuits together with mutual or self-inductance, or with

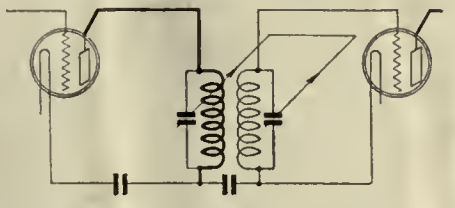


FIG 3

The band selector used in the Hammarlund-Roberts "Hi-Q 29" receiver. In this case the tuned circuits are coupled together by the mutual inductance existing between primary and secondary

capacity or resistance or combinations of all of these.

Here, then, is the second trend toward band selectors, electrical contrivances which cut out of the broadcast spectrum a swath of the desired width. Such circuits have been suggested as a relief in the present overcrowded ether conditions. We believe, however, that another year will see the band selector the rage in set construction. The Jones system is a preselector, that is, the signals are first selected and then amplified. In the Vreeland and the Master Hi-Q circuits amplification and selection go on at the same time.

THE ABBREVIATED AUDIO

THE third noticeable trend is toward the elimination of the first stage of audio, and working the power amplifier by the detector. Let us see what this means. First of all it means that the detector must supply a much higher output a.f. voltage and therefore must be supplied with a higher input modulated r.f. voltage. The Jones system does not use the usual first stage of audio. The detector is a C-bias affair with input r f. voltages of the order of 10 to 15 volts. A new R. C.A. super has also been put on the market which uses a.c. tubes and has only one audio stage.

The elimination of the first stage of a.f. reduces cost, makes a set simpler to construct and should reduce not only tube noises and the tendency toward severe microphonics, but eliminate considerable a.c. hum, which is a great advantage when the dynamic speaker is used with a good amplifier.

One well-known physicist-radio engineer states that in his opinion the proper place for the loud speaker is in the detector circuit. Whether the set of the future will have no audio amplification at all cannot be debated at present.

A NEW TUBE IN THE OFFING

IN ENGLAND there is considerable talk of the new special-purpose tube with five elements, the Pentode. This is a power valve built along lines similar to our present screen-grid tube. The idea is to get much greater output power with given input voltages. It is a tube with a large amplification factor and a high plate impedance; with our present low-impedance speakers it may require new coupling devices. A number of articles have appeared in *Wireless World* (England) recently on this tube, which lead us to believe that the Pentode will do much toward making unnecessary all the r.f. amplification that eliminating one audio stage demands at present.

WHAT ARE WE COMING TO?

HERE, then, are the trends in sight. The first, the dynamic speaker, is here now. It is one more step toward better reproduction, greater fidelity of voice and music. The second, the band selector, is another step toward fidelity, with the possibility of an increase in selectivity. In the hands of Lester Jones the problem of selectivity has been separated from that of amplification—a feat we predicted months ago. The superheterodyne is such a circuit, although not to the degree the Jones system is. The third trend is the elimination of the first stage audio. In the Jones system this is done by using greater r.f. amplification and detectors more heavily biased than those of the present. In the super-heterodyne the amplification is at intermediate frequencies. The Pentode tube may make it possible to eliminate some of the additional r.f. gain now necessary, with an obvious advantage from the standpoint of cost and simplicity.

It looks as though it is never safe to predict that the time has come when there is nothing new under the radio sun. The home constructor, however, need not feel it unwise to construct a set at present on the suspicion that next year's circuits will make obsolete his present gear. Receivers built to-day according to recognized engineering principles and equipped with good amplifiers and speakers will be standards of comparison for some time to come.

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

New Allocation Repairs the Broadcast Structure

THE Federal Radio Commission has, at last, bestirred itself. It has formulated an orderly plan of allocation, based upon conservative engineering estimates of the capacity of the broadcasting band. When the plan is in smooth operation, it will increase the program service obtainable with any radio receiver capable of reaching out beyond neighborhood locals.

We hesitate to praise any constructive step announced by the Commission because, up to this time, it has always reversed itself before promised reforms have been put into operation. It proposed to eliminate all stations persistently wandering from their channels, but backwatered before the echo of its brave statements had died out. It called a host of stations before it to prove they were operating in the public interest, necessity and convenience, with a grand fanfare to the effect that many would thus be weeded out, but the actual result of the hearings was negligible. From past experience, we cannot avoid fearing a complete reversal of form and a repudiation of the meritorious broadcast allocation plan. We hope that public approval of the announced plans will be so forcibly expressed that, this time, there will be no turning back.

The plan itself is a normal and sensible classification of channels into local, regional, and national groupings. Forty channels, eight per zone, are nationally cleared for exclusive service by stations of 5000 watts or more. Only one station is in operation on each channel at a time, although time division may be employed in the case of stations not prepared to operate on a full-time basis, or to permit division of channel facilities among the states according to population, as required by the Davis Amendment. This exclusive service band lies between 1190 and 640 kilocycles.

Four channels, 1460 to 1490 inclusive, are devoted to stations of a maximum power of 5000 watts, to be shared by two zones, presumably on opposite coasts of the country, thus providing good regional service.

Thirty-five channels, ranging throughout the dials from 1430 to 580 kilocycles, are assigned to stations having a maximum power of 1000 watts. These channels will be used in not less than two nor more than three zones simultaneously for night broadcasting, although in isolated instances, the maximum will, for the time being, be exceeded when no serious interference is caused. These are the so-called "regional channels."

Five additional channels, ranging throughout the band, for stations up to 1000 watts, will be duplicated in every zone, thus providing medium power, local, and limited regional service.

Finally, six channels at the lower end of the dials, will be thickly populated with 100-watt broadcasters, accommodating a great number of stations providing strictly local service.

This, in brief, is the skeleton of the allocation plan, as it was first announced by the Commission. Undoubtedly, it will be modified. Such dubious features as limiting the maximum power of permanently licensed stations to 25,000 watts, on the exclusive channels, is a useless curtailment of the service of these channels. Did it serve to increase the number of stations which might be assigned to a channel, it could be justified on that ground. It amounts only to an order compelling stations to render less than their best possible service. Apparently, it is a concession to Judge Robinson, who wanted to put a 5000-watt power limit on broadcasting, thereby reducing the total area of the United States served by high-grade broadcasting to considerably less than ten per cent.

EFFECT OF THE DAVIS AMENDMENT

THE Davis Amendment requires equal distribution of channels among the zones, and their distribution within zones according to population. As a consequence of the varying areas of the zones, more than half of the desirable regional and national channels necessarily are assigned to the Northeastern quarter of the country, comprising the first, second and part of the fourth zones. The Western half of the country, the fifth zone, has only one-fifth of the total number of cleared channels. The Southern zone, comprising an area of about a fourth of the country, is given only one third the number of preferred channels assigned the Northeastern quarter of the country.

The Commission naturally has found these silly requirements of the pernicious Davis Amendment a serious handicap in its work and has not overlooked any opportunity to impress the public with the effect of the provisions of the Amendment in unnecessarily depriving the South and West of broadcasting stations. However, had the Commission acted promptly upon the various allocation plans offered it from the very day of its organization (of which one, submitted by a member of the staff of RADIO BROADCAST, provided almost precisely the structure at last agreed upon), the Amendment never would have been passed. The year and a half of dilly dallying which preceded the adoption of the present plan has inflicted a more or less permanent handicap upon the broadcast structure in the form of the Davis Amendment.

To the broadcast listener, the faithful adoption of the present plan means clear reception on most of the positions of the dial. Forty channels are completely cleared, providing for eight stations in simultaneous operation per zone. Thirty-four channels are partly cleared for regional service, offering a standard of reception about equal to that heretofore found on the so-called cleared channels. The number of stations reasonably clear of heterodynes, is vastly increased and chain programs will no longer crowd the few choice dial positions.

By taking into consideration the channels which will be used simultaneously by more than one zone, the total number of stations in the regional class, operating simultaneously at night, will be 125, or 25 per zone. These regional stations will give satisfactory service for moderate distances beyond the so-called "high-grade service range" and should be entirely free of heterodynes within the high-grade service area.

The six channels devoted to local service may be duplicated at fairly short distances, but again the Davis Amendment acts to curtail the potential service of these channels. The number of stations per zone upon these channels must be equalized although, for example, there could otherwise be about twenty times as many local communities using these channels in the fifth zone as in the first, without having any greater congestion than is found in the first, so marked are the differences in the areas of these zones.

Another curious consequence of the Davis Amendment is the somewhat diverse effect it has upon the two centers of broadcast congestion, New York and Chicago. Because New York has such a predominant proportion of the population of its zone, it suffers a somewhat smaller curtailment of assignments than Chicago. Casual observation of the Chicago situation shows a heavy mortality in time on the air of its all-too-numerous 5000-watt stations, but the actual effect will not be nearly as drastic as it appears. Many of Chicago's 5000 watters have been operating on extensive time division in the past and others are merely call letters rather than actual stations. Practically no licenses will be cancelled any-



MARCONI'S NEW 6-KW, 2000-METER TRANSMITTER

This wireless telegraph station at Grytviken, South Georgia, maintains a daily telegraph service with the Falkland Islands which in turn communicate with Montevideo

where and, by liberal use of time division and limited application of power cuts, the new structure will work a minimum hardship upon station owners.

In spite of the dire predictions of opponents to a plan based upon engineering considerations, the plan supports the contention of engineers that allocation, based upon sound technical evaluation of the capacity of the broadcast band, does not require heavy mortality of stations.

PLAN BETTER THAN HOPED

FOR two years, we have urged in these columns that the number of stations on the air simultaneously be reduced to 200 or 225; the plan exceeds our fondest hopes because it places only 165 stations in simultaneous operation on 74 channels. The balance of the band is reserved for strictly local services. Receivers in good locations will bring in a parade of unheterodyned stations and good programs will again have almost nationwide audiences. The wall of local stations, in congested centers, will be partly levelled. Every section will profit by lessened heterodyning. The South and West are seriously restricted by enforced disuse of available channels. In the South, this is no immediate hardship, as there are fewer stations in operation but, on the Pacific Coast, a great many needless holes in the ether can be credited to the Davis Amendment.

We predict one unexpected result of the new broadcasting structure: the restoration of popularity of long-distance listening. Radio reception has arrived at a respectable degree of quality of reproduction. Cleared channels will bring back a limited amount of dial twisting and, within a year or two, long distance will again be a desired quality in a radio receiver. Long distance is the magic of radio, just as speed is the zest of motoring. Beauty in appearance and tone will always predominate as a sales appeal, but the flash of distance will rise again as improved conditions make its enjoyment possible. This repeats in radio the cycle of automobile sales appeal: first, speed, then an era of emphasis on comfort and beauty and, finally, these characteristics combined, as they are in the products of to-day.

What Is Public Interest?

LOUIS G. CALDWELL, as attorney for the Commission, on August 25, issued a detailed interpretation of the so-called public-interest, convenience and necessity provisions of the Radio Act. Inasmuch as the Commission must, sooner or later, prove in the courts that the new allocation plan is justified by these considerations, that interpretation is virtually the Commission's plan of defense. The statement points out particularly that the Davis Amendment, although calling for equalization of powers and stations in each district, does not set aside the public interest, convenience, and necessity clause and that, therefore, all new stations, authorized in under-quota districts, must pass qualification standards imposed by these four, all-important words. It further points out that renewal of existing licenses is not incumbent upon the Federal Radio Commission, unless it finds that public interest, convenience, and necessity are served; that the issuance of a license is not to be regarded as a finding beyond the duration of the period covered by said license; relicensing in the past, indicating that the station has met the test of public convenience, does not, however, bind the Commission to continue past mistakes, should any have been made inadvertently; that public interest, convenience, and necessity cannot possibly be defined and must be judged by individual situations and conditions; that there is demand for a variety of services, including high-power service, covering large territories, and low-power service for local interest; that the broadcasting of phonograph records as a considerable part of a station's service is not a public service unless special records are developed for broadcasting only; that advertising should be incidental to a real service rendered by a program; that stations of 500 watts power or more should not be located in thickly inhabited communities; that very low-power stations should not be permitted in very large cities; such channels being more usefully employed in smaller towns; that the character and financial responsibility of applicants for licenses are important considerations; that broadcasting time should not be used to air discussions of a private nature; that stations, not operating on a regular schedule, do not serve the public; that a broadcaster, who is not sufficiently concerned with public interest to equip his transmitter with adequate frequency control or check thereon, is not entitled to a broadcasting license. These considerations were the basis upon which the practical application of the broadcast allocation plan were founded when the Commissioners made their individual station assignments to national, regional, and local channels.



THE STAGE OF A TELEVISION DRAMA

This picture shows how WGY *broadcast the first television drama, "The Queen's Messenger." Three television cameras were used—one for each of the two players and the third for the "props"—and by a twist of the knob the director could bring the desired camera into the circuit. Also, a television receiver was installed in the studio to enable the director to check the image*

The Race for Television Publicity

THE race for television publicity continues. The latest to score is the Westinghouse Company, which demonstrated a sixty-line television scanner and reproducer. This is ten lines better than the television elephant which the Bell Laboratories built some years ago. Instead of scanning a living subject, light was passed to the photo-electric cell through a motion-picture film. This was proclaimed in the newspapers as a radical invention, although the first broadcasting of radio movies, as we recall it, was demonstrated to members of Harding's cabinet seven years ago. by C. Francis Jenkins. With amazing ingenuousness, the Westinghouse publicity stated that Mr. Conrad began his television researches only three months ago.

The uselessness of the device from a practical viewpoint could be gleaned from a single statement in the publicity to the effect that the frequencies used to transmit the sixty-line picture lay between 500 and 60,000 cycles, so that a total of 150,000 cycles of ether space would be required to radiate the signal by the conventional, double-side-band method. An extra 5000-cycle wave was used for synchronizing purposes.

The usual statement was made that the device would be marketed by the Radio Corporation of America when ready for public consumption. Mr. H. P. Davis, Vice-President of the Westinghouse Company, also stated to the press that the device would soon be ready for the home user. So are steam yachts!

WRNY Television Transmissions

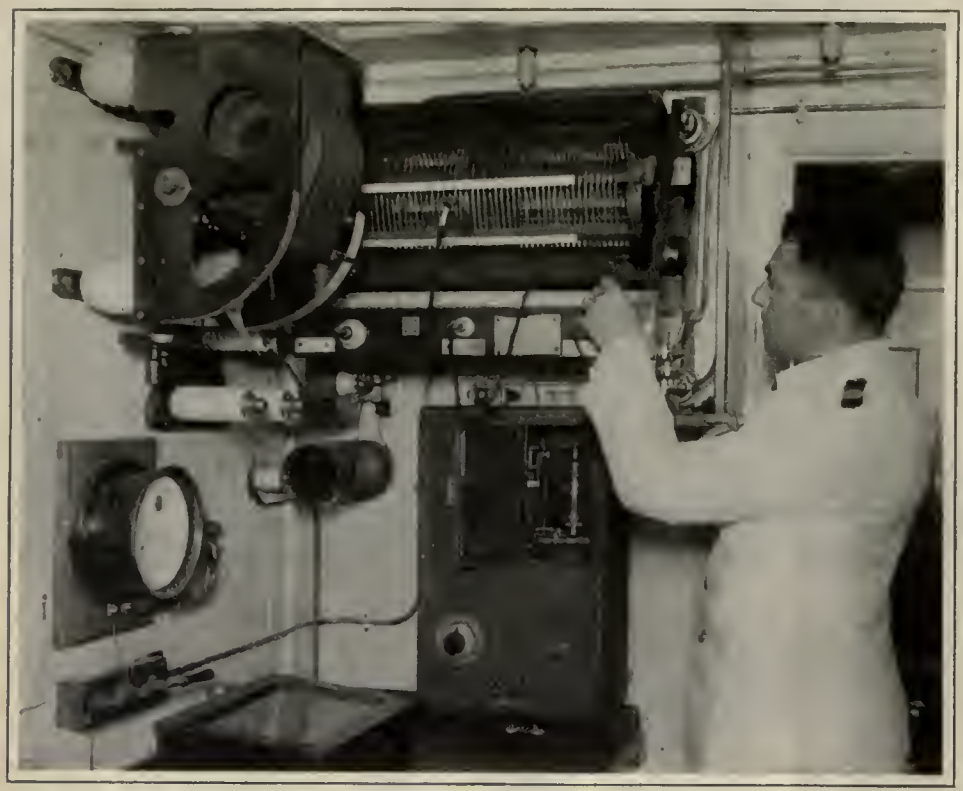
STATION WRNY began its transmissions on August 21. Its television signal is now heard from the fifth to the tenth minute of each hour that the station is on the air. A 48-line picture is transmitted on the broadcast band, but its channel width is restricted by sending only 7.5 pictures a second instead of sixteen. This does not improve the quality of the transmission.

A Milestone in Television

THE first time that remote-control television broadcasting has ever been undertaken was the occasion of Governor Smith's acceptance speech on August 27. On this occasion, WGY installed its portable television transmitter, which makes a 24-line picture, at the State House in Albany. The television signal was transmitted through eighteen miles of wire and then radiated by WGY, the General Electric station at Schenectady.

The television pick-up equipment, erected near the microphone, consisted of three units, two tripod-mounted, photo-electric cells in boxes, a light source, and a scanning device. The cells were placed at the left of the Governor, within three feet of his face, and the light source between the cells. A 1000-watt lamp was used to play on the Governor's face, the intensity of the light being broken up by a scanning disc.

The General Electric people did not issue any applesauce publicity about milestones in history at the time. When they issue a statement that home television is practical, we will believe it.



A MODERN RADIO INSTALLATION ABOARD AN ITALIAN LINER

New Nationwide Picture Transmission Service

A HEADLINE in the New York *Times*, announcing a nationwide television service, proved upon analysis to be the announcement of a proposed extension of commercial still-picture transmission by the R. C. A. A 5000-cycle signal, transmitted over a special carrier, is used for synchronization. The image is thrown upon a ground-glass screen and there photographed. The device was produced in the laboratories of the Westinghouse Company and may be used by the R. C. A. in competition with the A. T. & T. system. This is neither television nor broadcasting. Otherwise, the headline was correct.

Need for Defining Television Practices

SINCE many broadcasting stations appear to be groping toward television, it is desirable to reduce to a minimum the number of scanning disc apertures and their different combinations, and to agree upon the direction of disc spiral and disc speeds to be used. These factors are being determined in a very unscientific and haphazard fashion. Each individual television transmitter, being put into operation, seems to work according to the whim of its builder, with the result that any television receiver now built is capable of receiving from only a single transmitter, although it may be within range of two or three signal sources.

The variables are not confined merely to the number of holes in the disc. Some transmitters scan their subjects in such a manner that the first sweep of the disc makes the top line of the picture; others start at the bottom. Some require the receiving disc to run clockwise; others counter-clockwise. Still others, intending that universal or direct-current motors be used for driving receiving discs, are not operating at closely regulated speeds so that standard synchronous motors may also be used for reception.

It is too early to propose standards for these factors because standards imply agreement upon practical constants. Television is altogether too crude to be standardized. It would have been no more ridiculous, in 1904, to standardized upon 28 x 3 inch automobile tires, than to decide today upon 24 or 48 line scanning discs for television. But it is worth agreeing upon temporary standards of (1) disc speed, (2) direction of spirals, (3) common multiple for number of holes, and (4) direction of disc rotation.

Newspaper Has Radio Picture Transmitter

THE Edinburgh *Scotsman*, a leading newspaper, claims the distinction of being the first newspaper in the world to own and operate its own photo-telegraphic service for the regular transmission of news pictures. The time of sending pictures from London to Edinburgh has been cut from eight hours to eight minutes. The costliness of the several systems in use for commercial picture transmission in the United States have precluded their routine use by newspapers. The A. T. & T. system is well organized, but newspapers complain that they have to wait so long between the filing of pictures and the time they are actually sent that airplane delivery is more rapid and desirable. The R. C. A. transoceanic service is useful only in the case of pictures of extraordinary interest because transatlantic transmission of pictures is difficult.

Commercial Broadcasting Increases

A VERY healthy trend in the strengthening of the economic foundation of broadcasting is indicated by the growing percentage of national advertisers using commercial, goodwill broadcasting, as reported by the Association of National Advertisers. The figures represent investigation of the activities of 352 leading advertisers. For that number, the percentage using radio grew from 11.6 per cent. in 1927 to 14.5 per cent. in 1928 and the actual number from 41 to 51. Broadcasting is the only one of the eight classifications, into which national advertising falls, that has shown a marked increase in the number of users. The greater the number of national advertisers, seeking to please the public by goodwill programs, the greater the competition for public attention, and consequently the higher the program standards. Better commercial programs also mean further improvement in standards of non-commercial programs and a very happy outlook for the radio listener. Another field which is developing is broadcast advertising by local stations. The peak of direct advertising by the local broadcaster is passing and more intelligent and serviceable use of the radio announcement is being made by the smaller stations.

Here and There

A NEW chain is again announced on the Pacific Coast, comprising KJR, Seattle; KEX, Portland, KGA, Spokane; KYA, San Francisco; and KMTR, Los Angeles. Rival chains to the N. B. C. Pacific Coast network which did not materialize have been announced before. Perhaps this new one will.

MR. OSWALD SCHUETTE, professional radio agitator, employed by the Radio Protective Association, offered a petition to the Commission that the licenses of WEAF, WJZ, WGY, WRC, KOA, KGO, KDKA, KYW, KFKX, WBZ and WBZA be revoked on the grounds that the companies operating these stations constitute a radio monopoly. Louis G. Caldwell, counsel for the Commission, pointed out that, until the companies called are found guilty of monopoly in the courts, licenses cannot be revoked on that ground; that there being no point-to-point communication, and therefore no competition between cable, wire, telegraph or telephone systems involved, the Commission is powerless, under Sections XIII or XV, to take the silly action proposed by Mr. Schuette and his excited associates. This proposal is even more drastic than Judge Robinson's suggestion that the power of these stations be cut to 5000 watts. It might prove a healthy lesson to carry out such a threat, just to witness the storm of listener protest against the disruption of broadcasting service from favorite stations.

AS EVERYONE perforce knows, radio has come to its own as a political medium. The Democrats are spending about half a million for radio, using six half-hour periods a week, including a liberal appeal to the women's audience. They are also spending $100,000 for individual programs over independent stations. Entertainment is being broadcast in connection with political features. The Republicans are using the network three times a week, the entire country being covered once a week by the inclusion of the Pacific network. Also, 43 half-hour programs are being sent over the Columbia network, thus insuring the listener of no rest from political blasting.

Aircraft Radio

CAPTAIN S. C. HOOPER pointed out the importance of using the 500-kilocycle distress frequency on aircraft making over-water flights. This enables flyers to establish communication with ships at sea and shore stations, while utilizing the high frequencies, permitting long-distance transmission, often pre-

cludes nearby reception. For example, the *Greater Rockford*, which made an amazing landing somewhere between Newfoundland and Greenland, was heard successfully in Wisconsin. But none of the shore stations in Canada or Greenland could hear its signals because of skip-distance effect. Had it been possible to take compass readings in Greenland or Canada, the whereabouts of the place would have been much better known and the rescue would have been accomplished very much sooner.

NEW YORK STATE plans an aviation weather service and is establishing twenty weather bureau stations which will make reports to Gustav Lundgren, meteorologist, at Albany. The data will be compiled and telegraphed to every airport in the state, as well as broadcast twice daily through N. B. C. stations.

A DIRECT, high-power service between San Francisco and Tokio, the first occident to orient service to be directly connected by modern, high-speed telegraphy, was announced by the R. C. A. Messages to Japan heretofore have been relayed through Hawaii.

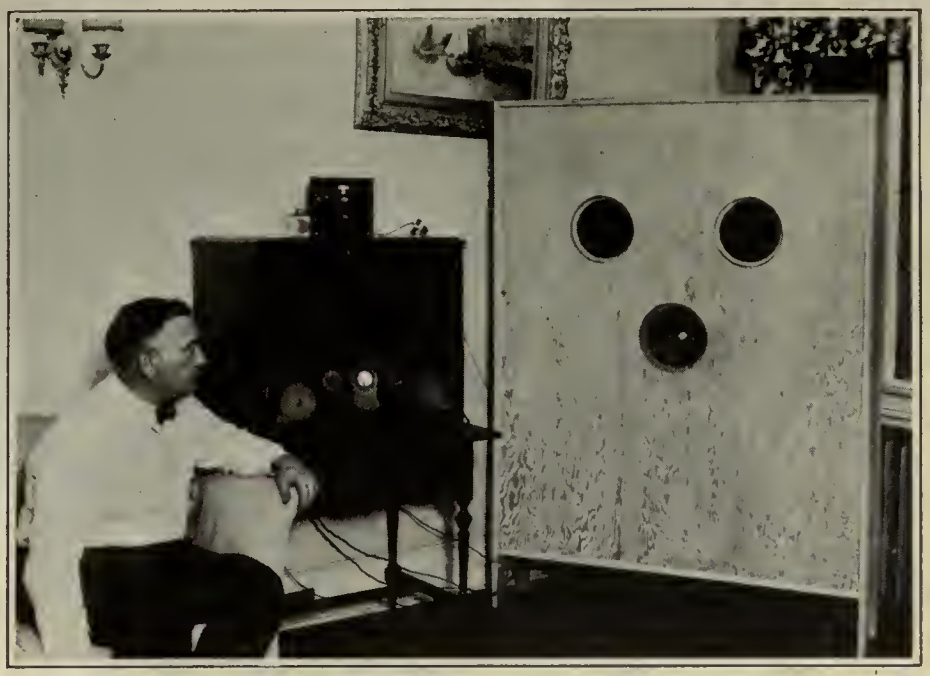
THE Federal Radio Commission authorized the R. C. A. to establish direct communication with Liberia, although a channel for that purpose already has been allocated the Firestone Company which, by the way, did not oppose the R. C. A.'s application. If the Commission is holding to its promulgated principle, a single radio link is not sufficient to handle all the traffic between Liberia and the United States and the duplicate services are warranted by the amount of message traffic to be handled.

ANOTHER pair of licenses granted for services of doubtful value are the permits issued to the Universal Wireless Communication Company for two 10,000-watt stations, one for New York and one for Chicago, to operate an overland radio-telegraph service. Filling channels with unnecessary services means later denials to essential services.

THE International Telephone and Telegraph Company has made an agreement with the Spanish and General Corporation to build a radio-telegraph station in the Azores for transatlantic communication. This will distribute North- and South-American traffic to European countries where the Mackay Companies have no direct communication through their agreement with Eastern Cables, Ltd.



REAR VIEW OF GIANT SPEAKER



AN ELECTRODYNAMIC SPEAKER OF DE LUXE DESIGN

Three dynamic units are used in the loud speaker shown above. The baffle on which the units are mounted is of box construction and measures 4½ by 5½ feet. The designer of the speaker, Mr. Mampe, of Palisade, N. J., is shown in the picture

THE call letters of the ship and planes of the Byrd Expedition are WFBT, WFA, WFD, WFE, KFK and, for the planes, WFC, WFB and WFF. The wavelengths in meters of the channels to be used will be 91.3, 68.1, 53.1, 45.6, 34.06, 26.5, 22.8, 17.95, and 13.72. Eavesdropping upon the affairs of the expedition will be possible all over the United States. The expedition will carry 20 transmitters and 26 receiving sets and a most comprehensive line of accessories and parts to keep the installations in operation for two years.

Radio in Foreign Countries

AT THE Berlin Radio Show, there were 350 exhibitors, including the Army and Navy, Lufthansa and the German Postal Administration. The most interesting television device demonstrated was the invention of one Mihaly, which gave the shadowy outline of the person spoken to on the telephone.

THE Department of Commerce report for June shows a marked increase in United States exports of radio equipment. The greatest growth was in transmitting sets and parts, which, compared with June, 1927, exports of $5,806, rose to just short of $50,000. Receiving sets rose from $174,433 to $228,983. Radio imports were more than $5000.

THE Radio Corporation has made an agreement for interchange of patent rights and for the sale of radio equipment with the State Electrical Trust of Leningrad.

A PUBLICITY statement from Russia reports that there are 67 broadcasting stations now in operation in that country, serving 250,000 listeners. Because of the great area involved, Russia will naturally require many broadcasting stations, although the number of receivers in use is still discouragingly small. Increasing public interest promises considerable growth in the future.

THE British Radio Union, a £30,000,000 concern, will acquire all the ordinary shares of the Eastern, Eastern Extension, and Western Telegraph Companies and all the ordinary and preference shares and debentures, if any, of the Marconi Wireless Telegraph Company. This is the practical consummation of the British cable merger plan.

THE British Board of Trade has passed a law, compelling Class 2 ships, freighters with more than fifty in the crew, to carry automatic distress-signal alarms. Class 3 ships, with less than fifty in the crew, are unaffected, while Class 1 ships, passenger liners and other vessels with more than 200 persons on board are permitted to displace one wireless operator with the automatic alarm.

DR. McINTYRE of the Ministry of Health of the British Board of Trade and Drs. H. C. Case and Philip Morton are experimenting, aboard the S. S. *Mauritania*, to develop an international medical chest, making possible a code, directing medical treatment at sea, which will be understandable in any language. This promises to be an aid to smaller ships which have no physician aboard.

THE National Electrical Manufacturers' Association estimates that, by cutting the total number of its meetings in half and holding the annual meeting in the fall instead of in the spring, it will save its members, through reduced time, traveling and other expenses, approximately $300,000. Attendance at some trade association meetings of the radio industry really makes it doubtful whether such expenses should be charged to personal amusements or as a legitimate business expense. The radio industry might employ an accountant to determine the financial loss it suffers by supporting two trade organizations and then follow the wise example of NEMA and reduce the number to one.

—E. H. F.



FIG. 5. FRONT VIEW OF RECEIVER

A Two-Tube T.R.F. Short-wave Receiver

By WILLIAM BOSTWICK and W. T. THOMAS

A RECEIVER to operate satisfactorily on short waves must fulfill several important requirements, and in explaining the design of the short-wave receiver described in this article, it will be well to consider these one by one, so that the reader may have a clear idea of the various phases of the problem at hand.

In the first place the receiver must be completely free from body capacity, and arranged so that its coils pick up no energy themselves. This means complete housing in good metallic shields.

The receiver should be equipped with a regenerative detector the control of which must be smooth and easy. Capacity control of regeneration has been selected as best meeting these conditions.

Any receiver placed before the public for construction, should, in the opinion of the authors, be a non-radiating device.

The receiver must be selective yet must not cut side bands, and it must cover the required wavelength range.

Lastly mentioned but far from last in order of importance, the set must have high overall voltage amplification, yet keep the amplification of noise at a minimum.

THE DESIGN OF THE UNIT

THE above résumé of what a short-wave set should be, is, of course, general, and outlines the things to be expected from the correct receiver for this job. The set that we propose to develop in this paper is one that fully meets this rigid set of requirements, and at a figure that will not strain the average pocketbook.

The set, as seen in the photographs and diagrams, is composed almost entirely of standard commercial parts. The tuning range of the receiver is from 15 to 140 meters, effected by means of three sets of easily interchangeable coils. This range covers to-day's domestic and foreign short-wave broadcasting, and the more important amateur bands. No audio amplifier is included in the set, which should preferably be used in conjunction with two stages of high-grade audio, or better still, with a power amplifier using a push-pull circuit. The set requires the use of a 6-volt storage battery or an "A" power unit, and three different B potentials, namely, the plate voltage for the screen-grid tube, the screen-grid voltage, and the detector plate voltage. The writers have found that 180, 60, and 45 volts, respectively, work out very well.

FOR the first time we are glad to be able to present a short-wave receiver using a screen-grid amplifier which is tuned. Up to the present time, designers of such receivers have been content to use the screen-grid tube as a sort of blocking tube which prevents oscillations from the detector getting into the antenna, and which gives a certain amount of amplification, it is true, but not an amount comparable to what is possible when the amplifier input is tuned.

In the Laboratory the receiver worked beautifully without any a.f. amplifier, the signals from the detector being as loud as those from an ordinary short-wave receiver using one stage of audio. It is true that such a receiver as this has an additional tuning control, and that for maximum signal strength and selectivity, both the amplifier and the detector circuits must be tuned, but it is believed that it is worth it.

The writer recommends that 180 volts be used on the screen-grid plate and 60 volts on the screening grid of this tube. In the Laboratory the receiver worked properly with only 135 and 45 volts, respectively, on the plate and grid.—THE EDITOR.

Impedance coupling is employed in the r.f. stage, as this is the only practical method of matching the plate impedance of the r. f. tube at short wavelengths. A screen-grid tube is employed on account of its high voltage amplification, and also because it is the only tube that can supply stability to a short-wave r. f. amplifier. A 200A detector tube should be used.

Perhaps a word as to results would not be out of place at this point. During the short time that this set has been in operation in our laboratory it has completely and easily covered the world. Phone reception has been effected with points ranging from Alaska to New Zealand and from England to Russia and Java, not to mention many other foreign stations at lesser distances, a low gain two-stage audio amplifier being used on the output of the set. Quite often signals from 5SW, the short-wave broadcasting station of the British Broadcasting Co., in Chelmsford, England, are strong enough to give loud speaker operation directly off the detector output. For those interested in amateur c.w. reception it will suffice to say that Australian amateurs have been heard in Ithaca, N. Y., at 3 P.M. with the phones on the table, and this also right off the detector, using no audio.

CONSTRUCTION

IT WILL be noticed that in the design of this receiver one of the shield cans called for is of rather large dimensions, necessitated by the placing of both the r. f. and detector tubes in the same compartment, the overall width parallel with the panel being 13". In some localities difficulty may be experienced in obtaining a shield of this size ready made, and for this reason it was thought advisable to include a description of the shields, for the benefit of those who wish to make their own. Let it be said, however, that unless one has had some experience in work of this nature, he had better take the drawings to a good tinsmith and have him make them, in which case it will be well to impress upon him the importance of having a close fit around the base; when the two halves are put together, the gap should not exceed $\frac{1}{32}$" at any point if a really good job is done.

The material may be either half hard brass or copper and should be slightly less than $\frac{1}{32}$". Half hard brass 0.0225" was used by the writers.

Aluminum may be used equally well but should be roughly three times the thickness mentioned.

Upon referring to drawings in Fig. 2 it will be noted that the developments and bending lines are given, the lettering corresponding with the assembly sketches, all dimensions being given in inches and all bends are at right angles and should be quite sharp. A wooden block roughly 6"x 4"x 7½" was carefully squared up and was found very useful as were also a pair of large wood clamps and a mallet.

It is advisable to commence with piece B in Fig. 2, being careful to bend exactly on the lines. Next the side pieces, G_1 and G_2, are cut out and bent along the dotted lines, these forming the sides of the cover can, being soldered along the two diagonal edges and also soldered inside the top piece, B. The rectangular slot shown in the cover cans are best cut after the soldering is completed.

Next piece A is cut out and bent along the dotted lines, care being taken that the lips on the portion fitting against the panel are bent so as to just allow room to slide the top piece in from above.

The large can is made in precisely the same manner except that the two rectangular slots are provided in the cover can to accommodate the two condensers. After the shields are completed, three small V-shaped notches are cut in both upper and lower portions in order to allow certain wires to go to the terminal strip and the jack, as can be seen from the pictures.

The next step is the mounting of the shields and the panel on the baseboard. The lower portions of the shields are screwed to the base using round-headed screws, being sure to place the small shield at the extreme left of the board, and the large one about ¼" from the right-hand extremity of the smaller, as shown in the pictures. The panel mounts directly to the baseboard with four 1" wood screws. The drilling of the panel is very simple and for that reason no layout is shown. A ⅜" hole is drilled ⅝" from the right-hand end of the panel to accommodate the filament-control jack.

The three variable condensers, C_1 C_2 C_3 in Fig. 1, are mounted symmetrically on the panel as shown in Fig. 5, holes being drilled through both the panel and the upright shield fronts; the templates furnished with the condensers giving the exact hole positions and sizes. The holes for the shafts of the two end condensers are 3⅝" from the respective panel edges, and 3¼" down from the top of the panel. The third and larger condenser, C_3, used for regeneration control, is mounted exactly between the other two and at the same distance from the top edge of the panel.

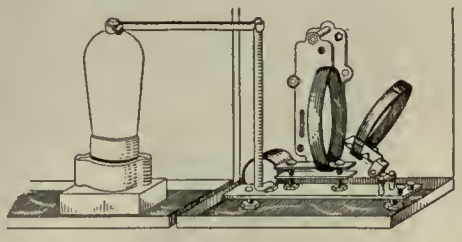


FIG. 3. DETAIL OF COIL ASSEMBLY

THE COILS USED

THE next job is the making of the coils for the various wavelength ranges of the r.f. tuner, together with their mounts. All coils are 3" in diameter and are of the so-called air wound type. The size of the wire is No. 16 and the winding is spaced the diameter of the wire. Windings of this type can be purchased by the inch from most radio stores. There are three of these coils to be made to cover the 15–140 meter range, having three, eight, and fifteen turns respectively. The general form of these may be seen in the photographs. The first step in construction is to cut three strips of $\frac{3}{16}$" bakelite, 2½" by ¼". Drill through all three of these strips two holes exactly 2" apart and on the center line of the strips, and of a diameter suitable to take the male portion of the General Radio coil mount plugs. The placing of the strips and the method of holding the coil may be seen from the Fig. 3. This procedure is followed in making the other two coils.

The next thing to be done is to remove the primary coil and its supports from the mounting base of the Aero coil set. A piece of Bakelite 5¼" x 1¼" has this primary mounted on it at a point ½" from an end in exactly the same manner as it was originally mounted on the Aero base. Drill two holes in the new base exactly 2" apart and symmetrically placed with respect to the base. These are to take the female portion of the General Radio plugs. Having completed this piece, mount it in the first shield as shown in the Fig. 4, taking care to raise it enough so that the plugs extending through it do not touch the metal shield. To this base is now attached, as the constructor sees fit, a rigid vertical rod of copper or brass extending to a height of 6½" above the shield base. This is the "signal artery" to the set, and is shown in the photographs and the diagram in Fig. 3. A connection is made at the base between this and the nearest female General Radio mount in any convenient manner. Care must be taken not to permit this upright rod to extend through the mounting far enough to come in contact with the shield base. Now placing the small 1½-volt biasing battery as shown in Fig. 4, and wiring according to Fig. 2, we are finished with the first can. It might be well to mention at this point that both shield bases are connected together by soldering a short "jumper" wire to each and that the ground, A minus, B minus leads are common and connect directly to base shields.

The base for the Aero coils can now be mounted in the large shield base by means of wood screws and the feet supplied for the purpose. Care must again be taken to prevent the coil plugs from touching the shield base when the plugs are fully inserted. The location of this mounting is very important. Its center is placed 6¼" from the right-hand edge of the large shield base and 3" from the back edge of the same.

The set of Aero coils that are to be used in the detector circuit, with the mount just mentioned, have to undergo a little treatment before they can be put into service. Due to the addition of the r. f. tube to these coils, the wavelength range is raised and we are forced to remove some wire. From the smallest coil one half turn is to be removed from the grid end (end farthest from the tickler coil). To do this unsolder the wire from the lug, slip the wire through the guide bars until you reach a point directly above the base, then run the wire directly down diametrically across the coil to the lug where it was at first, cut off the excess and solder. In the same manner one and one half turns must be removed from the medium coil and three turns from the larger.

The detector socket may now be mounted in the rear right-hand corner of the large base shield, so that the tube pin points toward the panel. Fig. 4 shows how much clearance should be left for the sides of the shield cover. The r. f. socket is also mounted in this base and is located in the rear left-hand corner, placed so that the pin is parallel to the panel and pointing toward the first shield. This socket is raised up on a small wooden block until the control grid cap of the tube is exactly 6½" above the shield base. The mounting positions of the two condensers, C_5 and C_6, and the two r. f. chokes, L_3 and L_5, are also shown. The 20-ohm rheostat, R_1, on the screen-grid tube should have one lug soldered directly to the plus filament lug on the r.f. tube

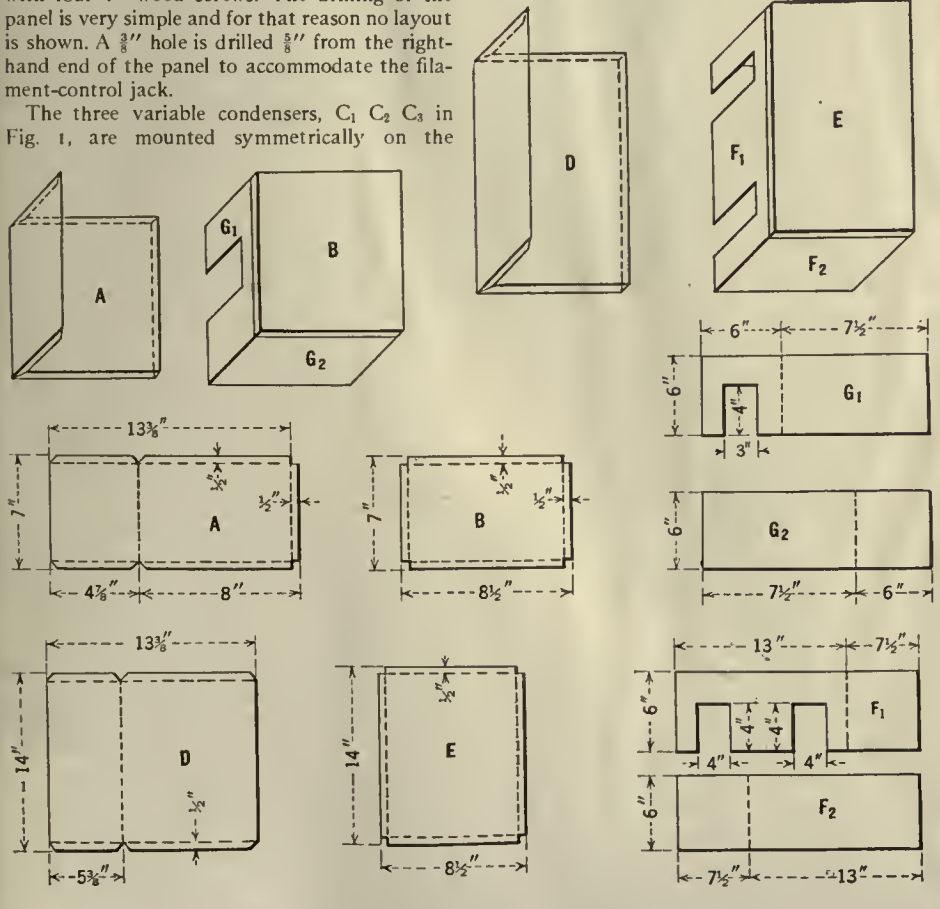


FIG. 2. DETAIL OF SHIELD COMPARTMENTS

socket, and the 10-ohm rheostat, R_3, is likewise fastened to the lug on the detector tube socket. The location of the two fixed condensers, C_4, C_7, and C_8, is also shown.

This places all the apparatus except the grid leak and condenser, whose locations are readily observable. The only point to be noted is the raising of the grid-leak mount from the base shield by the thickness of a ½" wooden block; these parts should be placed as near the detector tube as possible. The terminal strip at the back of the set and the filament-control jack are next mounted as shown.

The rheostats are adjusted once, to give the correct tube voltages, and thereafter are left alone. Using a 6-volt storage A battery, the respective settings were found to be as follows: The r.f. rheostat, R_1, was turned on one third from the full off position and the detector rheostat, R_3, was set one half from the full off position.

Should the constructor prefer fixed filament resistors may be used for R_1 and R_3, the size required for the screen-grid tube being the same as for the UX-120 power tube: the detector takes the usual ¼-ampere (four ohm) type.

In making the wiring to the terminal strip care should be taken to make sure that the notches provided to allow these wires to pass through the shields have their sides well rounded with a file so that they will not cut through the insulation on the wires.

Having finished the preceding operations, there are only two or three things more to be done before putting the set on the air. When the small shield cover is slipped in place it will be found that the vertical rod will hit the top of the cover and accordingly a ½" hole must be drilled in the cover to accommodate this rod. It will be found best to drill a smaller hole first to serve as a guide as to the position of the rod. Similarly a ¾" hole must be made in the larger shield to allow the cap of the screen-grid tube to protrude. Great care must be taken to prevent either of these coming in contact with the shield covers and a small wrapping of insulating tape or a small piece of rubber tubing is necessary to insulate these points. A removable connection must now be provided to join the top of the rod and the cap of the screen-grid tube when the shields are in place. This can be made out of bus wire as shown in the photographs, care being taken that a snug connection is made when it is sprung into place.

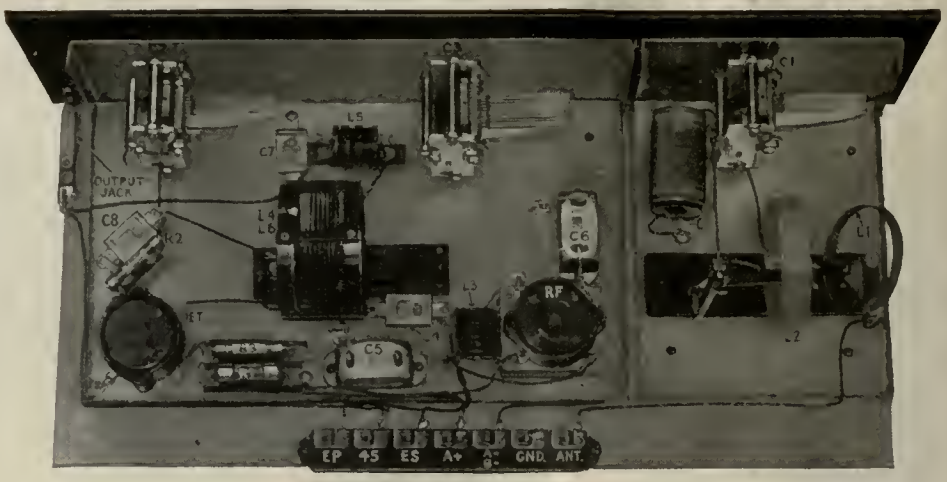


FIG. 4. LAYOUT OF PARTS ON BASEBOARD

OPERATING DATA

TO PLACE the set in operation it is but necessary to connect it to antenna and ground, as well as the required d.c. potentials, and feed the output into a two-stage audio amplifier, to give the necessary volume for consistent loud-speaker operation. It will be found that in all probability the dials on the tuned stages will not agree particularly well, as it is almost impossible to match coils and condensers at the frequencies with which we are dealing. The small coils will be found to cover 14–38.5 meters; the intermediate, 35–81 meters; and the large coils 80–140 meters. These are of necessity approximate values. It is understood that corresponding pairs of coils are to be used simultaneously in the coil mounts; the home-built coils in the r.f. stage and the commercial coils in the detector stage In changing coils care must be taken to handle them only by their bases as the fragile windings and frames are easily injured.

After adjusting the filament rheostats and applying the necessary voltages, we are ready to commence operations The set is operated just like any tuned r f set using detector regeneration, except that the tuning is extremely sharp.

The right-hand dial is the station selector, and the left tunes the r.f. stage (which must be kept in resonance with the detector circuit, for maximum energy transfer to the detector), and the center dial controls regeneration. It will be well to permit the detector to oscillate until a station carrier-wave is heard, then bring the r.f. stage into resonance with the detector. This may de-tune the detector slightly, but a simple readjustment will care for this. The regeneration control may now be backed off and the detector should slide smoothly out of oscillation; if it does not, a reduction in detector plate voltage is advisable. The broadcaster's modulation should now come through satisfactorily.

And now a word as to the antennae for use on short waves. The difference between high or low, short or long is not very marked. In general a single wire about 60 feet long placed as high as possible will answer well.

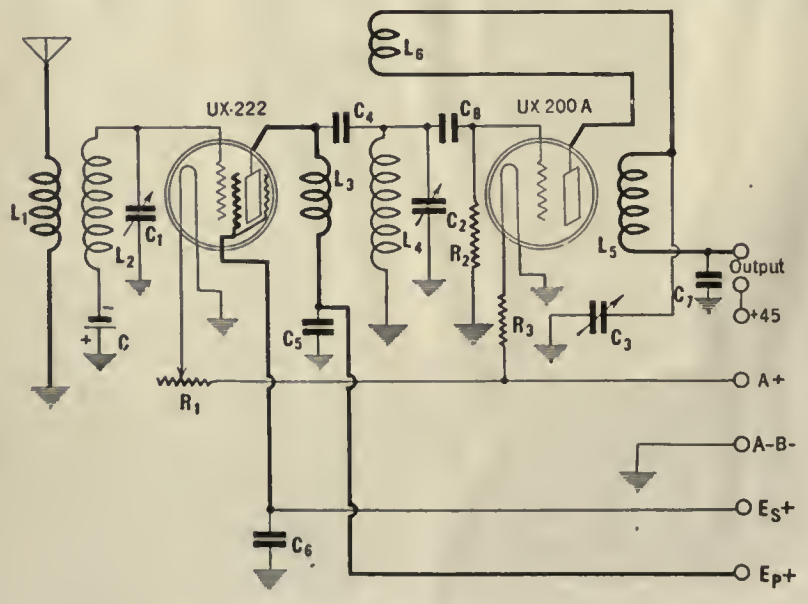


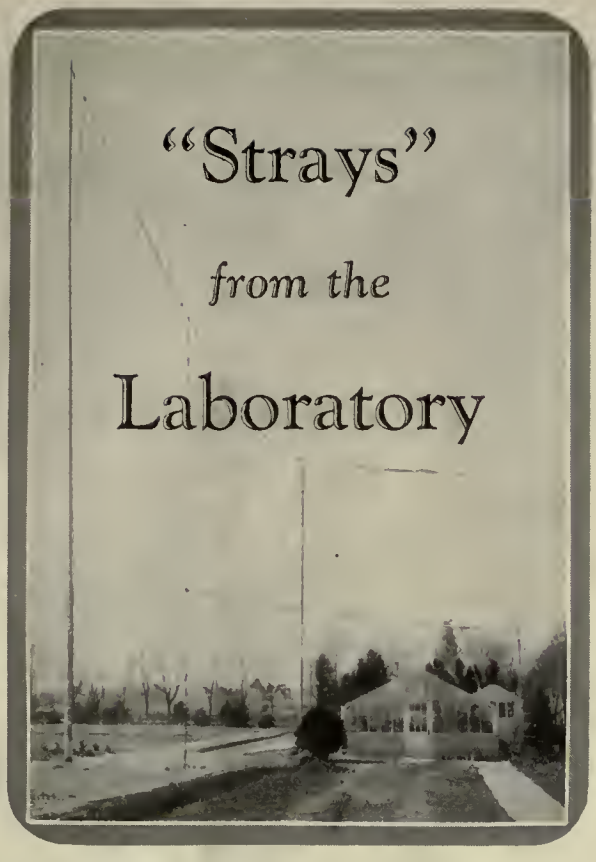
FIG. 1. COMPLETE SCHEMATIC DIAGRAM

LIST OF PARTS

THE parts used in the writer's receiver follow. Parts of equal electrical and mechanical characteristics may be used in place of those mentioned in the list, of course.

C_1, C_2—2 Amsco S.L.F. variable condensers, Type 1213
C_3—1 Amsco S.L.F. variable condenser, type 1223
C_4, C_7—2 Tobe fixed condensers, 0.001 mfd.
C_5, C_6—2 Tobe by-pass condensers, 1.0 mfd.
C_8—1 Tobe fixed condenser, 0.0001 mfd.
L_1, L_2, L_4—1 Set Aero short-wave coils and mount
L_3, L_5—2 Short-wave r.f. chokes
R_1—1 rheostat or fixed resistor, 20 ohms
R_2—1 Tobe grid leak, and mount, 10 megohms
R_3—1 rheostat, 10 ohms, or fixed resistor, ohms
1 1½-volt C battery (flashlight type)
2 Amsco full-floating tube sockets
1 Two-circuit filament-control jack
1 7-contact terminal strip
6 General Radio plugs
2 General Radio receptacles
1 Bakelite Panel, 7" x 21"
1 Soft wood baseboard, 9" x 20" x ½"
2 Shield cans as shown or stock for same
3 Marco vernier dials
Miscellaenous wood and machine screws, wire, etc., piece of scrap bakelite 1½" x 5½" and 9 pieces ¼" x 2½" x 1/16".

The last two items are for coil mounts and base.
To put the receiver into operation the following are needed.
1 Screen-grid tube
1 Detector tube (200A type)
6-volt storage battery or A supply
Source of B power (see text)
2-stage audio amplifier



Dynamic vs. Magnetic Speakers

WE ARE being asked our opinion of the "dynamic" speaker at least once a day, and our present ideas are as follows. In the first place, all loud speakers are dynamic, in the sense that some of their parts move. This includes the old horn type, the newer cone type, and the newest type in which the coil moves with respect to the field. So the reader had best look carefully into the claims of speaker advertising, or the claims of over-the-counter salesmen to make certain that the speaker he is buying is the type he wants.

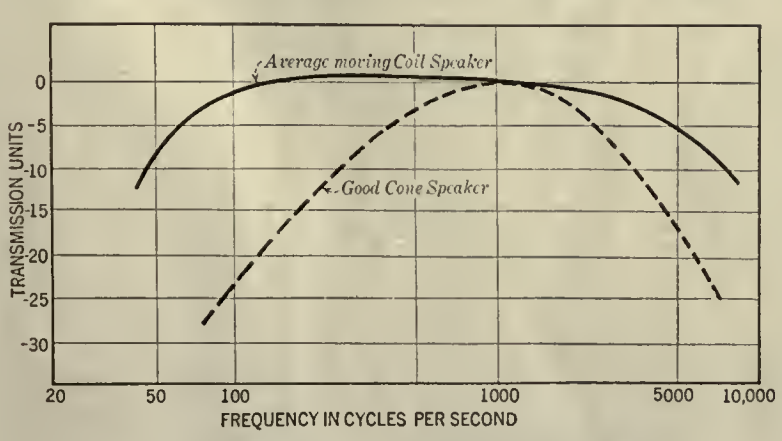
Considering the question of fidelity of response only, not the question of efficiency, the moving-coil speaker compared to a good cone will "prove in" only on frequencies below 100 cycles. Compared to the old stand-by, the W. E. 540-AW, a good dynamic speaker unit on a baffle 3′ x 5′ and one inch thick (a baffle 3′ square would be equally effective) reproduced notes below 100 cycles while the cone reproduced nothing below that frequency. It is true that tones come out of the cone when 100-cycle and lower notes are put on it, but these are not true tones, but complicated harmonics of the fundamental tones generated in the speaker itself. So when one listens to a good orchestra with a good amplifier and good cone from a good station, the viola he hears is a synthetic viola made up of harmonics generated partially in the speaker and partially in the ear.

On frequencies above 100 cycles the cone as tested in the Laboratory was about as good as the best of the dynamics. Of course, measurements show that the cone was "down" at frequencies as low as 200 cycles compared to the moving-coil speaker, but the ear is deceived and satisfied easily and reception coming from the 540-AW is, in our opinion, good enough for the average household. The Balsa-wood speaker, already described in this magazine, is somewhat better than the cones, but suffers from mechanical troubles.

The moving-coil speaker, then, is better than the good cones only on frequencies below 100 cycles. It must be mounted in a rather large and solid board, not in a small and beautiful cabinet. In the latter housing the lower tones will be lost, and certain frequencies will be badly reinforced due to cabinet resonance; these tones will "boom."

Because frequencies below 100 cycles are reproduced—some moving-coil speakers go down to 50 cycles easily—the filter of one's power-supply unit must be such that no 120-cycle or 60-cycle hum gets through. This means that a. c. tubes are almost out of the question—and our experience has been that when one places a socket-operated moving-coil speaker in the middle of a large baffle board, the hum is pretty bad. If the speaker is a d. c. unit, it does not produce a hum of its own, but if it has a small built-in rectifier the user may expect some hum—if a large baffle is used.

For one who wants the best, the moving-coil speaker in a baffle about three feet square—larger if possible—will give it. But with this combination one must have an almost perfect amplifier, one which is flat from 50 to 5000 cycles—there are very few of them—and a perfectly quiet power-supply unit, and there are very few of them, especially if a. c. tubes are used. And there are few stations transmitting programs that will cause one to note the difference between an excellent moving-coil speaker and a good cone. Even the few stations that transmit down to 100 cycles do not have many programs which make one wish for a better amplifier and loud speaker. A recent release from the Freshman Company states there is little music below 120 cycles. We venture to say that the majority of home-made receivers using good parts is ahead of the majority of broadcasting stations when one considers fidelity.



AVERAGE CHARACTERISTIC CURVES OF DYNAMIC AND ELECTROMAGNETIC SPEAKERS

Regarding Series-Filament Operation

SEVERAL of the readers of RADIO BROADCAST have written for information on the problem of series-filament operation. Are there other readers who would like to have an article on this subject? Some data was published in RADIO BROADCAST in the June, 1927, issue and an article appeared in *Radio Engineering* in the June, 1928, issue.

The advantage is as follows:

It is possible to build a quieter receiver for a.c. operation than by the use of a.c. tubes. With excellent amplifiers and dynamic speakers on large baffle boards this is important. With the ordinary amplifier and loud speaker it is not important as the average a.c.-operated set is quiet enough.

The disadvantage of series-filament operation is that small tubes, such as the 199, must be used. This fact makes it somewhat more tricky to design the circuit as when one tube goes bad the others may follow unless precautions are taken to prevent such difficulty. Also, under some conditions there may be a greater tendency for the receiver to motorboat.

Until the UX-201B tubes, which require only one-eighth ampere for the filament and which are now sold in Canada, are released, the 199-type tubes must be employed. These tubes have a rather low gain, and are quite microphonic. Some other tube manufacturers, Sonatron, for example, make an eighth-ampere tube but these have not been submitted to our Laboratory for test and we can therefore neither recommend nor discourage their use at the present time.

Who wants technical data on series-filament operation?

Present Designs Do Not Consider Economy

ECONOMY in radio receiver operation has been out of the question for several years. In the early days tubes were expensive, they required high filament currents, and anyway who would think of investing a hundred dollars in a radio and spending twenty dollars a year on upkeep? Nowadays the criterion seems to be how expensive a radio can I build or buy? Multi-tube sets, sets that take power—some of them take lots of it—from the lamp socket, sets in which tubes don't seem to last as long as in the old days are the rule to-day.

There is one notable exception to this seeming connivance between radio apparatus manufacturers and the power companies. This is the Eveready set which requires a plate current of only 8 milliamperes. This receiver is very clearly within the pocketbook requirements of the rural listener, or the listener who desires not to awe his neighbors by relating the tales of his 100-watt receiver. This Eveready product uses high-mu tubes, and, of course, the output will not be called a public nuisance. It is a receiver we are glad to see designed and sold.

How many readers of RADIO BROADCAST would like to build such a set?

And while we are asking for readers' opinions, how many would like to see the contents of the magazine marked with the Dewey decimal system for article classification? A reader brings up the point that it is difficult to index and to file the contents of the magazine at present, and that each month he must mark the articles he wants to file according to this

well-known system. Such a marking might take place in the editorial office before the magazine is put on the presses—but it takes work and time, and it is our present opinion that there are other things which the readers would sooner see in these pages than a classification of material.

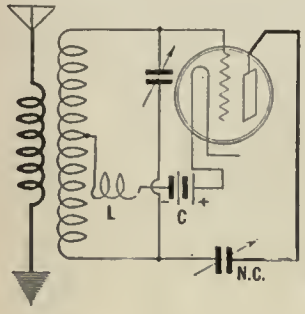


FIG. 1

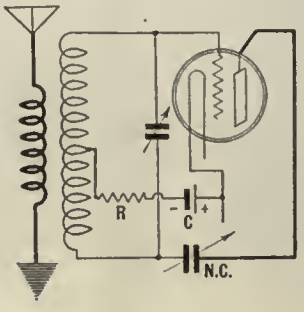


FIG. 2

Kinks on stabilizing a Rice circuit

How to Stabilize Rice Amplifiers

THERE are several methods of keeping a Rice neutralized amplifier from breaking into oscillations at a very high frequency determined by the leakage inductance of the input coil and the tube capacity in parallel with the neutralizing capacity. One method is to insert a choke coil in the center-tap connection of the amplifier input coil as shown in Fig. 1. This method is used in the R. B. Lab. Circuit. The choke may be replaced by a resistance as Mr. Knowles pointed out in his June, 1928, article. This method is illustrated in Fig. 2.

Another, and less expensive, method is to wind a turn or two of wire about the two ends of a solenoid coil in such a direction that no loss is introduced at broadcast frequencies but a large loss at the frequency at which the circuit tends to oscillate. The direction of winding is opposite to the direction in which the tuning inductance is wound.

If a few ohms of resistance is inserted in this winding either by using a concentrated resistor, or by using resistance wire—iron picture wire purchased in hardware stores will do—the parasitic oscillations will not be produced and everything will be lovely. This system is shown in Fig. 3.

New Radio Tubes Needed

THERE are three Radiotrons we should like to see released in the United States. One is the much heralded eighth-ampere general-purpose tube similar in its characteristics to our 201A. It is known as the UX-201B.

Another is a power tube, called the UX-121B, which is designed for use in the last stage. It consumes a filament current of one-eighth ampere, uses a C bias of 16.5 volts with a plate potential of 135 volts and can deliver 125 milliwatts of undistorted audio-frequency power, an increase of almost three times the power handling ability of the 201A-type tube. The third tube is the WX-25 which is a better $\frac{1}{4}$-ampere tube than the 201A but not as good as our 112-type tube.

The electrical characteristics of the three tubes described above will be found in a table on this page.

The "gyps" are still at it

PEOPLE who do business with "gyps" must expect to be "gypped." Not long ago we disclosed an interesting output device which cost but a dollar or two and which was worth nothing at all. Another example of the way some people acquire experience was brought to our attention recently.

In a certain store on "Radio Row," New York City, a transformer was being sold for $1.00 to which could be added a dry rectifier unit, like the Elkon, and a condenser. This equipment, it was said, would provide the purchaser with an excellent A-power unit at small cost. The idea is perfectly good, the transformer is good, the Elkon rectifier units and condensers were good. Where was the catch?

The transformer delivered only 7 volts, and after passing through the rectifier and filter the potential was reduced to 3.8 volts at the output. The combination was absolutely worthless unless one were going to use it on a dry-battery tube set—but nothing was said about the voltage obtainable when the purchaser paid out his money.

New Precision in Quartz Plates

WE HAVE a letter from Carl Zeiss, Inc.—whose name is known to every user of photographic, microscopic, or telescopic equipment throughout the world—stating the firm is now building glass discs for measuring purposes with an accuracy of $\frac{8}{100{,}000}$ of an inch and asking if there is need for quartz plates of this accuracy. At the present time quartz plates for frequency measurement and control are sold by but few companies. We should say that Carl Zeiss, Inc. might sell a number of quartz plates accurately ground.

Seven New Radio Booklets

THE following booklets are more than worthy of mention—they should be read by all readers who like to "keep up."

Through Electrical Eyes, by John Mills. A reprint of an address given at Atlantic City Nov. 26, 1927, on the physics and chemistry involved in television. Mr. Mills is Director of Publications of the Bell Telephone Laboratories.

The Electrad Truvolt Divider Manual, Electrad, Inc.

The Amperite Blue Book, Radiall Company.

The Polymet Manual of Engineering Data, Polymet Mfg. Corp.

The Gateway to Better Radio, Clarostat Mfg. Co.

The Boston Post Book on Television by Henry M. Lane.

Radio Facts and Principles. The testimony of John V. L. Hogan before *Federal Radio Commission*, July 23, 1928. This booklet, which may be obtained from the Superintendent of Documents for five cents, contains in few words a most readable summary of the entire problem of the transmission and reception of radio broadcasting.

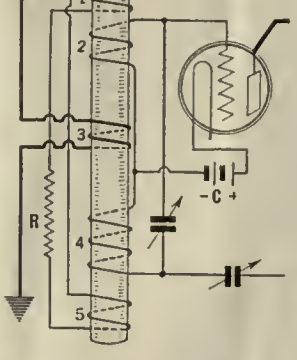


FIG. 3

Extra coil and resistor improves Rice Set

Designation	If	amp. voltage	C bias	Ip	Rp	μ	Gm	P
UX-201B	.125 amps.	90	4.5	2.5	11000	8	725	15
		135	9	3.0	10000	8	800	55
121B	.125 "	135	16.5	6.0	5000	5	1000	125
WX-25	.25 "	90	4.5	3.5	8000	7.9	1000	130

If = Filament current
Ip = Plate current in mils
Rp = Internal resistance of tube
μ = Amplification factor
Gm = Mutual conductance
P = Output power in milliwatts

Portable Radio Sets

A RECENT copy of the *Wireless Trader* (England) devoted sixteen full pages to describing 66 models of portable sets manufactured in that country by no less than 61 manufacturers. Only the most rudimentary arithmetic is necessary to count the number of portable sets made in this country; in spite of the fact that there seems to be a rather consistent demand for them, to judge by the letters that come to the Editors.

Underground Aerials

WE ARE finding it difficult to know what stand to take on the underground antenna business. At present the vote among readers of these pages seems about half and half; some do and others don't like them. A reader in Ontario writes: "have been using ground antenna for the past five years with excellent results. It consists of 50 feet of well-insulated cable attached to an old galvanized water tank three feet in earth. Am able to get British Honduras, Jamaica, and others on home-made three-tube regenerative set."

Another in Texas writes: "My experience with underground antennas is that they are not worth planting, and we don't have rocky ground, nothing but plain silt soil."

The following letter is from a reader in Bangor, Maine:

While I can't give you any signal-static ratio, measurements, comparing using an underground antenna with the usual types, I have formed my own opinion along these lines. I installed a much-advertised device, according to directions, and operated it with a Tyrman "70" screen-grid super-heterodyne, and I want to say that, as an eliminator of static and power-line disturbances, it proved to be a dismal failure. As an antenna it was very efficient, but it didn't even begin to live up to the claims made for it.

After reading the letters we are inclined to believe that the underground antennas are fine for those who like them and fierce for those who don't.

The trouble lies, not with the antennas, but with the advertising. If such advertising states that signals will be as loud as signals obtained with high clear antennas of the conventional sort but devoid of static, the copy should not be trusted too implicitly. On the other hand, if the advertisement states that the static will be reduced and that reception in geneal will be clearer it seems a fair gamble.

The underground antenna is not new. It is very old. It never gave as strong signals as a free wire high above earth, but under certain conditions it may give reception freer of static than the elevated wire. We often disconnect the antenna from our own receiver during bad weather in order to receive local stations with a minimum of static. This makes it necessary to make the set somewhat more sensitive, more sharply tuned, and more critical of adjustment.—KEITH HENNEY.

When the Set Stops Working

A Service Man's Experience

By B. B. ALCORN

FROM the standpoint of the radio dealer or service man, the problems arising from the service and repairing of radio sets are most complex, as each new advance in radio design creates new problems in repair, and almost daily some new radio ailment presents itself for correction. To cover all the problems of radio servicing is beyond the scope of this article, but there is room for considerable discussion of the ordinary service methods from the point of view of the man in the field who is meeting and solving these problems daily.

The troubles encountered in radio servicing may be divided into about ten major divisions, as follows:

1. Defective tubes
2. Defective batteries
3. Open circuits
4. Defective parts
5. Defective antennas
6. Defective grounds
7. Use of harmful gadgets
8. Misconnections
9. Short-circuits
10. Defective arresters

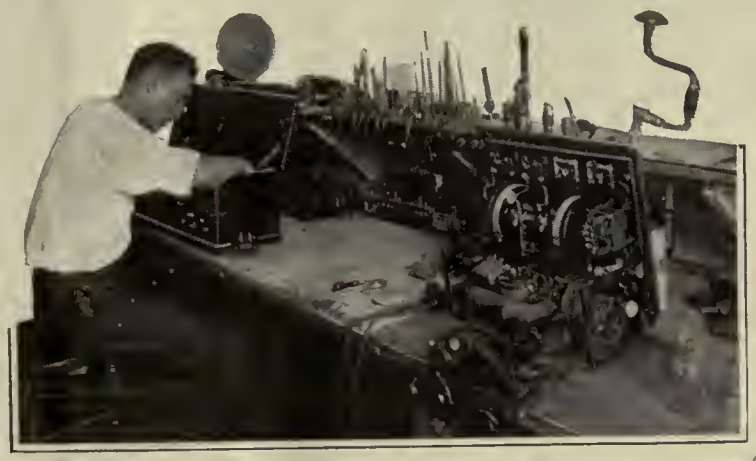
Under each of these major divisions are numerous subdivisions. It is the purpose of this article to cover the first three of these divisions, particularly the third, giving actual cases which have come before the writer. Subsequently articles will deal with service problems under the remainder of these divisions. Many of the cases cited are of an unusual nature, such as are not encountered in the ordinary day's work, but it is such peculiar problems which illustrate the repair man's technique better than the rank and file of radio ailments.

TUBES AND BATTERIES

THE location and treatment of troubles under major divisions 1 and 2 require little explanation. In the case of batteries a good voltmeter is all that is necessary for locating the trouble; for testing tubes, a tube tester or a set of tubes known to be good may be used. Defective tubes or batteries should, of course, be replaced with good ones. At this point, however, it is suggested that a very simple and accurate method of determining which tube or tubes are weak is to insert a 0–50 milliammeter in series with the minus B lead. First take the total reading, then remove the tubes one at a time and note the current drop at each removal. The tube (not counting the detector) whose removal gives the smallest drop in current is the weak tube—assuming, of course, that all the tubes are supplied with the same B and C voltages. A recheck on this method can be made by replacing the tubes one by one and noting the gain per tube.

OPEN CIRCUITS

UNDER the heading of open circuits the service problems are very numerous, and may apply to any part of the receiver or accessory apparatus. The methods of locating these troubles are as numerous as the troubles themselves; the best method, perhaps, is the use of a set checking device, of which a large number of types are available. While the manufactured set checkers are all good, their cost in most cases is prohibitive, especially when a dealer or service shop has a number of service men to provide with outfits. The writer has designed a set checker which is not too costly and which is built around the meters which every service man who takes his job seriously should already possess. This checker will show short circuits, open circuits, and the approximate condition of tubes. Since, however, this article aims only to tell of some of the cases encountered in radio servicing, the construction of this tester will be given in a future issue.



A RADIO SERVICE MAN AT WORK

The usual symptom of an open is a loss of volume or total lack of signal. In most instances of sets having three dials, the trouble, if it is an r.f. stage, will isolate itself by the fact that one of the dials will have very little effect on the tuning. Again it may show itself by a zero reading of the voltmeter connected between the plate terminal of the tube socket and B minus, which of course means an open primary in an r.f. coil. A simple test in such a case is to place the fingers, or a 2-megohm grid leak, across the primary terminals of the suspected transformer. If the set is inoperative because of an open-circuited primary the fingers or the grid leak will, I have found, cause the set to function, though not at its maximum efficiency. The fingers may also be used to determine whether or not the open is in the audio amplifier by touching the grid lead to the detector tube. If the audio system is o.k. there will generally be produced a low howl from the loud speaker.

Open circuits in the r.f. amplifier are among the most difficult of troubles to locate. In the case of open grid suppressors in modern a.c. sets, for example, the writer has found that few if any of the set checks will show this trouble, which manifests itself by lack of volume — a condition which might be attributed to a number of other causes. A quick test for faults in these resistors, which are usually of the wire-wound type, is to touch the stator plates of the variable condensers with the point of an ordinary lead pencil. If the suppressor is open there will then be a noticeable increase in volume; if not, the volume will decrease.

An unusual open was recently encountered by the writer in a Thermiodyne TF6 which for a time was very baffling. The set check showed that all the coils and connections were perfect, yet a jar would either cause the signals to disappear or come in more strongly. It certainly looked like an open or loose connection, and that was what it turned out to be, but in a very unusual place—the gang condenser. The condenser was of standard design, that is, the stator plates were wedged into aluminum supports, and it was found that the plates in the second condenser had become loose where they fitted in the stator support. Some ingenuity was necessary in remedying this trouble, as it was impossible to get a new gang condenser for some time, and difficulties in soldering aluminum made it impractical to solder the plates in place. As a solution a magneto file, such as is used to clean breaker points, was ground to a chisel edge, and a wedge driven under the condenser to break the force of pounding upon it. Then with the improvised chisel, which fitted easily between the stator plates, a burr was struck on each side of the loose plates, causing the metal of the plate supporter to grip them tightly. The job was reassembled, and the contact formed between the plates and the supporter was found to be sufficient to make the set operate without fading regardless of the amount of jogging.

At the shop we recently ran into another very

RADIO servicing problems, as they present themselves to the man in the field, is the subject dealt with in this article. Mr. Alcorn, who has a thriving service business of his own in Long Island, divides these problems into ten major groups, three of which he discusses in detail; the remainder will be treated in subsequent articles. If the great number of service men and professional set builders need any one thing, it is to exchange information with one another, and we hope, in these articles and a special page for service men which we shall soon inaugurate, to help in that direction. We will be delighted to hear from service men about the subjects they would like to have Mr. Alcorn discuss. Short illustrated contributions, not longer than 500 words, dealing with "kinks" in service work, are invited and if accepted, will be paid for at our regular rates.

—THE EDITOR.

peculiar open in the r.f. amplifier of a Radiola 18. This particular open had all the symptoms of a short-circuit. When the call for service came in over the phone the owner stated that the set had been performing satisfactorily when suddenly it had died down, come in strong again, and then stopped entirely. It looked as though the trouble came from a defective UY-227, and the only equipment taken on the call was a good tube. Upon arrival at the owner's home all the tubes were found to be lighting properly, but no signals came through. It was then noted that the power-pack was beginning to smoke; the set was therefore brought back to the shop, as it was thought that the power supply was at fault. Upon removal from the cabinet, one section of the voltage-divider resistance was found to be so hot that it could not be touched. Nevertheless, when the power unit was given the manufacturer's test it proved to be in good condition, and when connected to another receiver of the same type it worked without heating.

Next the receiver was given a continuity test and strange to say, came through with flying colors. There seemed nothing to which to attribute the heating of the voltage divider except a short-circuit. However, as a final test a set checker was used on the receiver, and when plugged into the third r.f. socket showed an open in the plate circuit. This was located in the primary of the third r.f. coil, and when remedied the set performed better than ever, according to its owner. In my opinion the heating of the voltage divider was caused by the feeding back to the power unit of the current that was supposed to flow through the defective primary. The symptoms were certainly those of a short-circuit and not an open. The reason that the open did not show up in the continuity test was that the break was so minute that the high voltage used in the test—we used 400 volts d.c. from a B-power unit that we happened to have in the shop—jumped the break and thus gave a reading on the meter. Fig. 1 shows the Radiola 18 circuit.

An easy method of localizing opens in the r.f. side of almost any receiver is the well-known one of disconnecting the antenna and connecting it successively to the grids of each of the r.f. tubes up to and including the detector. This method was tried without success in a recent case of an Atwater Kent Model 35 which had an open of such microscopic size that the circuit continuity seemed to be o.k. when tested. Still only two near-by and powerful stations would come through, and their signals came in accompanied by a hissing, frying sound. It was necesary in this case to resort to a voltmeter and low-voltage battery to locate the open in an r.f. coil. The coil had to be rewound.

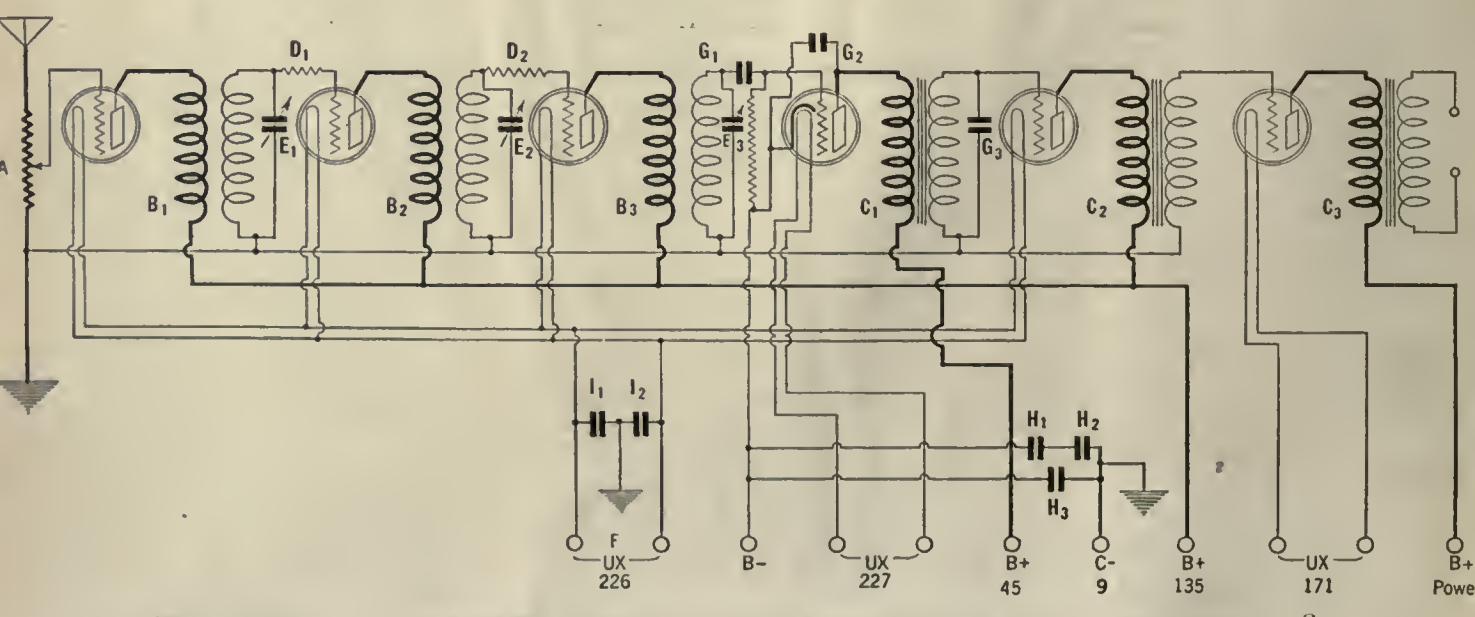
Another case occurred recently in which an open that appeared to be in the set turned out to be in a vacuum tube. The tube in question was used in the audio, and the first diagnosis was a burnt-out audio transformer. However, test of the transformers showed them to be in good condition. When a new tube was used in place of one of the audio tubes the receiver functioned perfectly. The defective tube was tested in the shop and showed no plate current, although it appeared to be in good condition. A section of the base was then cut off and showed an open circuit in the plate lead. This is the first case of this sort that we have encountered.

A curious case of coincidence once occurred when two sets in different parts of the town, identical in installation, came to us at the same time with exactly the same defect. The first diagnosis was an open circuit, but both sets were found to be in good condition, as were the antennas. Still neither of the receivers gave any signals, or at best very weak signals. The owner of one of the receivers was asked whether he had noticed anything unusual about his receiver previous to its breakdown, and recalled that about a week previous to the breakdown the set had stopped altogether and had started up again when he had opened a window. The window was the one through which the lead-in wire entered the house. An inspection of the lead-in wire showed that it was broken inside the insulation about a foot from the lead-in strip, and that when the window was raised it released the tension on the wire and allowed the two broken ends to meet and form a contact. However, after a week of constant tension the insulation stretched so much that it kept the two ends permanently separated.

A unique case of an open in an accessory occurred in a Zenith six-tube receiver equipped with a B-power unit, trickle charger, battery and relay. The combination had been giving good service for a long while when the service man was called in on the complaint that the set was very noisy. The set was turned on when the service man arrived, and a test showed it to be o.k. The man waited about half an hour, as the owner stated that the trouble did not always show up at first, but nothing happened. It seemed to be a case of local disturbance. The service man returned. He had hardly reached the shop, however, when the owner called by telephone to say that the receiver was "acting up" again. He was requested to leave the set going until the service man arrived. Upon arrival the service man found the loud speaker giving out a continuous buzz that the removal of the antenna, ground and three r.f. tubes did not diminish to any appreciable extent. The trouble turned out to be in the relay, the spring of which had somehow increased its tension to such an extent that it caused arcing at the contacts; this caused a noise that fed through to the set. It was necessary for the set to remain in operation from thirty to fifty minutes before this happened, the cause being the heating of the relay.

Before concluding it is well to call the attention of all service men to the importance of consulting the owner of a defective set as to any unusual effects he has noticed in its operation—just as a doctor inquires as to the symptoms of a patient. Many times the hints dropped by the set owner are invaluable in localizing the trouble and making an exhaustive test unnecessary. Another thing that all service men should ask is whether any attempt has been made to remedy the set before he arrived. In many cases an inexpert attempt to remedy a minor trouble has resulted in serious breakdown. A recent case occurred where the only trouble was the removal of the attachment plug of a light-socket operated receiver. The owner, who knew nothing of radio, attempted to remedy the receiver by changing six connections on the power unit. He said nothing of what he had done, and a service fee of ten dollars was charged against him for the tests which were necessary. If he had been asked or had told of his own attempt, the repair could have been made in a few minutes.

The foregoing are among the most unusual cases of open circuits encountered by the writer, and it is quite certain that equally peculiar cases will turn up in the future. It is hoped that space will permit to pass these on to the readers of RADIO BROADCAST. The next article in this series will be devoted to troubles arising from defective parts—a category that includes a wide variety of radio "griefs." The article will also include a description of the construction and use of the set tester referred to in this article.



THIS SCHEMATIC DIAGRAM SHOWS THE R. F., DETECTOR AND A. F. CIRCUITS OF THE RADIOLA 18.

No. 9 RADIO BROADCAST'S HOME-STUDY SHEETS November, 1928

The Effects of an Electric Current

SUPPOSE we have a source of electricity, a battery for example. How can we be made aware of its presence? To demonstrate the effects of the electric current, which are (A) chemical, (B) heating, and (C) magnetic, we shall need the following apparatus:

LIST OF APPARATUS

1. Six-volt storage battery or three dry-cells;
2. Mariner's compass costing about $1.00;
3. One-half pound of bell wire;
4. Copper-sulphate crystals, about 25 cents worth;
5. Glass tumbler;
6. Rheostat, 30 ohms;
7. Two Morse Eureka spring clips;
8. Two Fahnestock clips;
9. Brass angles, screws, bakelite strip, etc., for mounting compass;
10. Metals, such as brass screws, zinc battery case, iron, etc., for chemical experiment.

PROCEDURE

A. *To demonstrate the magnetic effect of the electric current:*

1. Wind about 30 turns of bell wire into a coil about six inches in diameter. The exact size of wire, number of turns, and size or form of coil are not important. At about the 10th and 20th turns make a twist in the wire and scrape the insulation from it so that the Eureka clip may be attached to these points.
2. Mount the compass on a supporting stand in the center of the coil as shown in Fig. 2.
3. Connect the rheostat, coil, battery, and clip as shown in Fig. 1.
4. Place this home-made assembly, known as a galvanometer, with respect to the earth's North and South poles so that when looking down on the device the compass needle is parallel with the coil.
5. Note the effect on compass needle when: (a) the clip is placed on various turns of wire and the circuit is closed by moving rheostat arm, (b) the battery connections are reversed, and (c) the voltage is varied by using only one, two or three cells of the battery with rheostat in same position.
6. Remove compass from its support and place it over, and then under, one of the wires connecting the battery and coil. Close circuit to coil. Note effect on needle when (a) position of compass is changed, (b) battery connections are reversed, (c) strength of current through wire is changed with rheostat arm and (d) distance of compass from wire is increased.
7. Note what is said about electro-magnetism on pages 100-105 of the Signal Corps book, "Principles Underlying Radio Communication." ($1.00 Government Printing Office).

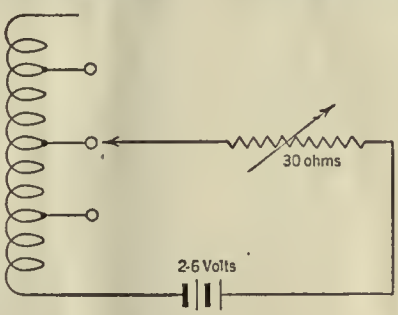


FIG. 1

B. *To demonstrate chemical effect of the electric current:*

1. Place a few crystals of copper sulphate in a glass container, such as a tumbler, and cover with water. Attach a large copper lug, a washer or a penny with a hole in it to a wire and connect it to one terminal of the battery. To the other terminal of the battery attach a wire to which may be connected, by means of an Eureka clip, with the various metals such as a steel screw driver, iron screws, brass strip, nickel-plated binding posts or washers, part of the zinc case of a dry cell, etc.
2. Note effect upon these metals when they are submerged in the copper-sulphate solution and current is passing through the circuit.
3. Reverse battery connections in each case and note result.
4. If a voltmeter, reading not over 5 volts, is handy, connect its terminals to the two wires from the copper-sulphate container. Note the voltage developed by the cell and its polarity when various metals are used. Use galvanometer already described if voltmeter is not available.
5. Replace copper-sulphate solution with a small amount of the electrolyte from the storage battery. Remove electrolyte from battery with a hydrometer or medicine dropper, taking care that no acid touches anything but the glass container. Repeat experiment above. Do not return electrolyte to the battery, since it is now quite impure. Dilute it with water and throw it away. If some of the acid gets on the hands or clothing, cover acid at once with ammonia or borax solution.



FIG. 2. DEMONSTRATING MAGNETIC FORCE

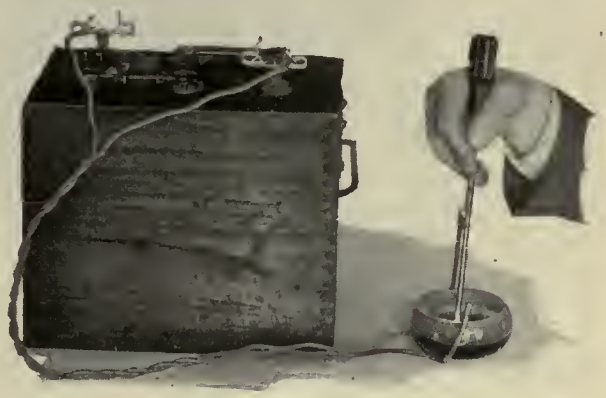


FIG. 3. DEMONSTRATING ELECTROLYSIS

C. *To demonstrate the heating effect of the electric current:*

1. If you have not already accidentally demonstrated the heating effect of the electric current in experiment A by turning the rheostat too near the "all out" position, do so now, taking care not to let the current flow through the last few turns of the rheostat long enough to burn them off.

DISCUSSION

A. The fact that the compass needle moves when it is near a wire, or a coil, carrying an electric current indicates that a magnetic field surrounds such conductors. When the current is turned off this field no longer exists and the needle is then influenced only by the earth's magnetism. The stronger the current, or the greater the number of turns of wire, the greater is this electric field, and for this reason it will exert an influence on a compass at a greater distance, or at a given distance the needle will be caused to swing a greater number of degrees. When the direction of the current flow through the wire or the coil changes, the needle changes its direction too. The galvanometer, therefore, is a sensitive detector not only of the existence of current but of its strength and direction too. Measuring instruments, such as voltmeters and ammeters, utilize the principle demonstrated here although in a much more exact and precise manner.

B. When two dissimilar metals are placed in a solution—copper and zinc in a copper-sulphate solution, for example—and a current is passed through the circuit, various things happen. The solution may change color, bubbles may be seen coming from one of the metals, or one piece of metal, known as the electrode, may have a deposit on it. This is the principle which underlies the electroplating of metals. Storage and dry cells are commercial applications of the fact demonstrated in paragraph B4, that two dissimilar metals in a proper solution develop a voltage.

C. The fact that a wire gets hot when sufficient current flows through it demonstrates another of the effects of the electric current. The amount of heat generated per unit of time depends upon the strength of the current and the resistance of the wire. This effect is made use of in electric irons, water boilers, toasters, etc. Some wires when heated change in length appreciably. If such a wire is stretched between two fixed points, the extent to which it sags may be used to determine the amount of current flowing. A device using such a principle is known as a "hot-wire ammeter" and such meters are used to measure antenna current, or for measuring current in circuits where an electromagnetic type of meter cannot be used.

QUESTIONS

1. Suppose current flows out of a battery from the positive terminal through the circuit and into the battery at the negative terminal. Can you determine a law relating the direction of current flow and the movement of the compass needle?
2. Do you know the "right-hand rule" for determining direction of current flow and needle-swing?
3. Can you explain what happens in the process of electroplating?
4. Why is a voltage developed in the copper-sulphate experiment?
5. What determines the polarity and magnitude of the voltage?
6. What are the bubbles appearing at one of the metals in the acid solution?
7. What generates the heat in a wire when current passes through it?
8. Do you know the law applying to resistance, heat, and current?
9. Why is manganin or nichrome wire used instead of copper where considerable heat is to be developed?

NOTE. The answers to these questions will be found in the Signal Corps book.

No. 10 RADIO BROADCAST'S HOME STUDY SHEETS November, 1928

Alternating Current

Part III

HOME-STUDY Sheets 7 and 8 gave some of the properties of a.c. circuits, and of the effects of an inductance upon such circuits. Since radio circuits are made up largely of inductances and capacities, it remains to study the effect of a condenser upon an a.c. circuit.

In many ways the effect of a coil and a condenser are opposite, for example, the larger the inductance the more it opposes the flow of a.c. current, but the larger the condenser the less it opposes the flow of a.c. current. The higher the frequency of the a.c. voltage, the less current will flow through a given inductance and the more current will flow through a condenser. When a combination of coil, condenser, and frequency is chosen so that a condition called resonance occurs, the effects of the inductance and condensr are exactly equal and opposite, so that their opposition to the flow of a.c. currents cancel each other.

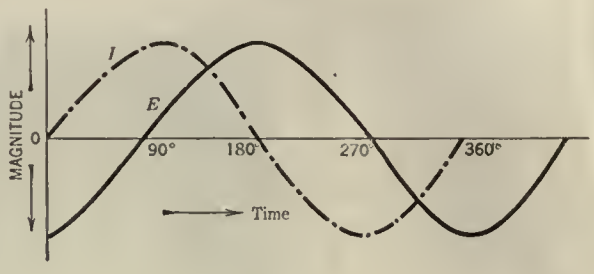


FIG. 1

CAPACITY REACTANCE

The opposition to the flow of a.c. currents offered by a condenser is inversely proportional to its *capacity*, the property of a condenser which tends to prevent any change in the voltage of a circuit

When current flows into a condenser, from a battery, for example, a voltage is built up across the plates. When this voltage equals the voltage of the battery no more electricity flows into the condenser, and we say it is charged. If the battery is removed, and a wire connected across the plates of a condenser, a spark jumps and the quantity of electricity stored there rushes through the wire. The condenser is now said to be discharged. When an a.c. voltage is impressed on a condenser, the quantity or charge flows into it until the condenser is at the same voltage as the charging voltage. At this point, the voltage of the a.c. circuit changes polarity; that is, it is now in the opposite direction. The condenser, however, is still at its original polarity, and tends to discharge into the line and to maintain the voltage of the line. A condenser, then, helps to maintain the voltage of a circuit constant, and by so doing it resembles a reservoir which is filled up when the voltage is high, and is allowed to discharge when the voltage is low.

When the condenser is charged, it is surrounded by an electrostatic field just as a coil carrying a current is surrounded by an electromagnetic field.

The opposition which a condenser offers to the flow of current is known as its *Reactance*, and is measured in ohms just as resistance or inductive reactance is. This capacity reactance is inversely proportional to the capacity and the frequency of the circuit. The abbreviation and formula for capacity reactance are,

$$X_C = \frac{1}{6.28 \times C \times f}$$

Thus, doubling the capacity or the frequency, halves the reactance.

Since the voltage across a condenser does not rise to its maximum value as soon as current flows into it, there is a lag between the times of maximum current and maximum voltage. However, as we express the current phase with respect to the voltage phase, we say the current into a condenser leads the voltage across it. As a matter of fact, the maximum voltage is not reached until the current has gone through 90 degrees, or one fourth of its cycle. In other words, the current in a capacity circuit is said to lead the voltage by 90 degrees. This is illustrated in Fig. 1 in which the maximum value of voltage is reached 90 degrees after the maximum current. It is also illustrated in Fig. 2 in which are two arms rotating at the same speed but 90 degrees apart. In the case of an inductive circuit the maximum value of the voltage is *ahead* of the maximum value of the current; in the capacity case the voltage is *behind* the current.

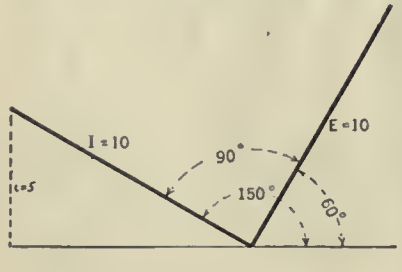


FIG. 2

Since the maximum values of current and voltage are 90 degrees apart, we must take this fact into account when we desire to know the instantaneous voltage or value of the current. If the voltage is at the 60-degree phase, the current is at the 150-degree phase. This angle of 90° is called the angle of *lead*, or the *phase angle* between the voltage and current. The instantaneous value of the current is given by

$$i = I \sin (\Phi + 90°)$$

EXAMPLE. What is the instantaneous current in a capacitive circuit when the voltage is at the 60-degree phase if the maximum current is 10 amperes? The answer may be calculated as follows:

$$i = 10 \sin (60 + 90°)$$
$$= 10 \sin 150$$
$$= 10 \times .5$$
$$= 5 \text{ amperes}$$

Note: The sin of angles greater than 90° may be found from the expression, $\sin (90° + A°) = \sin (180° - A°)$

Fig. 3 is a vector diagram of the above example. It is drawn to scale so that the various lengths of lines represent the various values of current and voltage.

CURRENT IN CAPACITIVE CIRCUIT

The current in a resistance circuit is given by Ohm's Law; the current is equal to the voltage divided by the resistance, i.e., $I = \frac{E}{R}$

The current in an inductive circuit is equal to the voltage divided by the inductive reactance, i.e. $I = \frac{E}{X_L}$

Similarly, the current in a capacitive circuit is equal to the voltage divided by the capacitive reactance, i.e., $I = \frac{E}{X_C}$

$$I = E \times 6.28 \times f \times C$$

and if the voltage is effective, maximum or instantaneous, the current has corresponding values.

IMPEDANCE

Suppose a circuit has resistance and capacity, resistance and inductance, or a combination of all three factors, each of which is tending to oppose the flow of a.c. current. What is the resultant opposition or *impedance?* In a resistance or reactive circuit we can add the several values to get the final resultant --remembering that the effect of a capacity is opposite to that of an inductance so their reactances must be subtracted—but when resistance and reactance are combined we cannot add them algebraically. They must be added vectorially, that is according to the formula

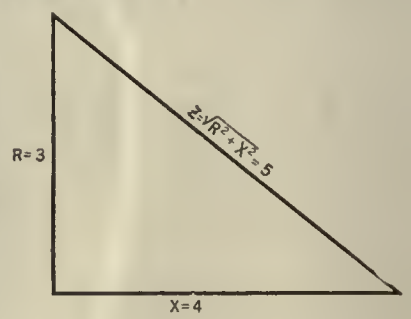


FIG. 3

$$Z^2 = R^2 + X^2$$
$$Z = \sqrt{R^2 + X^2}$$
$$= \sqrt{R^2 + (X_L - X_C)^2}$$

This can be done by arithmetic, or by graphical means.

Example. What is the impedance when R = 3 ohms, X = 4 ohms?

$$Z^2 = 3^2 + 4^2$$
$$Z = \sqrt{9 + 16}$$
$$= 5$$

This expression may remind the experimenter of one of the first laws in geometry he learned, namely, the "square on the hypotenuse of a right-angled triangle is equal to the sum of the squares on the two sides." If, therefore, in Fig. 3, we lay off a line equal in length to three units and label it R, and make another line perpendicular to it equal to 4 and call it X, the length of the line that closes the triangle will be equal to Z.

The reactance, X, in this problem can be pure a inductive reactance of 4 ohms or a capacity reactance of 4 ohms, or a combination of inductive and capacitive reactance such that the resultant obtained by subtracting them equals 4 ohms. For example, if $X_L = 8$ ohms, $X_C = 4$ ohms then

$$X = (X_L - X_C) = (8 - 4) = 4$$

or if $X_L = 4$ ohms, and $X_C = 8$ ohms, then

$$X = (X_L - X_C) = (4 - 8) = -4$$

When, however, this value of minus 4 ohms is squared it becomes a positive quantity equal to 16 and may be fitted directly into the equation to determine the impedance.

PROBLEMS

1. Plot the reactance of a 1-mfd. condenser as the frequency is varied from 100 cycles to 10,000 cycles. What is the reactance of a 0.001-mfd. condenser at 10 kc.? At 1000 kc.?

2. Make a vector diagram for the following condition and solve by means of the formulas above. In a capacitive circuit the instantaneous voltage at the 30-degree phase is 5 volts; what is the instantaneous current if the effective current is 10 amperes?

3. What is the reactance at 1000 cycles in a circuit which has a 0.25-henry inductance and a 0.01-mfd. condenser? If the condenser has a capacity of 0.001 mfd.?



PLOTTING TRANSFORMER CURVES IN A RADIO LABORATORY

A New Audio System for Dynamic Speaker Reproduction

By FRANK C. JONES

Consulting Engineer, Gray & Danielson Mfg. Co.

IN ORDER to reproduce radio programs in sufficient volume to fill a room from a loudspeaker, some type of audio amplifying system following the detector tube is necessary. Immediately difficulties are inevitable from this necessity, since to obtain good reproduction it is necessary to amplify equally all tones or frequencies up to at least 5000 cycles and down to less than 100 cycles per second. There are several types of audio amplifiers in widespread use which must first be considered briefly before going on to a description of a new audio system designed to overcome many of the defects of present systems.

RESISTANCE AND TRANSFORMER COUPLING

FIRST let us consider the usual resistance-coupled amplifier where the plate is connected to the next tube through a coupling condenser and the plate and grid potentials are fed in through resistances. If the plate resistor, R_1, in Fig. 1, is equal to or greater than the plate impedance of the tube, the tube will operate over a straight part of its characteristic curve, so that the voltage impressed on the first grid circuit may be amplified without distortion. Now if the coupling condenser, C, is made so large that its reactance is small in comparison to the grid resistor value, the loss in amplification will not be great. However, a large condenser takes a longer period to discharge, so that if a large a.c. voltage should be impressed across it—enough to swing the grid of the next tube positive—the tube will block and become inoperative. Using a small value of grid resistor, R2, or a small coupling condenser, the low frequencies will be discriminated against enough to cause the response curve to fall off rapidly. Another drawback to resistance-coupled amplifiers is the low gain obtained when using ordinary 201A or 226 tubes. The use of high-mu tubes will overcome this, but then the high frequencies may be lost due to the larger value of effective tube input capacity. This effect is generally overlooked, although it is actually very important, as can be seen from the following. The input capacity of a tube is obtained from the formula,

$$C = C_{gf} + C_{gp}\left[1 + \frac{\mu r_p}{r_p + r_i}\right]$$

THE question as to whether each piece of apparatus in a radio receiver should be perfected, or whether better results would be obtained if the entire system were designed to have a "flat characteristic," has been the cause of considerable discussion.. The advantage of the latter method is that a higher over-all amplification may be secured. The Remler amplifying system employs two audio-frequency stages, each of which produces some distortion, but the defects of one compensate those of the other.—THE EDITOR

Where Cgf = grid-filament capacity of tube.
Cgp = grid-plate capacity of tube.
r_p = plate resistance of tube.
r_i = coupling resistance.

A typical example is

$$C = 6 + 12\left[1 + \frac{30 \times 250{,}000}{250{,}000 + 100{,}000}\right] = 270 \text{ mmfd.}$$

This value is enough to practically short-circuit the higher audio frequencies. The higher the amplification constant of the tube, the greater this capacity will be.

The latter effect is present in impedance coupled amplifiers to even a greater extent than in other systems because the distributed capacity of the coupling choke coils adds to this capacity. The actual tube input capacity may be less but the other capacities generally more than make up for it. The low frequencies may be lost since the impedance at the lowest frequency desired must be several times greater than the tube impedance. The principle of resonance may be used to overcome this loss at low frequencies but not the loss at the upper audio frequencies.

Another factor for either of the above systems is the relatively low gain, so that with 201A or 226 tubes about three stages would have to precede a type 250 power tube. This means a four-stage amplifier, which is uneconomical besides having wonderful possibilities of singing or motor-boating.

The next amplifier to be considered is the transformer-coupled type. This type of amplifier has been developed about as far as it can within practical limits using special alloy cores and special windings. By keeping the turn ratio fairly low, 2 or 3 to 1, the response curve can be made to cover a frequency range of from 70 or 80 cycles up to 5000 or 6000 cycles without much droop at either end. The advantage of transformer coupling lies in the fact that low-mu tubes may be used and good gain per stage may still be obtained. Herein also lies a disadvantage, since with the new dynamic loud speakers and type 250 power tubes, a greater amount of gain is required. Let us consider the requirements set up by the use of a good dynamic loud speaker.

LOUD SPEAKERS AND POWER TUBES

ANYONE who has listened to a good dynamic loud speaker will admit that this type is very much better than the magnetic drive types. The improvement is so great that this coming year will see a rise in popularity probably as great as the magnetic-cone speakers had over the old horn-type speakers of a few years ago. The older type of cone speakers using a magnetic drive unit, are incapable of reproducting low notes or very high notes either. The magnetic type of speaker that will actually reproduce tones below 200 or 300 cycles per second is very rare and none will give a true response below 100 cycles. The

author has had the opportunity of running response curves on about three dozen different types of loud speakers and it was found that the response below the limits mentioned is only apparent; that is, the response is not actually the real low tones but consists of higher harmonics. For example, one very excellent magnetic-type speaker at 60 cycles gave a good apparent response but when the wave was analyzed it was found to consist of less than 5 per cent fundamental tones of 60 cycles. All of the "noise" consisted of higher harmonics which would mean very serious distortion of the low frequencies in music reproduction. On the other hand, a good dynamic loud speaker in a large baffle-board or large cabinet is capable of true response down to 30 or 40 cycles and up to between 5000 and 7500 cycles per second. Below the cut-off of the baffleboard or cabinet the response is similar to a magnetic-type speaker in that it consists nearly entirely of harmonics. A dynamic speaker requires an amplifier of large power rating if low frequencies are to be reproduced without overloading. A good loud speaker mounted in a large cabinet, or in a large baffleboard, or better yet, in a wall, will take nearly the full output of a type 250 power tube for even good room volume. A good deal of power is necessary for the low notes, and the better the frequency response range of a loud speaker, the greater must be the power output of the audio amplifier for the same apparent volume. A type 250 power tube or its equivalent must be used to prevent overloading on the very low notes such as may be transmitted from an organ, a bass viol or tuba, or even a bass voice. To hear the bass notes in their proper relation to the higher notes from a radio receiver is to have real enjoyment from good radio programs.

To project equal volumes of sound into the air at 1000 and 100 cycles it requires a much greater movement of the sound-producing diaphragm at the lower frequency. The dynamic speaker has the ability to reproduce these low notes partly because the movement of its diaphragm may be much greater without mechanical rattling than is possible in the magnetic type. These large movements, in turn, imply that considerable electrical power is available to drive the moving parts of the speaker, and this in turn means that a power tube with considerable output must be used. The 250-type tube has sufficient output for this purpose.

THE IMPORTANCE OF THE TURN RATIO

TO WORK a type 250 power tube to its full capacity the audio transformers preceding it should have a rather large turn ratio in order to prevent overload of the detector tube. A detector tube produces higher harmonics of any audio tone, and these are a source of distortion, since they change the character of the reproduced tone. The greater the output required of the detector tube, the more apparent this effect becomes, so it is desirable to limit the detector tube output to less than ½ of a volt. With outputs of less than ½ of a volt the ordinary 201A detector tube distortion is nearly negligible. Now consider the case where a pair of transformers having an effective turn ratio of 3 to 1 are used. The voltage available to swing the grid of the power tube can be figured from $E = \frac{1}{3} \times 3 \times 8 \times 3 = 24$ volts, which is not sufficient. This figure of 24 volts shows that the detector would have to put out nearly 1 volt across the primary of the first audio transformer to obtain a 70-volt power tube grid swing, and this would be an enormous overload on the detector. The above values of voltage are all in terms of maximum a.c. voltage, not average values, and the first amplifier tube was assumed to have an effective gain of 8, since the mu of a 201A tube is about 8.5 or more.

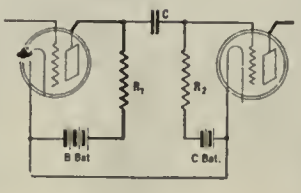


FIG. 1

This means that the transformers will have to have a much larger turn ratio than 3 to 1 unless more than two stages are to be used. More than two stages are rather undesirable from a cost and space required basis as well as because of more tube noise and motor-boating possibilities. Increasing the turn ratio means that the primary windings will have to be diminished in size or the secondaries increased. Decreasing the primary turn lowers the primary impedance to low notes so that the response to these notes will be poor. Increasing the secondary turn increases the secondary capacity to ground or distributed capacity to such an extent that the higher frequencies are lost. This is very important because brilliant reproduction depends on the presence of frequencies up to 5000 or 6000 cycles per second.

The only way seems to be to cut down on the primary number of turns, since even resonating the distributed and shunt capacities with the transformer leakage reactance does not make a good high-frequency response when a large secondary winding is used. By using a large core of very high-grade material, a nickel-steel alloy, the impedance presented to the tube can be increased so that it is still several times that of the tube even at the low frequencies. The impedance increases with frequency, so that most of the voltage generated by the tube appears across the transformer primary for higher notes. Since the primary impedance is less for lower frequencies, the proportion of voltage drop across the tube impedance is greater, causing a droop in the response curve. It was found by laboratory tests that a very good transformer of as high as 6½ to 1 ratio could be designed with a frequency response as shown by the curve of Fig. 2. There is a drop on the low frequencies even when using a 112A tube having a plate impedance of about 5000 ohms. Using a 201A tube having a plate impedance of about 10,000 ohms, there is a very bad drop at both the high and low frequencies, giving the effect of a peaked amplifier. Using a 112A tube, such a transformer would be fine for the second stage but would be hopeless for connecting to a detector having a high plate impedance. That problem and also the one of compensating for the low frequency droop of the second stage were solved as in the manner described below.

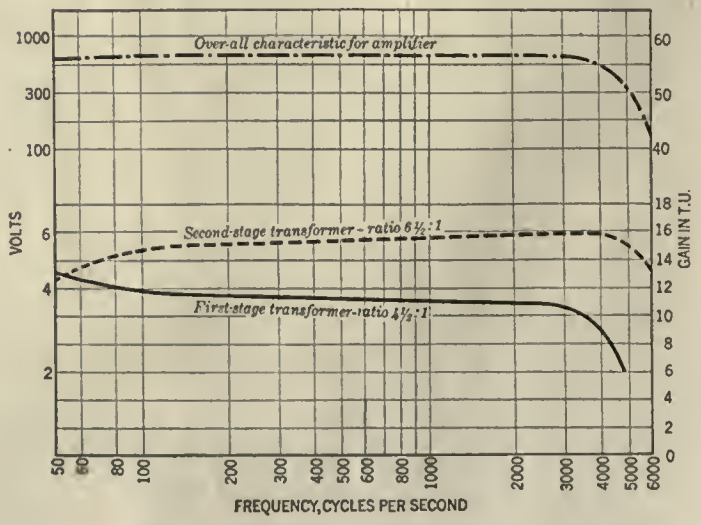


FIG. 2. RESPONSE CURVES OBTAINED WITH HIGH-RATIO TRANSFORMERS

A RESONATED PRIMARY

FOR several years the different telephone repeaters and many broadcast station amplifiers have used the principle of resonance in the transformer primaries to bring up the low-frequency response. There is no reason why this arrangement should not be used in radio receiving set amplifiers, so a first-stage transformer was designed with primary resonated at about 30 cycles per second. Fig. 3 shows a complete audio amplifier with the first transformer primary winding resonated by means of condenser C_1. Resonance has the effect of lowering the total plate circuit impedance to that of the a.c. resistance of the circuit only. The action is as follows: At resonance the current is increased through the detector plate circuit load, since the impedance at resonance is equal to the resistance component only. This means that the voltage drop across the condenser and across the inductance of the primary winding will be increased due to the increased current flow. The increased voltage drop across the primary, causes a larger voltage to be generated across the secondary, with a rise in the response curve. The amount of rise at resonance depends on the circuit constants, that is, the plate impedance of the detector tube, the value of the resistance, R_1, and the relative sizes of the condenser, C_1, and the primary inductance of the transformer. The resistance, R_1, may be made part of the resonant circuit by making it relatively small, or it may be made high, on the order of 100,000 ohms, so that it tends to isolate the resonant part of the audio circuit from the plate supply unit. In this case it confines the audio frequencies to the path through condenser C_1 and the primary winding to the filament. By keeping R_1 high in value, the loss due to it at higher frequencies is reduced. Since the audio-frequency path in this circuit is isolated from the plate-supply unit, the chances of audio regeneration or motor-boating are practically eliminated. This removes a bugbear which is generally very troublesome in high-gain amplifier systems.

An auto-transformer connection is used in the first stage, since the effective turn ratio is much greater for the same total number of turns. The response characteristic of such a resonated transformer is shown by the lower curve of Fig. 2. The resultant characteristic for the two transformers is shown on the same curve sheet and it is flat down to 50 cycles per second. Certainly no ordinary transformer-coupled amplifier could be designed which would amplify so evenly all frequencies as will this special combination. The total gain using a 112A tube and a type 250 power tube is about

57 TU. This does not include the detector audio gain.

The use of the same resonating idea in the second transformer is unnecessary, since we are interested only in obtaining a perfectly flat characteristic with a very large voltage gain. One difficulty is that the d.c. voltage drop through a shunt resistance would be enormous unless small values were used. For example, 3 milliamperes through 100,000 ohms would cause a 300 volt drop. The heating effect would be troublesome also since nearly one watt would have to be dissipated in the form of heat. If low values—less than 30,000 ohms—were used, the audio-frequency loss through the shunt resistance would be a large percentage of the gain of the transformer. In that case an ordinary low-ratio, high-quality transformer might as well have been used.

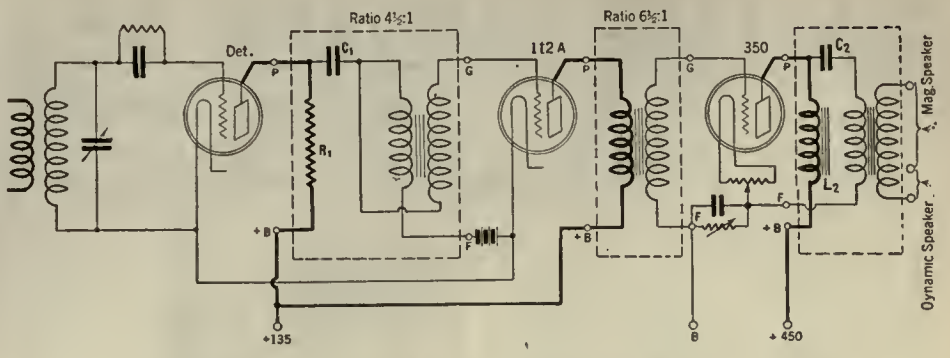


FIG. 3. SCHEMATIC DIAGRAM OF COMPLETE REMLER AMPLIFIER

THE OUTPUT TRANSFORMER

IN CONNECTION with the complete amplifier system, the last, and perhaps the most important link in the chain, is the output device. It was found that the best output transformers on the market were quite unsatisfactory below 200 cycles per second when the full plate current of a type 250 power tube was flowing through the primary. Core saturation takes place and even with a good-sized air-gap in the core few notes below 200 cycles reach the loud speaker. However, an output transformer is quite necessary with a dynamic loud speaker in order to match properly the load to the power tube. By keeping the d.c. current out of the output transformer by means of a choke coil, L_2, and condenser, C_2, as shown in Fig. 3, the transformer may be made very excellent for even the very low frequencies. The condenser, C_2, may be made to resonate with the transformer primary to compensate for the loss due to the shunt choke coil, L_2, and series condenser reactance on the low frequencies. Another advantage is that the audio-frequency path is through the condenser and transformer primary back to filament instead of through the power-supply unit. This prevents audio feedback to preceding stages.

The result is a very stable high-gain amplifying system which has more gain than even an audio amplifier using a screen-grid tube in the first stage. The use of a screen-grid tube, even as a space-charge amplifier, means that impedance coupling should be used between that tube and the power tube, which gives, roughly figuring, $\frac{1}{4} \times 3 \times 50 \times 1 \times 4 \times \frac{2}{3} = 100$ volts across the output device. This assumes a $\frac{1}{4}$-volt detector output, a 3 to 1 transformer, a gain of 50 in the screen-grid tube, a gain of 4 in the power tube and that $\frac{2}{3}$ of this voltage appears across the output device and $\frac{1}{3}$ across the power tube plate resistance. For the amplifier described, using $4\frac{1}{2}$ and $6\frac{1}{2}$ to 1 ratio transformers and tubes giving a gain of 8 and 4, the total voltage appearing across the output would be $\frac{1}{4} \times 4\frac{1}{2} \times 8 \times 6\frac{1}{2} \times 4 \times \frac{2}{3} = 156$. The ordinary amplifier using 3 to 1 transformers and tubes giving the same gains of 8 and 4 would give an output of $\frac{1}{4} \times 3 \times 8 \times 3 \times 4 \times \frac{2}{3} = 48$.

A MODIFICATION FOR A.C. OPERATION

THIS amplifier having such an excellent frequency characteristic should be used preferably with d.c. filament tubes in the r.f. stages, detector and first audio stage, since the amplification is so high at 60 cycles. However, experiments with special amplifiers cutting off very sharply just above 60 cycles per second, have shown that the hum when using a.c. tubes may be made nearly negligible. The reason for cutting off above 60 cycles is apparent when it is remembered that ordinary loud speakers are excellent harmonic producers on low frequencies. The use of raw a.c. on the filaments of the tubes causes a 60-cycle component to be impressed in the grid circuits with the result that if the amplifier system is good as low as 60 cycles, this frequency will be amplified and reproduced by the speaker. The speaker, in case it is a cone or small horn will reproduce it as 120 cycle and higher tones. The point is that by not amplifying the 60 cycle component, practically all of the composite a.c. hum in the loud speaker is eliminated.

Immediately the idea of resonating the primary of one of the transformers at about 80 cycles, was used to make the complete amplifier cut off sharply just above 60 cycles per second. The cut-off is a great many times sharper below resonance than when the transformer itself is made to have a fairly good audio response. The audio voltage drop across the resonating condenser increases as the frequency becomes less, giving a very sharp cut-off below resonance. By designing the circuit constants properly, one transformer may be made to compensate for the other as shown in Fig. 4 from about 5000 or 6000 cycles down to at least 80 cycles per second. This makes an ideal arrangement for receiving sets using a.c. tubes, since the low notes are well reproduced when a good dynamic speaker is used. Nearly 95 per cent. of the very low notes such as those from an organ, as played over the radio, are between 80 and 200 cycles per second. Very few people realize this and most people will quite willingly swear that they hear 30- to 50-cycle notes in their radio sets when in nearly all cases their loud speakers and amplifiers will not reproduce anything below 100 cycles per second.

Another advantage of cutting off sharply a little below 100 cycles is that a smaller power tube may be used, such as a 171 tube. The apparent room volume of sound with the a.c. system will be about the same as with the first d.c. amplifier system developed, since in this case the lowest note reproduced will be about 70 cycles as against 25 or 30 cycles in the d.c. system. This makes more power available for the tones which are reproduced. Incidentally, the cost of manufacturing such transformers is less. Most a.c. set manufacturers use audio transformers which will not pass 60-cycle signals, in order to minimize a.c. hum and in so doing generally lose in efficiency up to 300 or 400 cycles. This is bound to happen because it is not possible to obtain a really sharp low-frequency cut-off using ordinary transformers. The resonant primary principle should go far towards solving the a.c. hum problem in a.c. receivers.

It will be noticed that only the transformers working out of the detector tube in both the d.c. and a.c. systems have resonated primaries. This arrangement keeps the d.c. plate current out of the primaries and so prevents core saturation and generation of harmonics due to this effect. By the use of very large cores of nickel-steel alloy, the chances of core saturation from d.c. are practically eliminated. If small cores are used and large primaries, that is, a large number of turns, core saturation may take place with bad distortion effects. The transformers described are built along ample lines to overcome the possibility of trouble from core satuation.

The possibilities of audio amplifier systems using the low-frequency resonated primary principle are many and it is quite likely that this scheme will be widely used to make better audio amplifier systems. It is the engineer's problem to forever strive towards perfection, never reaching it but always advancing; and this design, it is hoped, is a step in that direction.

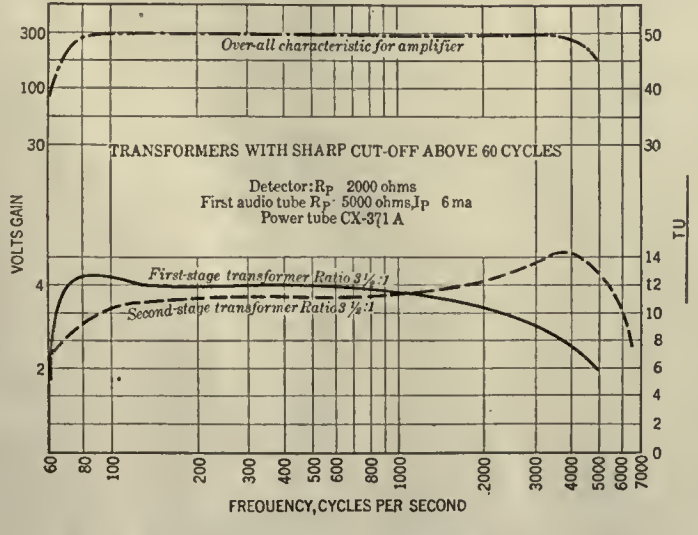


FIG. 4. RESPONSE CURVES OBTAINED WITH $3\frac{1}{2}$ TO 1 RATIO TRANSFORMERS

AS THE BROADCASTER SEES IT

BY CARL DREHER

Sound Motion Pictures—Part II

IN OUR October issue the processes of synchronous sound and movie-picture recording and reproduction were described in a general way. In successive articles some of the points which were only briefly touched on in the first paper will receive further discussion. I do not expect to present any original material in this series nor to assume a professional tone. The object is merely to bring together data from widely scattered sources which are not readily accessible to the many radio broadcast operators, motion-picture projectionists, and others who are interested in sound-movie technique.

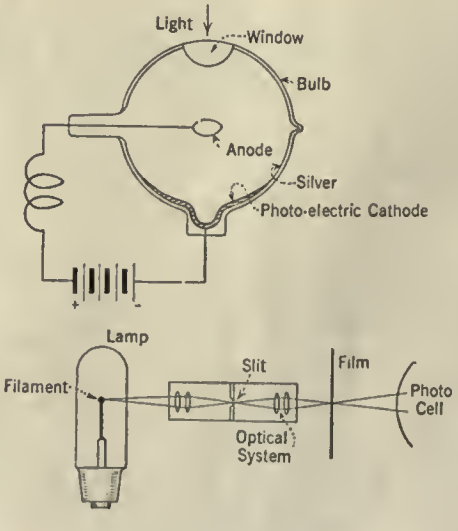
One portion of the reproducing equipment which was merely mentioned in the October article is the photo-electric cell used in film systems. This variety of electron tube has been likened to an electric eye; its function is to transform optical variations into proportionate electric currents. In the art of sound reproduction from films, as well as in television, the photo-electric cell plays a part analogous to that of the microphone in telephony. The microphone, however, takes speech or music directly from the air, whereas in motion picture work the photocell receives light which has been modulated by a film record. In this application, therefore, the rôle of the photo-cell is more strictly parallel to that of a phonograph pick-up, which takes mechanical vibration from a rotating disc and transforms it into corresponding electric pulsations.

Fig. 1 shows a schematic view of a photo-electric cell. The bulb is made of quartz or glass, coated on the inside with silver, except for a window a half inch or so in diameter which remains clear for the passage of the light which is to act on the cell. Opposite the window a layer of the active material of the cell is deposited on the silver. This substance is usually a compound of the so-called alkali metals, potassium, rubidium, or caesium, which have similar chemical and physical properties. They resemble silver in appearance and are quite soft. Some of their compounds, such as potassium hydride, have marked photo-electric qualities; that is, light causes them to emit electrons much as heat makes the filament of a vacuum tube do the same thing. The next step, referring to Fig. 1 again, is to place an anode in the tube to pick up the electrons as they are released. If this anode is placed in the path of the light coming in through the window it is made in the form of a wire loop but it may also be a small metal plate displaced a little to let the light pass. The final step is to connect between the photo-electric cathode and the anode a circuit for coupling the cell to the input of an amplifier and for keeping a positive potential on the anode so that it collects the emitted electrons more effectively. Frequently a gas, such as argon, is used to increase ionization and thus to make the cell more sensitive. Even so the space current in such devices amounts to only a few microamperes.

The photo-electric cell is liable to the same difficulty as a carbon telephone transmitter—it has its inherent noises arising from internal turbulences and the input must be high enough, even at its lowest levels, to override the noise. The exciting lamps used are on this account of the high-intensity type, so that the amount of light passing through the film during low volume portions will still meet marginal requirements. In some other respects the photo-electric cell is superior to the best grades of microphones. It has no natural period of its own and any lag which it may introduce would have to be measured in billionths of a second; the response, to all intents and purposes, is instantaneous. Selenium, the substance which was used as the original intermediary between light and electricity, did not change its resistance immediately under the influence of light.

As the energy output of the photo-electric cell, although accurately proportional to the light entering it, is so small, it must be used, even for measurement purposes, with vacuum-tube amplifiers. This combination was described in the *Physical Review* as long ago as 1917, and there may be earlier citations. Figs. 3 and 4 show two methods of coupling a photo-cell to the input of a vacuum tube. The transformer method seems to be preferred in commercial sound motion-picture systems.

Inasmuch as our interest in photo-electric cells is in connection with motion-picture projection, two special points may be taken up here. One is the method of getting the light through the film to the cell, as shown in Fig. 2. The lamp in this case has a straight filament at right angles to the paper, so that it is shown in the diagram as a dot. This source is brought approximately to focus on a parallel horizontal slit about 1.5 mils high, and the image of the slit projected onto the film, giving a light rectangle a little narrower than the sound track (about 80 mils) and about a mil high. The gates and aperture plates about the film are not shown. The light which gets through the film then spreads out and goes through the window of the photo-electric cell. Of course if the cell is displaced, so that only part of the light gets through, there will be a corresponding loss in volume, so the whole system must be properly lined up. If the filament of the exciting lamp sags, the image cannot be accurately centered on the slit, and a loss of volume results. In this case, as well as when the glass of the high intensity lamp begins to darken, the lamp must be replaced. However, a loss in volume may also result from a photo-cell losing its emitting qualities. A microammeter is useful in checking this.



FIGS. 1 AND 2

These drawings show how photo-electric cells are used in sound motion-picture apparatus

The method of fading from one projector to another, insofar as it affects the photo-cells, is another point of interest. This is shown in Fig. 5. A potentiometer with a neutral midpoint is the essential part of the diagram. As the transformers pass only the alternating component of the photo-cell current, the operation of the potentiometer will be noiseless. It will be noticed that there is considerable similarity between this circuit and microphone mixers in broadcasting.

Commercial Publications

NATIONAL RADIO TUBE COMPANY. This concern, whose address is 3420 Eighteenth Street, San Francisco, is circulating an offer to rebuild burned out, or otherwise defective transmitting tubes, for broadcast stations. They claim means of re-processing tubes so that they will be as good as new at about half the cost of a replacement.

GENERAL RADIO COMPANY. The *General Radio Experimenter* continues to present material of interest to broadcasters. The May issue contains an article on "An Artificial Cable Box." Such a device makes it possible to simulate the behavior of actual telephone lines and cables in the laboratory. The circuit used is shown in Fig. 6. Here the loop resistance of the section, 4R, and the shunt capacitance C, are made the same as the equivalent quantities in the type of line whose behavior is to be studied.

Inasmuch as an actual cable has its constants distributed along its length, an artificial cable simulates the behavior of a real one more closely when it is built up of a considerable number of uniform sections.

A type of cable box with the designation 321-C, marketed by the General Radio Company, is the electrical equivalent of 32 miles of standard paper telephone cable in the usual wire gauges. Within a cabinet 15 by 8 by 5½ inches there are seven units of the following electrical lengths, respectively: 19–8–4–2–1–0.5–0.5 miles. These are controlled by telephone key switches so that any combination may be secured, making it possible to get any length up to 32 miles in half-mile steps.

The 16-, 8-, and 4-mile sections are not lumped, but built up of 2-mile units, and the smaller lengths are similarly split up. The resistance elements, wound non-inductively, are calibrated to 0.25 per cent., while the rolled paper condensers have a precision of 0.5 per cent. The maximum potential which may be safely applied to the box is 300 volts.

Boxes of this type are supplied to represent 16, 19, and 22 gauge non-loaded paper cable. The constants at the mean speech frequency, 796 cycles, are given as follows:

Gauge	Resistance per Loop Mile	Capacity per Mile
16 B & S	42.2 ohms	0.062 mfd
19	83.2	.062
22	171.	.073

In cables of this type the inductance may be neglected, but General Radio also designs special artificial circuits to simulate loaded lines, in which case an appropriate amount of inductance is included in each loop mile, or open wire lines.

The same issue of the *Experimenter* describes a 600,000-ohm potentiometer suitable for use in the grid circuit of an amplifier tube as a gain control. The circuit, which is familiar to most broadcast engineers, is shown in Fig. 7. Such a potentiometer requires a high resistance in order that it may not draw appreciable current from the preceding element. This particular design, known as the Type 452, covers 30 TU in 15 steps of 2 TU each.

The August issue of the General Radio Company's bulletin contains a discussion of electrical filters, which are divided into four groups: (1) Low-pass filters which cut off all frequencies above a certain value; (2) High-pass filters which cut off all frequencies below a certain value: (3) Band-elimination filters which block all frequencies between certain limits; and (4) Band-pass filters which block all frequencies on either side of a section which is permitted to get through.

Classes 1, 2, and 4 have been discussed previously in this department. Type 3 is new in this respect, and as it is not described in the General Radio article I might point out that an audio rejector of the sort shown in Fig. 8 is an elementary form of band elimination filter. In parallel with the speech coil of a loud speaker, for example, it may be used to smooth out a peak in the response. The effect of the resistance in series with the capacitive and inductive elements is to broaden the resonance curve and to limit the effect of the device. If the resistance is very low practically no current of the resonant frequency will get past the shunt circuit, but by adjusting the resistance one may balance the by-passing effect of the shunt circuit against the undesired peak in the instrument under treatment and get a flat over-all characteristic. Compare this use of the resistance element with its similar function in a line equalizer (Fig. 9) which is also a form of filter.

Coming back from this digression to the General Radio discussion, we note there sketches of sections of high-pass and low-pass filters, here reproduced as Figs. 10 and 11, respectively. The types of filters regularly marketed by General Radio are of these classes, designed for impedances of 600 and 6000 ohms, and with cut-off frequencies of 500, 1000, and 2000 cycles. That is, one may order from stock a 6000-ohm filter of the high-pass type, for example, to cut off everything below 1000 cycles.

It may be shown that, given the iterative impedance Z and the cut-off frequency F for which a filter is to be designed, the value of the elements is given for a high-pass filter section by

$$C_1 = \frac{0.07958}{FZ} \text{ farads}$$

$$L_2 = \frac{0.07958Z}{F} \text{ henries}$$

while for a low-pass filter we have similarly

$$C_2 = \frac{0.3183}{FZ} \text{ farads}$$

$$L_1 = \frac{0.3183Z}{F} \text{ henries}$$

In each case F is in cycles per second, while Z is in ohms.

The September issue of the *Experimenter* carries as the leading article, "Notes on Group Address Systems," by C. T. Burke. Since papers on public address technique have appeared in this department of Radio Broadcast Mr. Burke's discussion will not be abstracted here, but it should be interesting as a general treatment for broadcast operators who have not devoted attention to the subject. A schematic diagram is included.

This issue also contains a description of the Type 426-A thermionic voltmeter, including a diagram of the bridge circuit employed with the vacuum tube. The range is 0-3 volts, and under the usual conditions of use the calibration is maintained to within 0.5 per cent. for about 1000 hours, and is good over the whole audio-frequency range. Even at 20 kilocycles there is only a 2 per cent. error, and less than 3 per cent. at 300 kilocycles. At broadcast and higher frequencies the calibration is no longer valid. The entire instrument, including the battery, is self-contained.

Another item in the September issue concerns the Type 532 Station Frequency Meter, the entire scale of which covers only 0.3 per cent. of the frequency of the designated station, the variable condenser being connected across a larger fixed capacity. This gives ten scale divisions per kilocycle. The resonant frequency is read by an ingenious method, which consists in connecting across the main condenser a small auxiliary capacity to shift the peak of the meter from one side of the station peak to the other. The frequency meter is adjusted until the indicating galvanometer does not change its reading when the button connecting this condenser is pressed. This gives a more accurate setting than an attempt to find the exact peak by the maximum galvanometer reading. The accuracy of this meter is certified as within 500 cycles with a temperature variation of not over 5 degrees Fahrenheit from the temperature specified in the calibration. The guarantee is for six months, after which the instrument must be recalibrated.

The General Radio *Experimenter* is a very commendable publication, to my mind, and broadcast technicians should get their names upon its mailing list. It is sent free on application to the company's offices at Cambridge, Mass. It is a commercial publication, but the discussions are severely free from advertising blather and generally contain as much general theory on the subject as specific description of the General Radio Company product. A commercial publication which is scientifically and informatively written is better than a sensational medium whose ultimate commercial aims are less frankly revealed, and if you fail to extract a few dollars' worth of data from the *Experimenter* it is your fault.

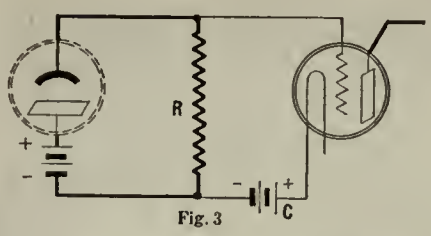


Fig. 3

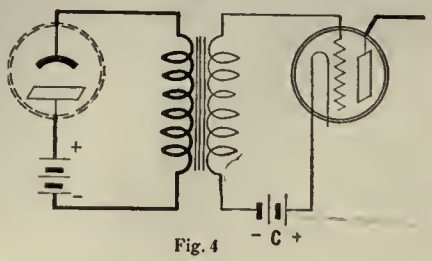


Fig. 4

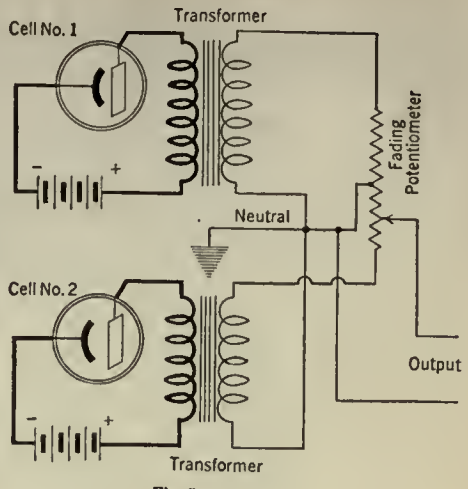


Fig. 5

PHOTO-ELECTRIC CELL CIRCUITS USED IN SOUND MOTION PICTURES

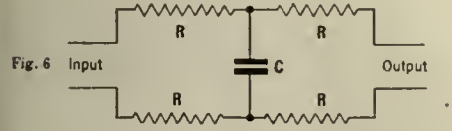


Fig. 6

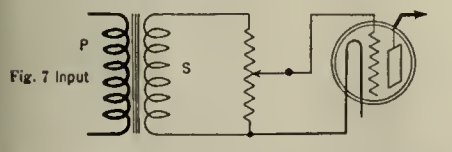


Fig. 7

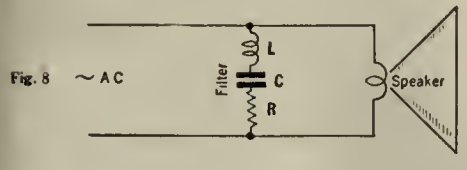


Fig. 8

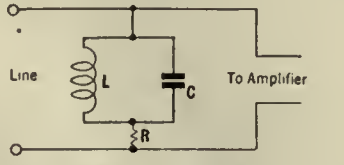


Fig. 9

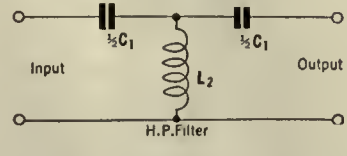


Fig. 10

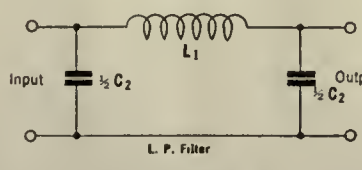


Fig. 11

A GROUP OF INTERESTING FILTER CIRCUITS

A and B Power from the D. C. Lines

By WILLIAM B. DALL

WHERE 110 volts d.c. is the house-lighting current supplied by the local power company, there is opportunity for supplanting storage or dry batteries for both filament and plate circuits in a radio set by means of comparatively simple and inexpensive devices. These have been described in the columns of radio periodicals and are fairly well understood by those who "roll their own" in d.c. districts.

There are a few pitfalls in this sort of apparatus which have been touched on in the form of warnings, but practicable solutions do not seem

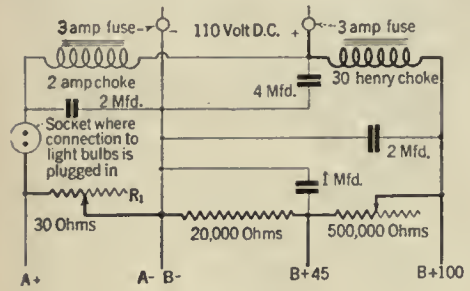


FIG. 1

to be generally known. The purpose of this article is to indicate means for polishing off some of these rough edges.

First let us state briefly the sort of A battery substitute used. In simplest form it is a bank of electric light bulbs, wired in parallel, in series with the filament circuit of the radio set and the light socket. The total wattage of the bulbs is adjusted to the current consumption of the set, the basis being about 30 watts per quarter-ampere tube. This is a little in excess of actual needs, but the excess may be bypassed around the set through a 30- or 50-ohm rheostat, R, in Fig. 1, the varying of which offers a form of filament control to compensate line voltage variations. This resistance is *across* the current source, and consequently the current into the set increases as the resistance is increased. The bank of bulbs may be one or several reading lamps which in the evening would be lighted anyway, and, as a result, the set current costs the user nothing additional except for daytime operation.

HOW TO REDUCE COMMUTATOR HUM

A CHOKE coil, capable of carrying about 2 amperes, and capacities across the line, although not always necessary, are frequently used as a filter to curtail commutator hum which is present in the d.c. supply voltage. See Fig. 1.

The writer has found that various types of 5-volt tubes operate with complete satisfaction at 4½ volts. His ear at least can detect no difference between a set operating at 4½ and one operating at 5 volts. An inexpensive and compact dry battery of 4½ volts is everywhere available in the form of a C battery. If the voltage at the set is adjusted to 4½, and a 4½-volt C battery is placed across the A substitute, the plus to plus and the minus to minus, the hum, if there be any in the speaker, will decrease to a negligible amount. In normal operation there will be no current drawn from the battery and its life will consequently be long.

This little battery has another important function if used as indicated, which cannot be performed by high-capacity condensers. It will absorb what otherwise might be a considerable voltage rise and so protect the tubes in the set against burn-out.

The danger in the use of the d.c. A battery substitute described, lies in the fact that if a tube be removed from the set while the current is on, or if a tube filament should fail or a filament prong become open-circuited, the voltage at the A plus and A minus posts will at once increase considerably. Excess current will consequently be forced on the remaining tubes in the set. If that shock blows a second tube, another rise occurs and the remaining tubes are sure to go. With the handy little 4½-volt battery across the set, one tube may be taken out of a 4-tube set and the voltage on the remaining three will rise only about $\frac{3}{10}$ of a volt (varying a bit with the internal resistance of the battery), instead of jumping about 1½ volts as would be the case without the dry battery shunt. Consequently a tube filament may fail and the other tubes in the set will be perfectly safe. On the same principle this battery also absorbs voltage surges.

Were the dry battery to be left in this circuit after the house current was turned off it would drain itself in a few moments in a vain endeavor to supply current to the set. To make disconnection of the battery automatic, a relay comes in handy wired as indicated in Fig. 2. Any of the types used for cutting out chargers and cutting in B power units will serve. In such a relay the two contacts on the plug by which connection is usually made to the light socket may be connected to A plus and to A minus, and the leads from the B power unit socket on the relay connected to the C battery. The actuating coil of the relay goes in series with the A plus lead. It is essential that this coil lie between the point at which + C is connected and the line, and *not* between the C battery connection and the set. In the latter position the relay will not function properly and there would be a considerable drain on the C battery as the latter would still be feeding the set through the relay. In the correct position, the relay action is instantaneous. One C battery lead may be broken, or two, as many commercial relays are equipped with a double set of contacts.

WAYS FOR ECONOMIZING ON CURRENT

OPERATING multi-tube sets on 110-volt d.c. for filament supply is not economical unless the current-limiting resistances (in the case described, electric light bulbs) are used at the same time for lighting the room. A six-tube set using quarter-ampere tubes would require the use of the equivalent of 180 watts of such bulbs, which, on an average use of four hours per day, would add 22 kilowatt-hours to the electric light bill each month. To cut this current consumption the kink is to use the 199-type tubes up to, but not including, the last audio stage.

If five tubes be so changed, we have .06 x 5 = 0.3 ampere, instead of .25 x 5 = 1.25 ampere for 201A-type tubes, a saving of nearly one ampere of filament current. The saving is nearly 120 watts, or two thirds of the original consumption. A 15-ohm rheostat in series with the A plus lead to the 199-type tubes is sufficient to cut the 4½ volts across the A-battery substitute to 3 volts for the set of five 199's.

If the reading lamp used in connection with this A-battery substitute is to be lighted at times when the set's operation is not desired, a snap switch, indicated in dotted lines in Fig. 2, may be connected across the A plus and A minus just back of the relay. When that switch is open, the lamp will light and the set operate; when that switch is closed, the lamp will light but the set will be off. It is understood, of course, that the switch on the set itself is always left in the "on" position, the whole apparatus being controlled from the light socket at which the current originates.

A B-POWER UNIT FOR D.C. OPERATION

THE B-power unit side of a 110 d.c. outfit is simple. One 30- to 60-henry choke, of d.c. resistance not exceeding 600 ohms (preferably lower), and two 4-microfarad condensers (good by-pass condensers will do, as the voltage does not exceed 110) comprise an adequate filter. Allowing for a voltage drop through the filter, an output of 90 to 100 volts is obtained. One variable high resistance gives the 45-volt tap for detector. Fig. 1 shows the hook-up.

With a push-pull last stage audio for four power tubes, as described in RADIO BROADCAST for May, 1928 (page 18–19), the B plus is taken directly from the light-socket connection around the filter, since thereby the full 110 to 115 volts is obtained for the power tube plates and any hum is balanced out by the push-pull arrangement.

It is customary to equip these power devices with 3-ampere fuses. This is of course protection to the house fuses, but not to the radio apparatus. At 3 amperes, a short-circuit could play considerable havoc with good radio equipment. To obviate this danger, the writer has inserted an old 199 tube in series with the B plus 110-volt plate supply lead. This limits the current through this lead to 60 milliamperes. The drop across the tube at a drain of 40 mils is only 2 volts, and all tubes and associated apparatus are well protected. The 199 tube used may be an old one, whose decreased filament emission renders it unfit for radio set use.

The tapped choke output for push-pull stage is a satisfactory substitute in the use of two 30-henry chokes, the two outside connections going to the plates and speaker, and the inside common connection to both chokes going to the B plus. This kink permits the use of chokes which the builder may have on hand.

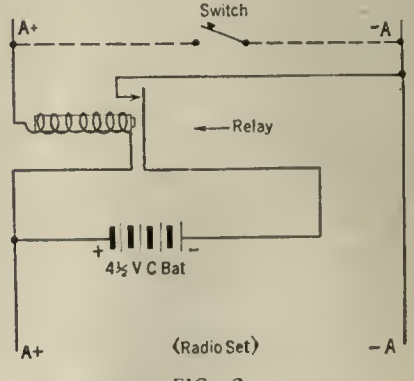


FIG. 2

Complete Equipment For Television Reception

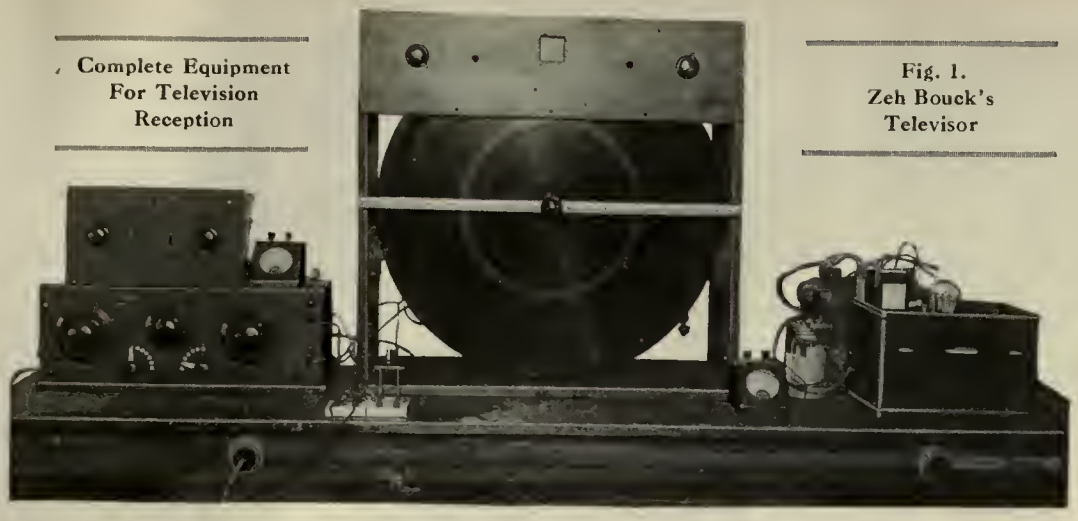


Fig. 1. Zeh Bouck's Televisor

Building Receivers For Television

By ZEH BOUCK

TELEVISION signals are transmitted to-day to a rapidly increasing number of experimenters throughout the world. The interest and pleasure associated with their reception is found in the novelty and fascination of the achievement with home-made apparatus rather than in esthetic considerations associated with the reproduction.

Television signals when properly transmitted and received portray the instantaneous characteristics of the object being scanned at the transmitter. This is accomplished by interpreting at the transmitter the visual aspects of the televised object as electrical variations which, at the receiver, are reconverted into properly distributed shades and high-lights.

The quality of the received picture depends upon how good a signal is transmitted in the first place, and upon how well it is reproduced at the receiving end. Here the amplifier used following the detector plays the important part. Theoretically the signal to be received should contain important frequencies from as low as the number of pictures per second to those lying far above the highest audio frequency used in music.

However, television programs in the broadcast band cannot contain frequencies above 5000 cycles since this is the highest frequency at which a broadcasting station is permitted to modulate, and even when the transmissions are on short waves, the improvement in reception obtained through the use of a special amplifier going up to 15 or 20 kilocycles isn't worth the expense of constructing it—at least it doesn't appear to be worth doing until the quality of the transmissions are much improved over what they are to-day. A start can be made with any good amplifier and, after the best possible results have been obtained from it, there will be time to construct an amplifier designed especially for television reception.

It is the purpose of these notes to describe the amplifier and scanning combination used by the writer. This apparatus will reproduce television images when attached to any receiver capable of delivering a signal of requisite strength from the desired transmitting station.

(*Continued on page 36*)

By JAMES MILLEN

INSTALLING and operating an experimental television receiver is not difficult for the average radio set builder or amateur experimenter. In this connection a description of the equipment used by the writer should be of considerable interest, especially as the same apparatus may be employed by experimenters in other parts of the country for receiving any television station by merely selecting a scanning disc of the proper type for the particular signal being received. For instance, when using a 24-hole disc the WGY 21-meter television signal may be received all along the West coast. Then, there are the KDKA experimental signals which require a 60-hole receiving disc. The majority of stations, however, are transmitting a 48-line picture.

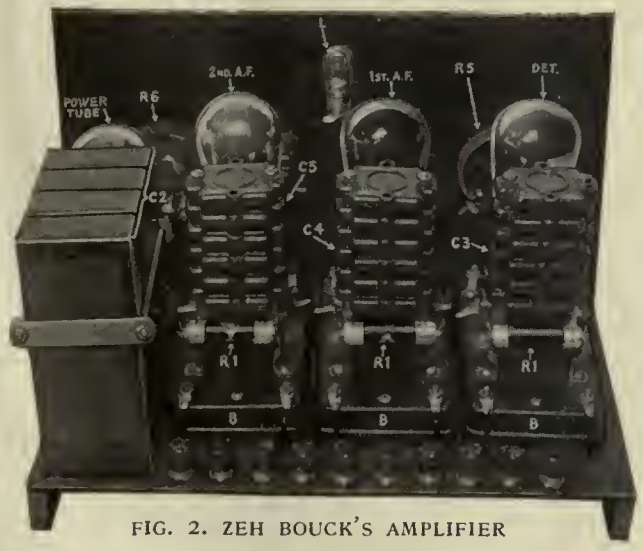


FIG. 2. ZEH BOUCK'S AMPLIFIER

Any good receiver capable of being tuned to the wavelength of the desired television transmitting station may be used. The short-wave receiver employed by the writer is the standard kit sold by the National Company, all of the parts of which are available in the open market. It was described in detail on page 286 in the August, 1928 issue of RADIO BROADCAST. The 222-type r.f. tube is followed by a regenerative detector. This system prevents radiation—a problem which would soon become quite serious if all the short-wave receivers were of the radiating variety.

In building any type receiver, especially for short-wave reception, and particularly one for television work where a motor and scanning disc are located in the same room, considerable attention must be given to rigidity of construction. This applies to the coils and their mountings as well as the wiring and other parts of the set.

We find from experience that the ordinary audio amplifier, such as you use at present for speech and music, is good enough to provide picture reproduction sufficiently clear to distinguish forms, such as the outline of a hand or head, and to follow motion. This is perfectly O. K. for a starter, and your present audio amplifier can be used, provided it has at least the gain of a good two-stage transformer-coupled unit.

For receiving 3XK in Boston it was found ad-

(*Continued on page 37*)

IN THIS article are given descriptions of the work of two experimenters well known to readers of RADIO BROADCAST—*Zeh Bouck and James Millen—both of whom have set up apparatus and successfully received television programs. The differences in the apparatus—especially the amplifier equipment—will give the reader a good idea of the circuits which may be adapted to present day television reception. As the art develops more stringent requirements will be set up as to the characteristic of the audio amplifier but it is evident from the data given here that for the present at least almost any good amplifier may be used.*

—THE EDITOR.

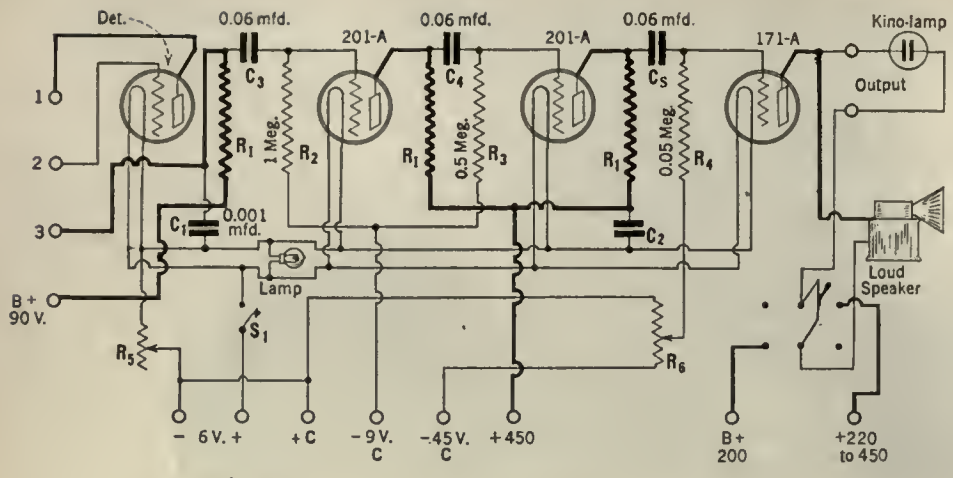


FIG. 3. SCHEMATIC DIAGRAM OF TELEVISION AMPLIFIER

(*Continued from page 35*)

The essential parts of a television reproducer are a tuner (any kind will do that is capable of providing a good loud-speaker signal in ordinary reception), an audio amplifier, a neon tube and a scanning disc turned by a motor mechanically arranged so that the holes in the disc scan the surface of the glowing plate.

The amplifier used by the writer is shown diagrammatically in Fig. 3, while constructional points are suggested in the pictures, Figs. 1 and 2. The amplifier can be built from any standard apparatus; it employs the usual three-stage resistance-capacity-coupled circuit.

APPARATUS REQUIRED

THE following is a complete list of the parts required for the construction of the writer's television amplifier:

R_1—3 Wire-wound resistors, 100,000-ohm;
R_2, R_3, R_4—3 Grid-leak resistors, 1-meg., 0.5-meg., and 50,000-ohm, respectively;
R_5—1 Rheostat, 10-ohm;
R_6—1 Potentiometer, 200,000-ohm;
C_1—1 Mica fixed condenser, 0.001-mfd.;
C_2—4 Filter condensers, 400-volt, 2-mfd.;
C_3, C_4, C_5—6 Mica condensers, 0.01 mfd.;
L—1 Pilot light;
S_1—1 Toggle switch;
4 Vacuum-tube sockets, UX-type;
6 Resistor mountings;
10 Binding posts;
1 Front panel, 7 x 10 x $\frac{3}{16}$-inch;
1 Sub-panel, 7 x 10 x $\frac{3}{16}$-inch;
2 Sub-panel brackets.

The pilot light and toggle switch are, of course, unessential, but were incorporated in the amplifier for convenience. The amplifier eventually will be mounted in the cabinet, and the pilot light will give some indication of current conditions behind the panel. The switch (S_1) controls the filaments of the detector and amplifier tubes, while the other switch, visible in the pictures, was used to start the motor turning the scanning disc.

The four filter condensers (C_2) are connected in parallel to bypass the amplifier plate voltage, and reduce the tendency to motorboat. In the amplifier pictured the coupling condensers are built up in stack form, and consist of six 0.01-mfd. mica condensers.

In operation it will be convenient to be able to switch easily from the loud speaker to the neon tube, an operation that is facilitated by the double-pole, double-throw switching arrangement suggested in Fig. 3. By means of the two battery taps the voltage applied to the tube is practically the same with either the loud speaker or neon tube, thus prolonging the life of the 171A tube and making unnecessary any variation in the C-bias potentiometer, R_6. When the amplifier is operating the loud speaker about 200 volts are employed, while with the neon tube the full 450 volts is applied. These voltages can be supplied either by a B battery or a power-supply unit. A Receptrad Powerizer was used in the author's laboratory as shown in the picture of the entire set-up, Fig. 1.

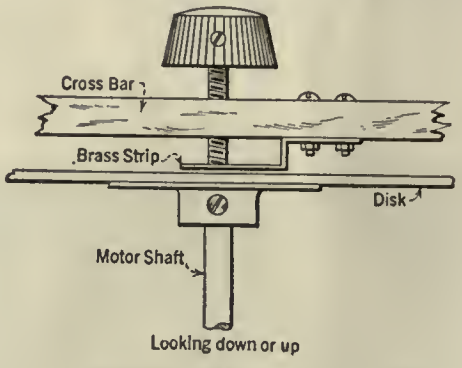


FIG. 4. MECHANICAL SPEED CONTROL

SCANNING DISC ASSEMBLY

THE televising apparatus consists of the scanning disc driven by an adequate motor, some form of motor speed control, and the neon tube, combined in a convenient and efficient mechanical arrangement. A box frame, such as is illustrated in the pictures, Figs. 1 and 5, provides a simple and satisfactory unit. The motor shelf is so positioned that the driving shaft can be centered exactly. The shelf is clamped between cushions of soft rubber which reduce the vibration.

The neon tube is mounted with its plates parallel to the scanning disc, so that the holes in the latter pass over its entire surface. The neon tube is a Raytheon Kino-Lamp and it should be placed in a horizontal position on the upper shelf as close to the scanning disc as possible. The Baldor type-MV2 variable-speed motor may be used for turning the disc. For observing the picture square hole, 1½ x 1½ inches, is cut in the face of the front panel exactly in front of the plate of the neon tube.

The inside dimensions of the entire box, as pictured, measure 25 x 25 inches. It is built of half-inch wood (heavier material is desirable) and the front panel is 7 x 26 inches. Two ten-ohm rheostats, connected in series, are mounted on the panel, and these provide a very accurate motor control. The rheostats are in series with some additional resistors in accordance with the directions accompanying the motor.

By means of the rheostats, in conjunction with a simple mechanical brake described in the paragraph on operating directions, it is possible to maintain the speed of the motor sufficiently close to synchronism with the transmitting disc.

THE CIRCUIT ARRANGEMENT

THE detector tube has been incorporated in the amplifier constructed by the writer. When used with the average receiver, posts one and three in Fig. 3 will be bridged, and post two will be plugged into the grid prong on the detector socket of the receiver. In the case of a regenerative receiver, the plate of the exterior detector tube will be wired to the plate terminal on the detector socket while post three will be led to the plus detector terminal on the set. In other words, the tickler or regenerative coil is connected in between the plate of the detector tube and the coupling resistor. If it is desired to use the detector socket in the receiver (and this may be the more simple procedure in many cases) post three is led to the plate terminal of the detector tube.

The neon tube is connected in place of the loud speaker or output device. This is a simple series connection and is quite effective. While there are other systems of inputting to the neon tube, concomitant complications hardly recommend them for an initial attempt.

The apparatus described was designed primarily for the reception of the television signals broadcast from WRNY, New York City, employing a 48-hole disc at a speed of 450 revolutions per minute. A National Company disc is used in the illustrated apparatus.

OPERATING DIRECTIONS

THE signal is first tuned in on the loud speaker in the usual way, a loud clear signal being the desired result. The motor should be started and the disc brought up rapidly to approximately the speed desired. This can be accomplished by means of a switch short-circuiting the speed-governing resistors.

The output of the amplifier is now switched over to the neon tube, which, when the television signal is received, should show a definite pattern when viewed through the disc. As the disc approaches synchronism with the transmitting disc, the pattern will resolve itself into more definite lines slanting away from the perpendicular. The lines become more and more perpen-

(*Continued on page 37*)

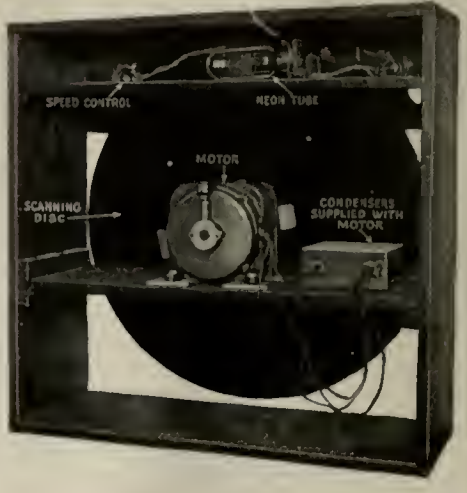


FIG. 5. REAR VIEW OF TELEVISOR

(*Continued from page 35*)

visable to use a three-stage amplifier using National transformers—see Fig. 3. Then again, the pictures being transmitted by 3XK at present are merely silhouettes, which do not require an amplifier with as wide a frequency range as if half-tones were being transmitted.

As a rule, with a three-stage a.f. unit, the amplifier noise will not be very great. Vibration from the receiving disc or its motor, which are transmitted to the amplifier or especially the detector tube, however, will introduce a periodic noise that will cause a black streak across the field of the picture. Any periodic interference, such as a 60-cycle hum, that may get into the signal will also cause streaks across the picture, but these will not remain stationary, but will move upward or downward across the field of the picture.

THE OUTPUT CIRCUIT

THE output circuit of the amplifier is arranged so that the neon or Kino-Lamp is always illuminated, and, when a station is received, the brilliancy of illumination merely varies in accordance with the signal. A good background will be obtained if the d.c. current through the neon tube is limited to 10 or 20 milliamperes. More current will cause the lamp to glow brighter and brighter but there is no advantage in this so far as the picture is concerned and it only serves to shorten the life of the lamp. Accordingly, care should be taken to adjust the current to the minimum satisfactory value.

A Clarostat has been found excellent for such use, and it may be mounted conveniently on the front of the frame supporting the scanning apparatus, as shown in Figs. 1 and 2. For illuminating the Kino-Lamp either a standard high-grade B socket-power unit or heavy-duty B batteries may be used.

Several different concerns are manufacturing scanning discs suitable for use in receiving the signals now on the air. The better grade discs are well made mechanically, so as to run true and require little power. The holes in such discs are also punched to the degree of accuracy necessary if the received image is to be free from black lines and streaks. The National disc uses radially-shaped holes, rather than round holes, for with this design the "lines" across the image are much less obvious.

In driving the scanning disc successful results have been obtained with a number of different types of small motors. However, the motor which the writer is using at present is the $\frac{1}{8}$-horsepower type-Y1V variable-speed condenser-type Baldor which is intended for operation on 110-volt, single-phase, 60-cycle a.c. line. This is a ball-bearing motor that operates very smoothly and quietly. The swish of the disc through the air constitutes the major portion of the noise, and this is quite insignificant. Special rubber vibration absorbers are supplied with the motor for mounting purposes.

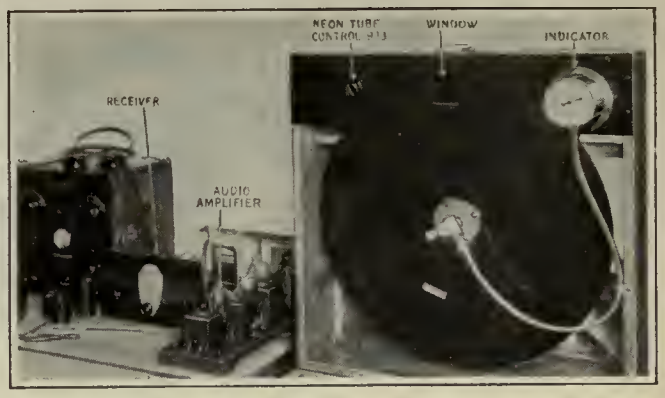


FIG. 1. GENERAL VIEW OF TELEVISION LAYOUT

MOTOR SPEED CONTROL

THE diagram (Fig. 3) shows the method for speed control. For the variable resistor R_2, a 75-watt, 4- to 100-ohm wire-wound resistor with a sliding contact is used. The other resistor may be a 10-ohm 10-watt resistance. This is labeled "R_1" in the diagram and is shunted by the push-button speed-control leads.

The resistance R_2 is so adjusted that with the push button released, the motor runs at slightly below the proper synchronous speed. Then, when the push button is depressed, the disc tends to speed up.

Do not mount the television receiver in the same cabinet with the disc. Vibrations of the motor will introduce a synchronous noise that will result in a series of horizontal lines being drawn across the picture. Therefore, it is important to keep the receiver and amplifier on a support separate from that for the disc.



FIG. 2. REAR VIEW OF SCANNING DISC

The experimenter will find that the following convention has been adopted by the Raytheon Company in regard to neon tube mountings. The tube is fitted with a standard UX base. The plates inside the tube are placed in a plane at right angles to the axis of the "Pin" of the base. If the pin, therefore, is pointed toward the disc when inserted in the socket, the plates inside the tube will then be parallel to the disc. The tube should be mounted at the proper height to cover the $1\frac{1}{2}$-inch square scanned by the revolving disc. The plates are connected to the "plate" and "filament" prongs of the tube base.

Zeh Bouck's Televisor

(*Continued from page 36*)

dicular as the correct motor speed is approached, finally forming the image of the televised object. Final tuning should now be effected on the receiver. Also, the bias to the last tube should be varied, by means of the high-range potentiometer R_6, for best results.

MECHANICAL BRAKE NEEDED

IT IS desirable to use some simple form of mechanical brake in conjunction with the rheostats to control the motor. The device shown in Fig. 4 was designed by the writer for this purpose.

An iron cross piece was fastened to the box housing the revolving apparatus so that it crossed in front of the motor shaft. A hole was drilled to the exact center of the shaft, and the nut from a $\frac{1}{4}$-inch iron bolt was soldered to the cross arm. A brass strip was bent as shown in the illustration, and bolted to the cross piece. The head of the $\frac{1}{4}$-inch bolt was sawed off and a knob mounted on the end. By screwing in the bolt, the brass strip is pressed against the end of the shaft, giving a very delicate braking action. The brass strip should be taped where it touches the shaft.

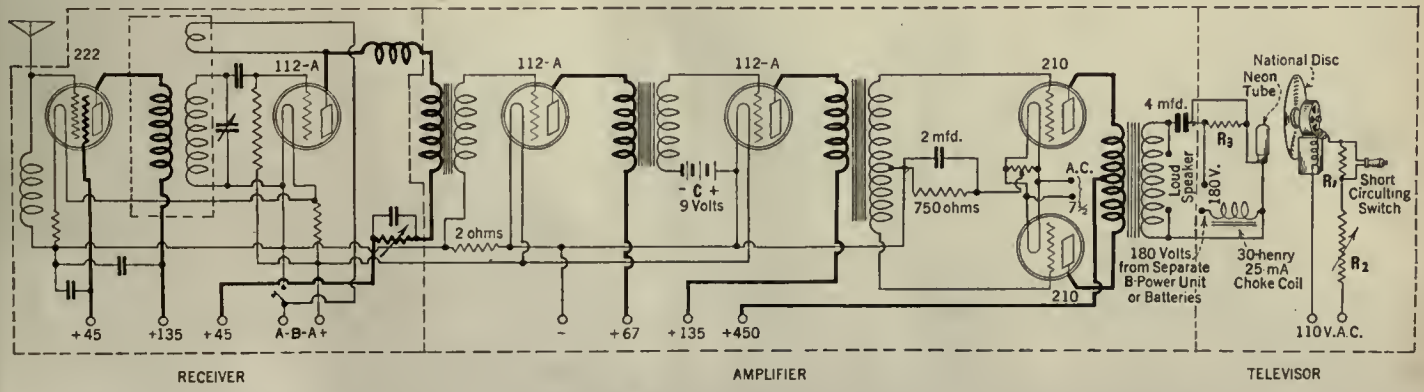


FIG. 3. COMPLETE SCHEMATIC DIAGRAM OF JAMES MILLEN'S TELEVISION RECEIVER

A Modulator for the 1929 Short-Wave Transmitter

By ROBERT S. KRUSE

A WRITER on the Hartford *Times* tells me that all radio men write stories badly; that is, they always leave the thrill until the last, instead of putting it into the headline. In this three-part tale of improved short-wave transmission, I seem to be guilty of this offense, for I am waiting until the third installment to speak of the uses of such transmitters, and, of course, that is where the thrill comes in. For the present we shall give additional data on the constant-frequency transmitter described last month, and explain those devices which make it useful, which is to say the key or microphone.

A transmitter without modulation is useless, since it can send out only a "carrier wave." To place variations on that carrier which a radio receiving set can "unscramble" into code or voice is the business of the apparatus described in this article. It was explained in the October issue that voice, or radio-phone transmission, has the advantage of speed while, with the same power, radio-telegraph transmission has the advantage of greater range. Very evidently these two systems may be used with the same transmitter to excellent advantage, and it is my suggestion that provision be made for both.

CONCERNING INTERFERENCE

TOO MANY amateurs a recommendation of radiophone is as a rag to a bull; it causes them to paw up dirt and bellow about the awful interference caused by the microphone-operated sets. This opinion is a bit out of date. Two years ago amateur oscillators were so unstable that the addition of modulating equipment did have a distressing way of causing the signal to smear over a wider band than one cares to think of. Also, the transmitters did exactly the same thing when keyed, but, in that case, the interference consisted of mumbles, thumps, and "yips" which were harder to identify. Since that time our preaching for better tuned circuits has had a good effect, and the coming of crystal-control has set examples. As a result the number of good amateur radiophones has increased so that we must withdraw the accusation against the phone.

To sum up—with an oscillator-controlled battery set we may modulate with key or voice as we please with no fear of "wobbulation" being added to "modulation." The circuit of the oscillator-amplifier set-up is shown in Fig. 3.

THE CIRCUIT ARRANGEMENT

THE circuit is the almost standard Heising constant-current arrangement. In Fig. 2A we review the general principle. Current from the battery flows through the high-inductance choke, L, to the point B, then divides and returns in two parts through the two resistances R_1 and R_2. If we suddenly change the setting of the variable resistence R_2 we find (by watching the meter I) that the current through R_1 changes for only a moment when this is done. The explanation is this; the choke L is (after the fashion of inductances) an electrical "stand-patter," i.e., always opposing a sudden change. Thus, if we suddenly reduce R_2 we do not change the *total* current through the choke immediately but simply change its division between the two paths, therefore, the current through A drops sharply until L finally agrees to allow more current to pass. On the other hand, if we suddenly raise the resistance of R_2 we force additional current through R_1 until L permits the total current to die down. Thus, the effect of any *sudden* changes in R_2 causes corresponding sudden changes in the current passing through R_1.

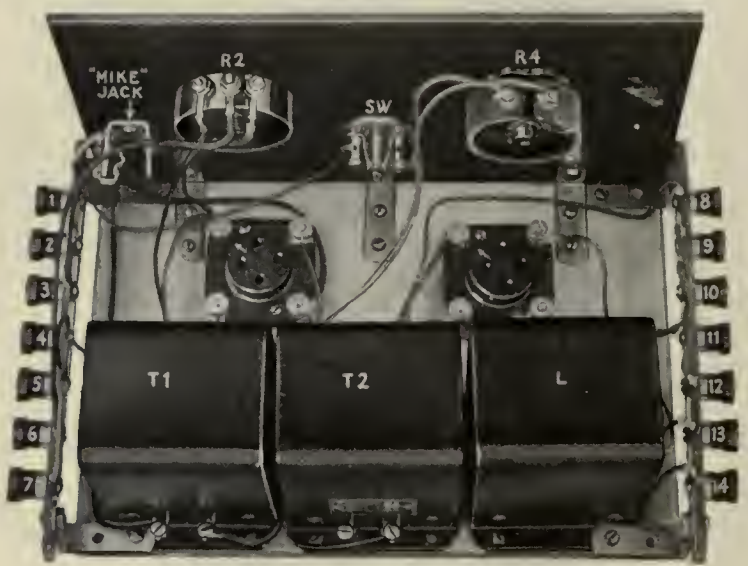


FIG. 1. TOP VIEW OF MODULATOR UNIT

A TRANSMITTER, according to Mr. Kruse, without a means of modulation is as bad as a ship without a sail. Inasmuch as the transmitter itself was described in October, a transmitter that is designed to stay on its assigned frequency, the modulation equipment necessarily had to follow. Here it is.—THE EDITOR

In Fig. 2B we show how this principle is used in our set. The oscillator tube feeds radio-frequency power to the grid of the r.f. amplifier tube where it is amplified and passed to the circuit L_2 C_2. The current is then transferred to the antenna, but this does not concern us just now. The plate power for the amplifier tube is supplied through a choke coil L, of at least 6 henries, just as the current in Fig. 2A was supplied. The radio-frequency choke (r.f.c.) is to prevent the r.f. wandering into L and the tube "Mod" where it would be wasted. The vacuum tube labeled "Mod," which is used as a voice-operated resistance, is substituted in the circuit in place of the resistor R_2. A microphone and amplifier feed voice-currents to the grid of this tube, and, as they cause the voltage of this grid to change, the current to the amplifier tube varies, causing corresponding changes in the r.f. current in the L_2 C_2 circuit from which the antenna power is taken. It is only fair to say that this method of operation does not permit the highest amplification to take place in the amplifier and that a "straight" r.f. amplifier should be added if the full power-rating of that size of tube is desired. However, this added complexity does not seem warranted in a small set since the range increase is not large.

The circuit arrangement in complete form is shown in Fig. 3. The picture in Fig. 1 shows how simply the whole works goes together. In listing the particular makes of apparatus which are given below, the writer has no particular desire to favor any manufacturer but rather his motive is to remove uncertainty by listing those parts which have been used with satisfaction in short-wave transmitters. In several cases it was found that other equipment, which seemingly had every right to be as good, was thoroughly unfitted for this somewhat special purpose. If changes in the assembly are considered necessary they should, therefore, be made one at a time and the effect noted. The parts used in my set-up are as follows:

LIST OF APPARATUS

Mike—Western Electric type 348BW or Federal type 260W.
R_1—Used to reduce microphone current to proper value. Not necessary in most cases.
R_2—Gain control. Frost 100,000- or 200,000-ohm type.
R_3—Shunt resistance, exchangeable in clip to suit tube and transformer used. 1 megohm is usually satisfactory.
R_4—Filament rheostat, 6-ohm.
L—General Radio choke, type 485-S.
TR_1—General Radio type 485-M (for single button mike)
TR_2—General Radio type 485-D
SW—Switch to cut off d.c. filaments and microphone. No a.c. circuits should go through or near this switch.

CONCERNING TUBE EQUIPMENT

FOR the sake of simplicity, and to minimize A.C. hum, it is recommended strongly that for voice operation 201A-type tubes be used in the oscillator (see p. 344 of October RADIO BROADCAST) and in the first socket of the modulator, and that their filaments be operated from

a 6-volt storage battery, which is necessary for the microphone in any case. The r.f. amplifier tube in the October article and the modulator tube in the present set-up may be a 112-, 171-, or 210-type tube, or a corresponding a.c. tube. The UX250 may be used but is not recommended. It is possible to use a.c. tubes in place of the 210 tubes recommended, but make sure that they are of the "heater" type, such as the Arcturus tubes or the UY227, and not of the "thick-filament" type represented by the UX226. Care must be taken to keep the filament leads clear of the grid circuits and even with these precautions the hum problem is apt to be bothersome. With batteries on the tubes mentioned above this difficulty is removed. Still another combination is possible, namely to operate 201A-type tubes in the first sockets and 210-type tubes in the Amp. and Mod. sockets with a.c. on all the filaments. This is done by connecting the 201A filaments in parallel and running them through two equal fixed resistors to posts D and F of the October set-up. If the October set alone is used for c.w. these resistors must produce a drop of 1.25 volts each at a current of $\frac{1}{4}$ amp., therefore, they must have a resistance of 2.5 to 3 ohms. If the complete set-up, i.e., oscillator, amplifier, and modulator is being used the current will be $\frac{1}{2}$ amp. and the resistors may have a resistance 1.25 to 1.5 ohms each. A pair of $\frac{1}{4}$- or $\frac{1}{2}$-ohm filament-ballasts resistors will do very nicely. It is advisable to twist all a.c. leads into pairs and to inspect the various center-tapped resistors to make sure they are in good condition. An open resistor will cause considerable noise; an off-rating one will produce less noise that is still quite noticeable.

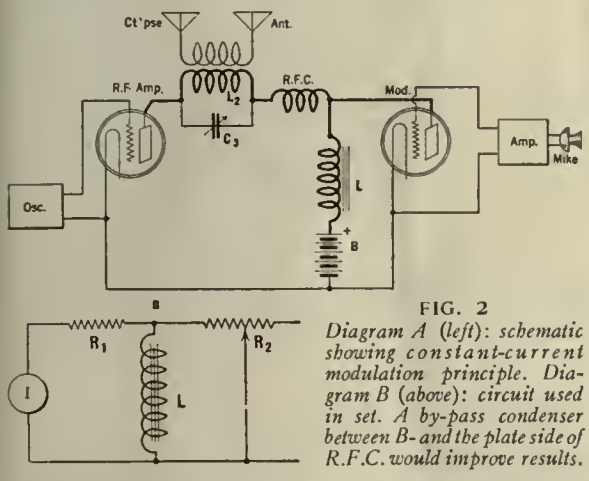


FIG. 2

Diagram A (left): schematic showing constant-current modulation principle. Diagram B (above): circuit used in set. A by-pass condenser between B- and the plate side of R.F.C. would improve results.

THE UX-210 TUBE

IF ONE uses 112- or 171-type tubes in the r.f. amplifier and modulator sockets it is possible to cut down the plate voltage of the oscillator, thus reducing the drain from the batteries. This should not be carried to the point where unsteadiness results. In my particular set 90 volts at the oscillator handles a 171-type amplifier running at 300 volts with very fine steadiness.

When using the UX-210 tube or equivalent in the amplifier and modulator sockets the oscillator tube should have a plate potential of approximately 180 volts. It must, of course, never show plate-heating to a visible degree. If desired, the feed condenser C_f may be changed in size, provided it is not made large enough to cause difficulty in reaching down to the 10-meter band. The neutralizing condenser C_n must of course be readjusted when such a change is made.

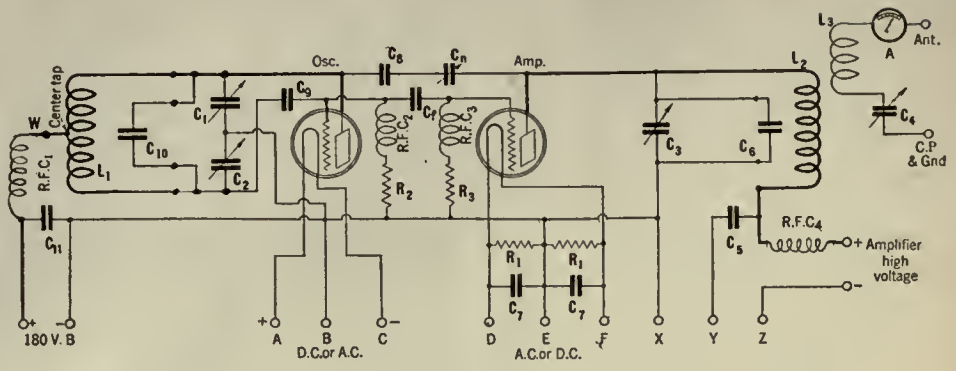


FIG. 3. THE SCHEMATIC DIAGRAM OF OSCILLATOR-AMPLIFIER

Since the 210-type tube is used with the thought of obtaining an increased output it is operated at high voltage and with a plate current of about 40 milliamperes per tube—making 80 for the modulator and amplifier. This current would destroy the windings of the National type 90 choke in the plate circuit of these two tubes, and, therefore, it must be replaced by a more substantial choke which will operate over all the wavebands we are interested in. I can find none of the transmitting-type chokes which will do this, and, therefore, suggest a combination consisting of a single-layer choke in series with a General Radio type 379 T, Aero Products type 248 (transmitter type) or a National Type 90 re-wound with No. 32 or 34 d.c.c. wire. The single-layer choke, which is substituted in the clip for the former choke, consists of a $\frac{3}{8}$" rod of insulating material wound for $1\frac{1}{2}$" with a single layer of No. 34 or 36 d.s.c. or s.c.c. wire. The other choke may be mounted on the back of the panel near the amplifier tube and antenna ammeter. Its business begins at 20 meters where the little choke stops.

In Fig. 8A other changes are suggested that may be necessary if the 210-type tubes are operated at voltages above 250—as they usually are since their rating is 350. The condenser C_5 should be replaced by a 1000-volt Sangamo unit of the largest capacity available. If this cannot be done conveniently a change to the shunt method of feeding (shown in Fig. 8B) is advised. This may be necessary in any case if voltages above 400 are used. Here C_s replaces C_5.

The 250-micro-microfarad plug-in condenser (C_6) used to load the amplifier plate circuit will not survive with the 210, therefore one of two things may be done. Either the coil inductance must be increased or else the 250-mmfd. tuning condenser C_3 should be replaced by a 500-mmfd. Equitune. The dial degrees of the two tuned circuits, i.e., the oscillator and the amplifier, will then not run together as nicely as was the case before. Of course, if one is really fussy about this point it is possible to use two Equitunes, of the 250 size, set end to end and connected in parallel, one being fixed at maximum and the other variable as usual. Personally, I prefer increasing the inductance.

Finally—if someone wishes to use a 210-type tube as oscillator, that too can be done by connecting posts ABC in Fig. 3 to DEF in Fig. 5. The plate potential of the oscillator should not be increased above 180 volts. This combination isn't bad at the upper wavebands but offers some slight difficulty at 10 meters. At present I cannot give the exact dimensions of the somewhat smaller coil that will be required. The diameter will be about 1" smaller than shown in the October article. The other wavelengths will shift somewhat but not badly, because of the large condenser which is used.

KEYING AND OPERATING WITH VOICE

NO MATTER which sort of operating is to be taken up the first job is to secure a steady output. Some suggestions were given in the October article. To these can be added the fact that it is of comparatively little importance what plate voltage is used as long as the plates remain at a sane temperature. For the oscillator this means no visible color, for the amplifier it means a red that is not too violent. The type of tube used and the recommendations of the maker should be considered. It is helpful to listen to the un-modulated output with a little "breadboard" receiver using the circuit of Fig. 6. With a 199 tube and a 22-volt battery the whole thing can be put on a 7" x 10" base, including a $4\frac{1}{2}$-volt C battery for the filament supply. Shielding is neither necessary nor desirable for such a device; it is a nuisance in fact. When the note seems O.K., and free from 60-cycle ripple, one may key slowly and then proceed with voice-modulation. For this the pick-up receiver is stopped from oscillating.



FIG. 4. FRONT VIEW OF MODULATOR UNIT

"PERFECT MODULATION"

THE voice-input system shown will do good work if given a chance. There are several ways of making the adjustments. One is to have an assistant speak into the mike—preferably reading steadily from a book—while various things are changed and the results noted as the signal is heard

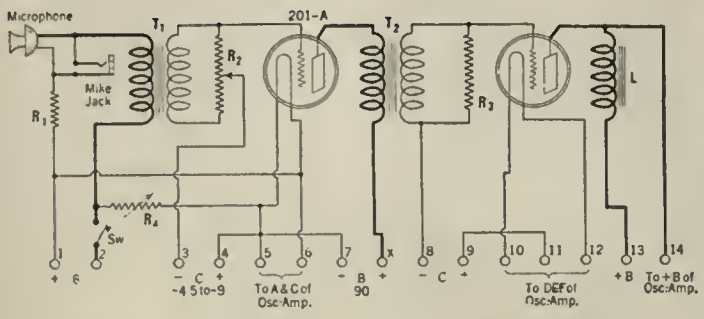


FIG. 5. SCHEMATIC DIAGRAM OF MODULATOR

in the phones of the pick-up receiver. The assistant *must* enunciate decently as otherwise he is worse than useless. He also *must* hold the mike in the proper position and at the correct distance. With these conditions as a good start one may now adjust the gain control, microphone voltage and bias of the modulator tube. The bias may be set at 10 per cent. of the modulator plate voltage at the beginning, and varied from this point. In general a large bias has an advantage in keeping the tube cool. If one has meters available it will be found good practice to adjust the currents to modulator and amplifier tubes so that they are of nearly equal value. Having once found a good setting one may watch the antenna meter thereafter, judging from its movements the degree to which things remain the same. A better way of doing this is to put a d.c. milliammeter in the modulator plate lead—and leave it there.

If an assistant is not available one may place the "mike" before a good loud speaker running at a moderate level on some decent input—not a jazz band. The listening is then done as before. It is scarcely necessary to say that all adjustments of this sort should be made with the antenna cut off.

The beginner will find himself confused when trying to determine the difference between good and bad speech from his own set. He is able to find some help from the fact that a bad phone makes no difference between the letters F and S, and very little between P, B, D and T. In addition to this it very probably will "blast" on some notes and on some of the vowel letters, especially O. Repeating alphabet and the groups of letters just mentioned, together with reading and counting are all good tests. One entirely useless test is to get on the air and work someone. The truth does not lie in that quarter—or perhaps I lack faith through being neither a "brass-pounder" nor very much of a "ragchewer," but mainly an occasional transmitting experimenter.

One very important point to remember is that the best of phones will not compensate for sloppy handling of the "mike." One *must* keep at a fixed distance and speak in an even tone of voice. Looking around the room does not help, nor does a cigarette or cigar between the lips. Consider the good care taken in broadcast announcements as compared to the ignorant use of the same equipment by a new speaker on his first broadcast from a not-too-good station.

AND AS FOR THE KEY—

WITH the key one may do many things incorrectly. The best rule is to send little and listen much until one learns the manner in which not to do things. This is easily done for

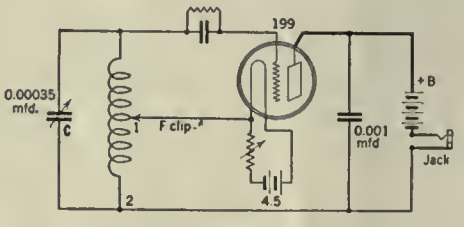


FIG. 6. PICK-UP RECEIVER USING A 199 TUBE

the average performance is not perfect and the air is still cluttered up with tireless "CQ" callers who make the most imperfect phone seem holy and pure. When one does call—let it be at a speed where the sending will be readable for "It isn't the words per minute but the messages per hour that count"—and again—"What profiteth speed when but used to repeat what was sent badly?"

Of the set itself little need be said when operating for radio-telegraph transmission only. The connections are explained in the diagrams; the standard practices are too lengthy to be put down here. The Radio Manual by Sterling at this moment seems alone to contain the new regulations.

One comment with regard to the set can be made. If for any reason it is desired to use C bias on the r.f. amplifier tube in place of the unorthodox resistance bias shown in the October paper this may be done by feeding the C battery to the clips of the cartridge-resistance-mounting. The oscillator-amplifier set-up has been so laid out that the C battery can be placed behind it and leads run in without difficulty. If, as in my case, the intention is to use the set-up portably the clips themsevles should not be disturbed.

Perhaps I have been wrong in the assumption that tuning the oscillator-amplifier is self-evident. The procedure is to set the oscillator with the aid of the wavemeter, then to place the little lamp-loop near the amplifier plate-coil (Aero Coil L_2) and tune that circuit for greatest brightness, finally to revolve the antenna condenser until the greatest antenna meter reading is obtained. Warning—the antenna meter is easily burned out if kept off-scale long. If it runs off—detune or pull the switch instantly. Then shunt the meter with a length of wire—6 inches at a guess—and try again. If it still runs off shorten the shunt until it does not. The process takes some practice and should be done for all the bands after which we will be ready to—but that's next month's story.

AMATEUR WAVELENGTHS

THAT there be no confusion regarding who may transmit, and what frequencies are available for amateur operations, the following quotation from "Revised Amateur Regulations" dated March 6, 1928, and signed by W. D. Terrell, Chief, Radio Division of the Department of Commerce, gives all the necessary information.

"An amateur station is a station operated by a person interested in radio technique solely with a personal aim and without a pecuniary interest. Amateur licenses will not be issued to stations of other classes.

"Amateur radio stations are authorized for communication only with similarly licensed stations, except as indicated below, and on wavelengths or frequencies within the following bands:

Kilocycles	*Meters*
401,000 to 400,000	0.7477 to 0.7496
64,000 to 56,000	4.69 to 5.35
30,000 to 28,000	9.99 to 10.71
16,000 to 14,000	18.7 to 21.4
8,000 to 7,000	37.5 to 42.8
4,000 to 3,500	75.0 to 85.7
2,000 to 1,500	150.0 to 200.0

and at all times unless interference is caused with other radio services, in which event a silent period must be observed between the hours of 8:00 p. m. and 10:30 p. m., local time, and on Sundays during local church services.

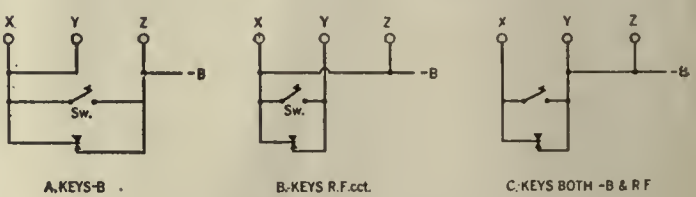


FIG. 7. CONTROL CIRCUITS

Amateur radio telephone operation will be permitted only in the following bands:

Kilocycles	*Meters*
64,000 to 56,000	4.69 to 5.35
3,550 to 3,500	84.5 to 85.7
2,000 to 1,715	150.0 to 175.0

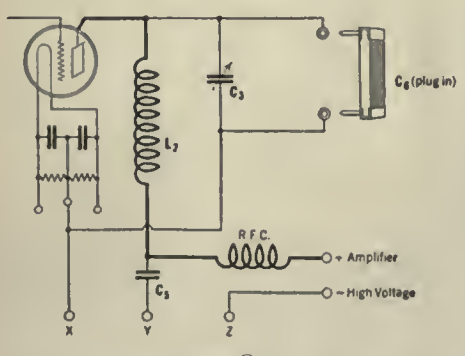


FIG. 8A.

This circuit is utilized when a 210-type r.f. tube is used with a plate potential in the order of 400 volts

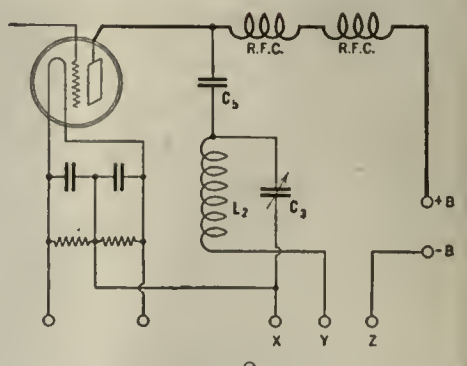


FIG. 8B

This arrangement must be employed if the condensers will not stand the high amplifier plate voltages

No. 11. November, 1928.

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

Freshman Model "G" Radio Receivers



The Model "G" Freshman receiver is six-tube tuned radio-frequency set having three stages of tuned radio-frequency amplification, a detector and two stages of audio-frequency amplification. The receiver is operated directly from 110- to 120-volt 60-cycle alternating-current house-lighting mains and employs the G-60-S power-supply unit to convert the current into the form necessary for the operation of the receiver. In normal operation the receiver has all its grid returns grounded to the frame and its filaments floating at positive potentials above the frame to furnish the necessary grid-bias voltages. The power-supply unit contains a transformer for heating the various filaments and a rectifier-filter system for furnishing the plate current.

1. *The Tuning System.*

This receiver has four tuned circuits, including a tuned antenna stage. The primary of the antenna r.f. transformer connects to A and A_2, the first terminal to be used with a long antenna and A_2 to be used with a short antenna. Across the first tuning condenser, C_1 is connected a midget condenser C_5 to permit adjusting the first tuned circuit to exact resonance.

The method of preventing oscillations in the r.f. amplifier is unusual. "Equaphase" is the name which has been given to this part of the circuit, as indicated in the circuit diagram. The circuit, consisting of R_1, C_6 and the effective primary inductance, of the r.f. transformer, when properly adjusted acts like a pure resistance at all frequencies and the tube cannot oscillate.

2. *Detector and Audio System.*

A leak-condenser system is used in the grid-circuit of the detector in this receiver. This is followed by a two-stage transformer-coupled a.f. amplifier. A small fixed condenser in the plate circuit of the detector bypasses the r.f. current to ground and provides the low-impedance path for the r.f. current, essential if the detector is to operate efficiently. No output device is included in the set but it generally is advisable that one be used unless the loud speaker is equipped with a coupling transformer that can carry safely about 20 milliamperes, the plate current of a 171A-type tube.

3. *Volume Control.*

The volume control consists of a high-resistance potentiometer, R_2, connected across the secondary of the first-stage audio-frequency transformer. The low-potential end of the secondary of this transformer is grounded as is the movable arm of the potentiometer.

4. *Filament Circuits.*

The filaments of the three radio-frequency and first audio-frequency tubes are connected in parallel and supplied with current from a 1.5-volt transformer winding (S_2) in the power supply. The midpoint of this circuit is obtained from the center-tapped resistor (R_3) connected across the filament circuit. The heater leads from the 227-type detector tube are fed from the secondary (S_2) which delivers 2.5 volts. The winding is arranged with a center tap which is grounded to prevent hum. The secondary S_1 supplies 5 volts for the 171A-type power tube, and this winding is also used to light the dial lamp.

5. *Plate Circuits.*

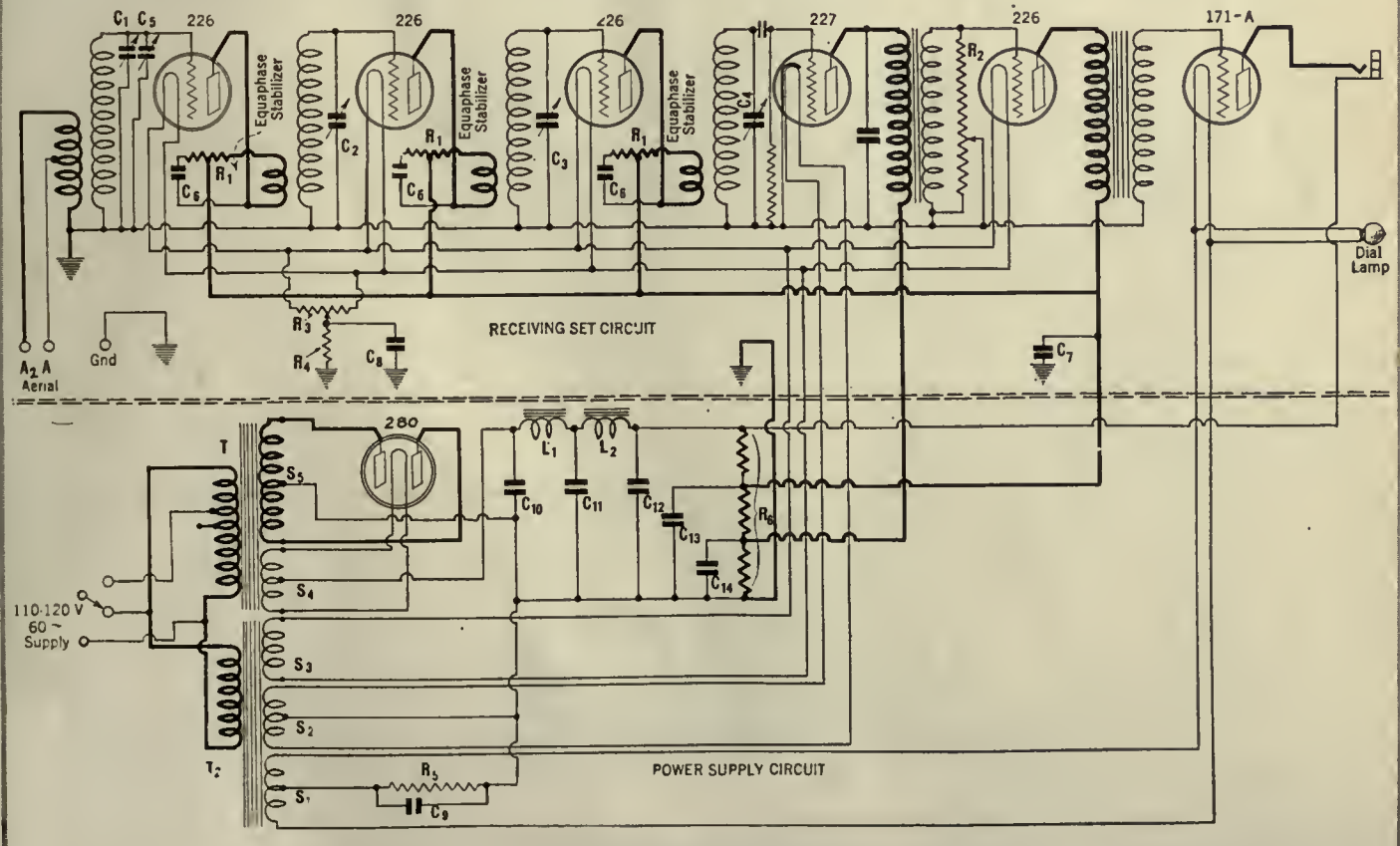
The plates of 226-type tubes in the r.f. and first a.f. stages are supplied with a plate potential of about 130 volts from the power unit. The plate of the detector receives about 50 volts. The plate of the power tube receives about 180 volts, which is the maximum permissible voltage for a 171A-type tube.

6. *Grid Circuits.*

At a plate potential of 130 volts, 226-type tubes require a grid bias of about 9 volts which is supplied, in this receiver, by the resistor R_4 connected between the ground and the center-tapped resistor, R_3. This resistor is bypassed by condenser C_8. The grid leak of the detector is returned directly to the cathode of the 227-type tube. A grid bias of about 40 volts for the 171A-type tube is obtained by connecting a 2000-ohm resistor (R_5) as shown.

7. *Power Supply.*

The B-power unit employs the power transformer (T) with two secondary windings, S_4 and S_5. The 280-type rectifier tube is supplied with filament current from S_4 and plate voltage from S_5. The filter system consists of L_1, L_2 and C_{10}, C_{11}, and C_{12}, and the voltage-dividing resistor R_6 with the necessary by-pass condensers C_{13} and C_{14} connected across the output terminals of the filter. Transformer T_2 supplies filament energy for the various tubes in the set. The receiver is designed for operation on a 110- to 120-volt 60-cycles a.c. supply.



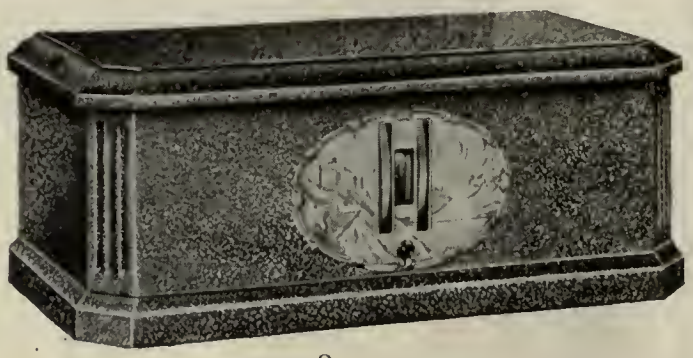
THE RECEIVER CIRCUIT

No. 12. November, 1928.

RADIO BROADCAST's Service Data Sheets on Manufactured Receivers

Freed-Eisemann NR-80 Receivers

THE NR-80 is one of the latest receivers developed by the Freed-Eisemann Company. The set is mounted in a reinforced steel cabinet and is designed for use on 110- to 120-volt, 60-cycle alternating-current supply.



THE NR-80 RECEIVER

TECHNICAL DISCUSSION

1. *The Tuning System.*

There are four tuning condensers, C_1, C_2, C_3 and C_4. In the antenna circuit is employed a special choke which is designed to give somewhat greater gain at the low-frequency end of the broadcast band, thereby off-setting, to some extent, the opposite characteristic of a tuned r.f. amplifier. The antenna circuit does not require any tuning condenser. To compensate for the slight variations in the tuning coils of the individual stages small "vanes" are used. These may be moved nearer to, or away from, the main inductance of the tuning coils, and are adjusted at the factory to the correct position. Each r. f. transformer is shielded as indicated by the dotted lines. The various tubes are neutralized by connecting neutralizing condensers, marked N.C. in the diagram, from the grid of the tube to the secondary of the following r.f. transformer.

2. *Detector and Audio Systems.*

The grid leak and condenser type detector used in this receiver utilizes a 0.00025-mfd. grid condenser and a 2-megohm grid leak. The detector tube is a type 227. The plate circuit feeds into a two-stage transformer-coupled amplifier using 3:1-ratio transformers. The 171A-type power tube feeds into an output transformer with a turns-ratio of 1:1; the purpose of this transformer is to keep the d.c. plate current of the power tube out of the loud-speaker circuit. The plate circuit of the detector tube contains a condenser C_8, with a value of 0.001 mfd. to bypass the r.f. currents to the ground.

3. *Volume Control.*

The volume control of the receiver is located in the r.f. amplifier. It consists of a variable resistor, R_1, with a value of 2000 ohms. It is connected directly across the primary of the last r.f. transformer. As the arm of the unit is rotated in the direction which reduces its resistance, it gradually shunts the primary winding and decreases the amount of signal voltage which is fed into the detector tube.

4. *Filament Circuits.*

Four filament windings which supply current to the tubes in the receiver are placed on the power transformer. A 1.5-volt winding (S_3) supplies all the 226-type r.f. tubes, a 2.5-volt winding (S_4) supplies the 227-type detector tube, another 1.5-volt winding (S_4) supplies the first audio tube, and a 5-volt winding (S_6) supplies the power tube. Two 1.5-volt windings, one for the r.f. tubes and one for the first audio tube, are used so that a better hum balance may be obtained. These windings are shunted by potentiometers R_2 and R_3, each of twenty ohms, which are adjusted at the factory to the point of minimum hum in the loud speaker.

5. *Plate Circuits.*

Three different values of plate voltage are supplied to the receiver by the power unit. The same value of voltage is supplied to the plates of the r.f. tubes and also to the plate of the first a.f. tube; this potential is approximately 100 volts. The detector receives about 45 volts, and 157 volts is delivered to the plate of the power tube. Individual 0.5-mfd. bypass condensers C_6, C_7 and C_8 bypass the plate circuits of the various r.f. tubes so that there will be no r.f. current flowing through the power unit where they might cause coupling which would make the r.f. amplifier oscillate. These condensers also serve to bypass the audio-frequency currents in the plate circuit of the first a.f. stage.

6. *Grid Circuits.*

The grid circuits of the r.f. tubes obtain a bias from the power unit and somewhat greater bias is supplied from the power unit to the first audio tube. To obtain bias on the power tube a separate resistor is used, R_2 in the diagram, with a value of 1650 ohms. These various resistors which supply bias are bypassed by various condensers in the condenser block. If these resistors were not bypassed, an audio-frequency voltage would be impressed back on the grid circuits of the various tubes and either an increase or decrease of amplification at certain frequencies would result.

7. *The Power Supply.*

The power supply is a conventional one using a 280-type tube as the rectifier in a full-wave circuit. The filament of the rectifier is supplied with current by a secondary winding (S_1) on the power transformer T. Plate voltage for the rectifier is supplied by secondary S_2. The output of the rectifier feeds into a filter system consisting of C_9, C_{10} and C_{11} located in the condenser block and L_1 and L_2, which are filter choke coils.

The output of this filter system in turn feeds into the potential divider, R_3 consisting of a number of fixed resistors connected in series and having the values indicated on the diagram. At the junctions between these resistors wires are connected for obtaining the various voltages required for the correct operation of the different tubes in the receiver. Power to the receiver is controlled entirely by the switch connected in series with the primary winding of the power transformer.

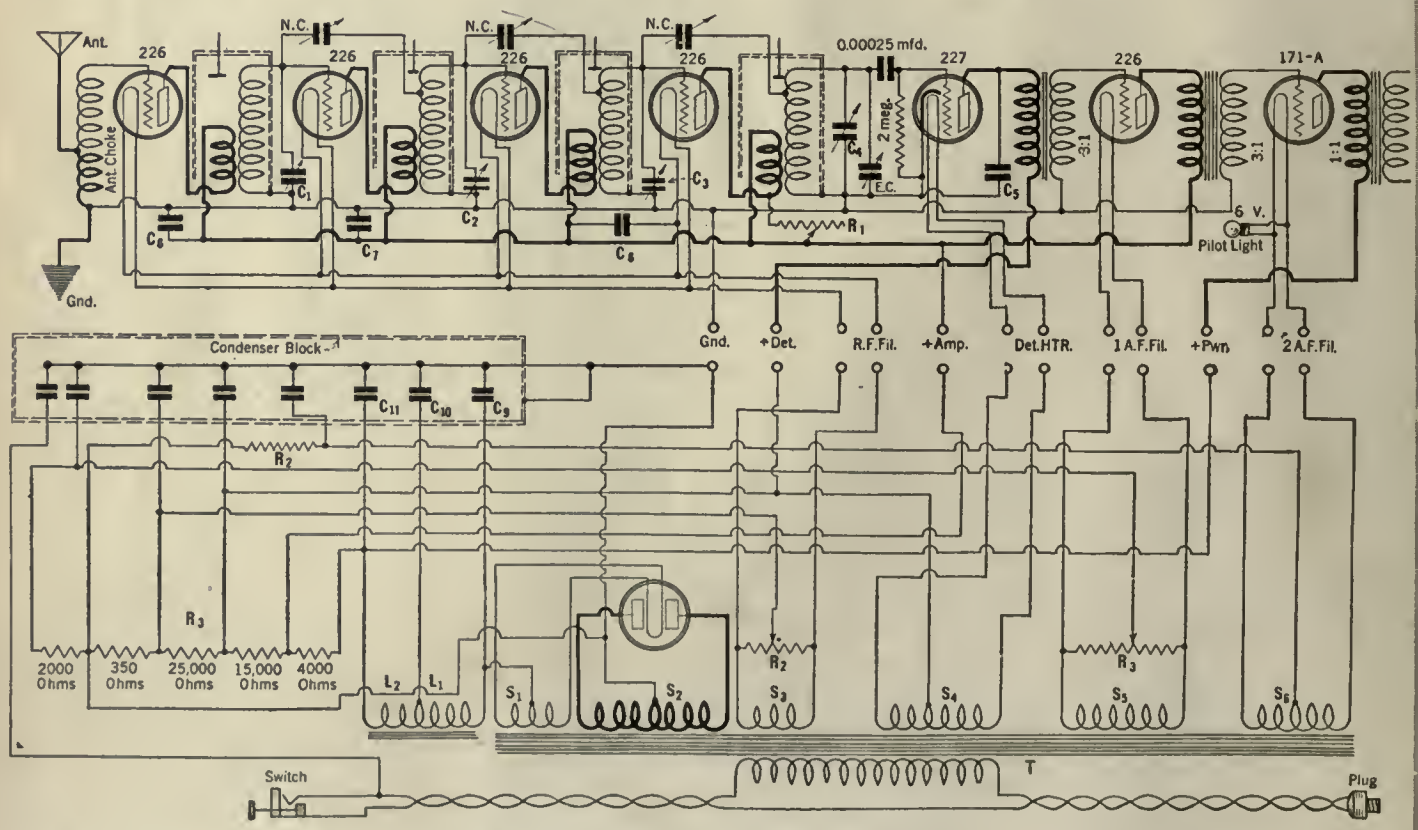


DIAGRAM OF RECEIVER AND POWER SUPPLY

The Improved Knapp A-Power Unit

OBTAINING a satisfactory source of power for heating the filaments of tubes in a radio receiver has been one of the chief problems confronting engineers since the early days of broadcasting. Of course, from the electrical viewpoint the storage battery is ideal for the purpose, but broadcast listeners and radio experimenters demand a device which is capable of providing equally satisfactory results and which does not require constant attention. When a receiver is operated with a storage battery it is necessary to recharge the battery and add distilled water at quite frequent intervals.

Filament-supply units consisting of a power transformer, rectifier and filter system have proved to be one of the best solutions to the A-power problem, and this article describes one of the most recently developed devices of this type. It is known as the Knapp A power, and was developed in the engineering laboratories of Knapp Electric, Inc., of Port Chester, N. Y. The unit is available as a kit, i.e., in knocked-down form, and the information contained in this article relative to the electrical characteristics, assembly and operation of the device was supplied by the manufacturer.

The Knapp A Power converts current supplied by a standard 110-volt a.c. line into a filtered 6-volt d.c. supply, which is satisfactory for the operation of standard radio tubes. The rectifier and filter condensers of the unit are of the dry-electrolytic type, thus avoiding entirely the usual maintenance operation of adding distilled water to the cells. Also, because of the enormous capacities which it is possible to obtain with dry-electrolytic condensers, the a.c. hum is eliminated almost entirely in the filter circuit and cannot be detected with the usual receiver.

From a practical viewpoint this A-power unit has other advantages. When operated from a 110-volt a.c. supply it may be employed to supply filament current to any standard home-made or factory-constructed receiver using up to 8 tubes of the 201A type, or a combination of tubes which requires a filament current of not greater than 2 amperes. The unit may be connected directly with the A binding posts of the receiver without making any changes in wiring, and it is connected with the house current by inserting a plug in a wall receptacle. The efficiency of the device is comparatively high; that is, it should not increase the electric bill more than 25 or 50 cents per month.

SIMPLE ELECTRIFICATION SYSTEM

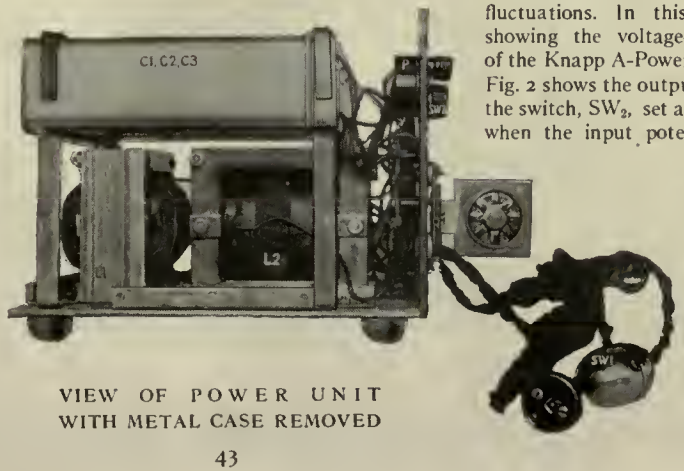
ANOTHER thing which should be pointed out in connection with this power unit is that it provides the nucleus for converting any d.c. receiver into a completely-electrified set. Many excellent devices are available which provide B and C potentials for the operation of all types of receivers, thus the use of batteries may be avoided entirely. Provision is also made in the unit for controlling the power to the B-supply unit with the switch employed for turning the A power on and off; for this purpose a standard 110-volt receptacle is included in the unit.

Power units of the type described in this article are not a new development; in fact, they have been in use generally for almost a year. In the March, 1928, issue of RADIO BROADCAST an article entitled, "A New A-Power Unit" by Ralph Barclay described an early model of the device now under consideration. This power unit has provided many readers with excellent results, but the new model is improved considerably and is capable of giving better performance, especially with modern receivers which employ amplifiers with better bass-note reproduction characteristics. Also, in the July, 1928, issue of RADIO BROADCAST the early model of this power unit was the basis of the power unit described in an article entitled, "An Interesting A-B-C-Power Unit and One-Stage Amplifier" by J. George Uzmann. This article served to illustrate how any home-made or factory-constructed set could be electrified easily and inexpensively.



THE POWER UNIT WITH METAL CASE IN PLACE

A glance at the pictures and diagram on these pages shows how the new Knapp A power differs from last year's model. In the first place, it is completely enclosed within a metal case, more pleasing in appearance and of more sturdy design. The electrical circuit has been improved but is fundamentally the same as before. It was found that the general use of high-quality amplifier systems in 1929 receivers demanded that the background of a.c. hum be reduced still further than it was in last year's model, and this improvement was effected by a change in the choke construction and through the use of an extra high-capacity, dry-electrolytic condenser. Another improvement is found in the rotary switch which replaces the old-style, plug-type voltage adjustment. The result of these changes is that the unit is not only more efficient electrically but it requires less space in the cabinet.



VIEW OF POWER UNIT WITH METAL CASE REMOVED

POWER UNIT VS. A. C. TUBES

BEFORE continuing further with this article it might be wise to clear up one point which probably has entered the minds of many readers; namely, why should a power unit be employed for supplying filament current for d.c. tubes when it is possible to electrify a receiver with a power transformer, wiring harness, and set of a.c. tubes? Of course, both systems possess merit, but it is safe to say that the A-power unit provides the simpler and more "sure-fire" method of the two, as in order to employ a.c. tubes it usually is necessary to make a number of changes in the circuit as well as several adjustments to reduce the hum. Also, the arrangement of apparatus in a set may be such that the constructor will not be able to eliminate the hum without considerable difficulty.

When comparing the cost of equipping and operating receivers with these two systems of electrification several points must be taken into consideration. With the power-unit method the cost of electrifying the set is limited to the cost of the power unit, but when a.c. tubes are installed it is necessary to buy a power transformer, wiring harness, volume control, voltage regulator, complete set of tubes, etc. With both systems the current consumed from the 110-volt line is about the same, but the cost of replacing tubes is two or three times as great when a.c. tubes are used. In both cost and simplicity it would seem, therefore, that the method of obtaining light-socket operation by the use of a B-power unit in conjunction with an A-power unit, is to be preferred to rewiring the receiver for the use of a.c. tubes. A set will operate from an A-power unit just as satisfactorily as from a storage battery—and the power unit requires no attention.

In selecting an A-power unit the amount of current and voltage which it will deliver at the output binding posts is another important factor; that is, it is necessary to make sure that an ample supply is available for heating the tubes of the receiver, notwithstanding normal line voltage fluctuations. In this connection two graphs showing the voltage-regulation characteristics of the Knapp A-Power are given in Figs. 2 and 3. Fig. 2 shows the output voltages obtainable with the switch, SW_2, set at each of the eight contacts when the input potential is 116 volts. Fig. 3 indicates the output of the power unit with the switch, SW_2, on the fifth contact when input potentials of 95, 100, 105 and 110 volts are applied.

The graphs described above show that the power unit is capable of supplying about two amperes of rectified cur-

rent at a potential of six volts, or in other words it will deliver ample power for heating the filaments of eight tubes of the 201A, 112A or 171A types. Secondly, it is shown that by means of the rotary switch, SW2, the voltage may be adjusted to the proper value for receiver whether the line voltage is above or below normal.

CONSTRUCTION OF UNIT

THIS article has now reached the point where the construction of the A power unit may be considered. The reader interested in building the power unit will find a complete list of the apparatus used in this new model at the end of this article. Also, there are two pictures which show the appearance of the unit, and a complete schematic wiring diagram is given in Fig. 1.

The picture of the completed power unit shows clearly the outward appearance of the device. All of the apparatus is housed within the metal case and the voltage-control switch is regulated by the knob on the right of the panel. The output binding posts are located in the center of the panel near the top, and at the left of the panel is a receptacle for plugging-in the B socket-power unit. The metal box mounted on the front panel conceals the rectifier unit, the cord on the left is for connection with the light socket and the cord on the right is equipped with a switch for turning the unit on and off.

Fig. 1 shows the complete wiring of the unit. T is a power transformer having a secondary with eight taps for voltage control, and R is a full-wave dry-electrolytic rectifier. The two heavy-duty choke coils, which are of identical construction, are located at L_1 and L_2, and the three dry-electrolytic condenser units, also of similar design, are connected at C_1, C_2 and C_3. P is the receptacle for the power lead from B-power unit, SW_1 is the off and on switch, and SW_2 is the voltage control.

The actual construction of the power unit is very simple. The assembly divides itself into three major steps; viz, mounting parts on base plate, mounting parts on front panel and assembly of mounting contacts for the rectifier unit. After the parts have been mounted the wiring may be accomplished quickly and easily.

The base plate for the power unit is die cast and has been drilled with all holes necessary for mounting the chokes, transformer, condenser brackets, front panel and steel box body. First, the two choke coils, L_1 and L_2, are mounted in place in the positions indicated in the picture. Next, the transformer is fastened on the right side of the base opposite the choke L_2 so that the taps are on the front edge. However, before mounting the transformer the primary leads should be arranged so that they pass through the top and they should be scraped free from insulation. To complete the assembly of parts on the base the condensers are fastened in place with their brackets, as indicated in the picture.

The front panel of the power unit is supplied with all necessary holes drilled and tapped, and the mounting of parts requires only a few moments' time. The receptacle for the B socket-power unit is first mounted in the large hole provided for it in the upper left corner, the eight-contact switch is mounted in a similar position on the right side of the panel, and the output binding posts are located in the two holes in the center of the panel near the upper edge.

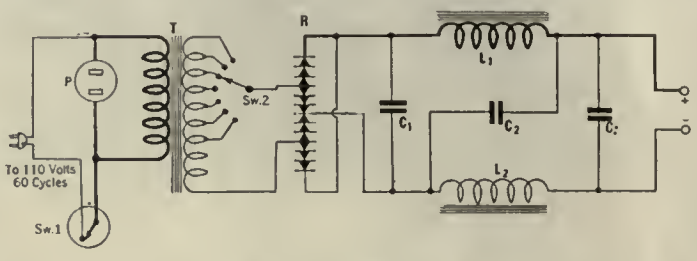


FIG. 1. SCHEMATIC DIAGRAM OF THE POWER UNIT

The assembly of the rectifier mounting contacts is very simple. Five holes are drilled in the front panel for the contacts which are fastened in place with nuts and washers.

The wiring of the unit is shown clearly in the diagram and an explanation of the connections is hardly necessary. In wiring the complete unit only eight feet of rubber-covered hook-up wire is needed and, of course, the connections should be soldered if best results are desired.

OPERATION

AFTER the construction of the Knapp A Power has been completed the wiring should be checked carefully, and then the unit may be placed in operation. However, before the unit is connected to a radio receiver it should be operated for at least an hour without load. This precaution is necessary to insure the elimination of all moisture which may have collected in the condensers.

Through experience it has been found that best results are obtained from the power unit when it is used every day. On the other hand, if the receiver is not used for a week or two the power unit should be disconnected from the set and operated for an hour without load. Also, the operation of the power unit may be improved materially by operating it without the receiver connected two or three hours each month.

After long service it will be found that the output voltage of the power unit will begin to decrease and it will be necessary to correct the control, Sw_2, to a tap giving greater voltage. The rectifier unit will finally require replacement. It is a very simple task to put in a new rectifier and these units are available at all radio stores.

In operating the power unit there is only one knob, Sw_2, which may be adjusted and this controls the output voltage of the unit. In adjusting this control the proper setting may be determined by placing the switch at the lowest tap which provides satisfactory performance, but a much more satisfactory arrangement would be to connect a 0-10 volt d.c. voltmeter across the output binding posts of the power unit. The meter is particularly valuable in districts where there are frequent variations in the line voltage.

LIST OF PARTS

THE following is a complete list of the apparatus included in the Knapp A Power Kit:

T—One Power Transformer
L_1, L_2—2 Heavy-duty a.f. choke coils
C_1, C_2, C_3—3 Dry-electrolytic condensers
R—One Elkon dry-electrolytic rectifier unit
SW_1—One Pendant switch and cord
SW_2—One Special 8-point switch, knob and plate
P—1 Receptacle for B unit
1 Attachment cord and plug
1 Celeron front panel
1 Base plate
1 Set of condenser brackets and clamp angles
1 Metal box and cover
1 Rectifier cover
1 Celeron connector strip
1 Rubber bushing
2 Output binding posts
1 Roll of hook-up wire
Mounting screws, nuts, bushings, etc.

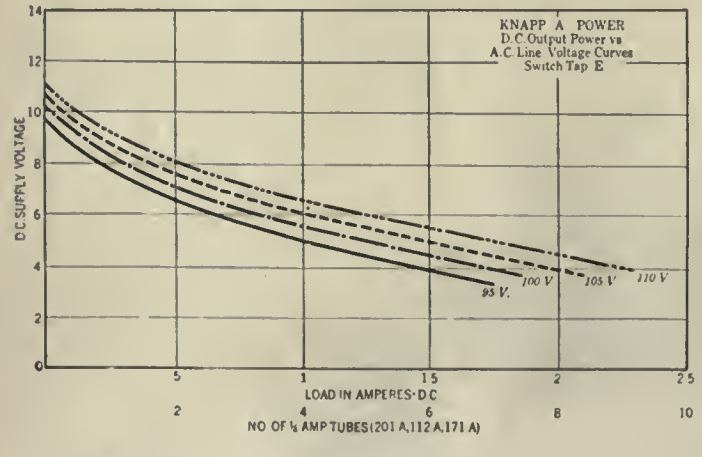


FIG. 2.

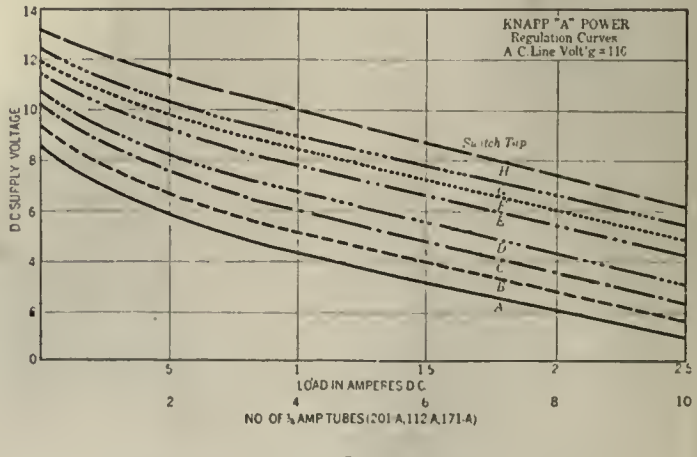


FIG. 3.

THESE GRAPHS SHOW THE OPERATING CHARACTERISTICS OF THE KNAPP A-POWER UNDER VARIOUS CONDITIONS

An Amplifier and Power Supply for the "Vivetone 29"

By R. F. GOODWIN

IN THE October number of this magazine the writer introduced the "Vivetone 29" receiver. Readers of the article will recall that in the design of the tuner quality and efficiency were the main objectives. These same qualities are outstanding in the power supply and amplifier unit which has been designed to work in conjunction with the tuner, and which is described in this article.

Power amplification is, of course, an admitted necessity in the modern receiver. Radio entertainment is no longer a novelty or plaything, and radio builders and owners now demand the quality of reproduction that comes only with power amplification and the use of an up-to-date loud speaker, such as the dynamic cone. This quality is assured in the Vivetone amplifier by the use of a 310 tube in the output and a scientifically designed coupling device. It has enough reserve power to eliminate the danger of overload distortion, and it will be found that full volume is seldom necessary for satisfactory reproduction in the home.

The power supply incorporated in the unit furnishes all the operating voltages for the amplifier and the tuner, and serves to make the ensemble completely light-socket operated. One of the most important features of the power supply is the incorporation in it of an adequate means of voltage control. This feature appears to have been neglected in most of the designs of our present all-electric receivers.

Practical control of voltage is accomplished in the Vivetone power unit with two low-resistance power rheostats, one being a 50-ohm voltage-control rheostat, PR-050, which is connected in series with the primaries of both the power transformers, while the other is a 0.2-ohm rheostat, PR-210, which is connected in series with the 1½-volt secondary winding of the low-voltage transformer, T-2445. Fig. 1 shows the location and wiring of these parts.

Many may wonder why a rheostat was not also connected in series with the 2½-volt winding. The reason is, first, that the 2½-volt windings of these transformers generally have the correct voltage, whereas the 1½-volt winding will be found to deliver slightly more than its rating; and second, the voltage-control rheostat will take care of any change in line voltage that would increase or decrease the voltage of the 2½-volt secondary or any of the other voltages after they have been once adjusted. Therefore, only one secondary rheostat is required, which is in the 1½-volt circuit.

This method of voltage control is not automatic; it need not be, because line voltage variations seldom occur more than once or twice in 24 hours, with the exception of dark stormy days when the power station is heavily taxed. Under such conditions the voltage control, PR-050, is decreased until the meter on the receiver panel reads one or two tenths below the proper specified reading.

THE amplifier and power-supply unit described in this article was designed especially for use in connection with the "Vivetone 29" receiver which was presented in the October issue of RADIO BROADCAST. *However, equally successful results may be obtained when the unit is connected with other standard a.c. receivers. The amplifier of the unit employs two transformer-coupled stages with a 310-type tube in the output circuit. The power-supply circuit provides normal values of B potential for the receiver and amplifier, as well as the necessary a.c. potentials for heating the filaments of the tubes.*—THE EDITOR.

Although it was designed especially for the "Vivetone 29" receiver, the amplifier power unit can be used with other a.c. tuners as an audio channel and power supply. It will operate excellently as a phonograph amplifier by connecting a good electrical pick-up unit across P and B plus of the first-stage transformer.

CONSTRUCTION

THE entire amplifier and power unit is constructed on a baseboard measuring 8" in width and 10" in length, being ½" thick. The audio portion, as shown in Fig. 2 and 3, is mounted at the left-hand end of the baseboard and the supply portion on the right. A Micarta 8" by 20" panel is used to mount the necessary resistances, binding posts, a.c. outlet and speaker jack.

The audio portion incorporates two stages of transformer-coupled audio amplification utilizing the new Thordarson R-300 transformers. For the output a choke and condenser device is used to prevent the high voltage from damaging the speaker windings. For the first audio stage a type CX-327 tube is used, and in the last stage a CX-310 power tube is required.

The power supply portion utilizes a half-wave rectifier system using a CX-381 tube. The voltage required to operate this tube is procured from a Thordarson R-210 power pack. It supplies the high voltage for the plate of the rectifier and has two filament windings, one for the rectifier tube and one for the 310 power tube. There are also the two necessary filter chokes incorporated in the unit.

The low-voltage transformer, T-2445, which supplies the voltage for the 326 and 327 tubes and the pilot lamp, is also rather compact in design. It will be noticed that this unit is mounted alongside of the power pack, R-210. Next to it is the filter condenser block, PL-575, a 12-mfd. unit properly divided with terminals placed so as to simplify wiring.

Since the entire layout of the parts is so clearly shown in the top view and the picture wiring diagram, Figs. 2 and 3, it will be unnecessary to give further details concerning their positions.

OPERATION

A STUDY of Fig. 1 and the figures in the article in the October number of RADIO BROADCAST (page 367–368) illustrating the construction of the Vivetone 29 receiver, will show the constructor exactly how to connect the two units for operation. The only operating adjustment that is necessary on the power unit is the adjustment of the voltage-regulating rheostats, which is a very simple matter.

To obtain smooth voltage regulation from the power unit is a simple matter. With all the specified tubes in their respective sockets, all the leads of the receiver correctly connected to their proper posts on the power unit, and an a.c. voltmeter temporarily connected across the heater terminals of the detector tube socket (type 27 tube) the house power is turned on, the secondary rheostat, PR-210, turned entirely to the left (full resistance), and the voltage control rheostat, PR-050, turned entirely to the right. Allow the detector tube about one minute to heat up and then adjust the setting of the voltage control rheostat, PR-050, until

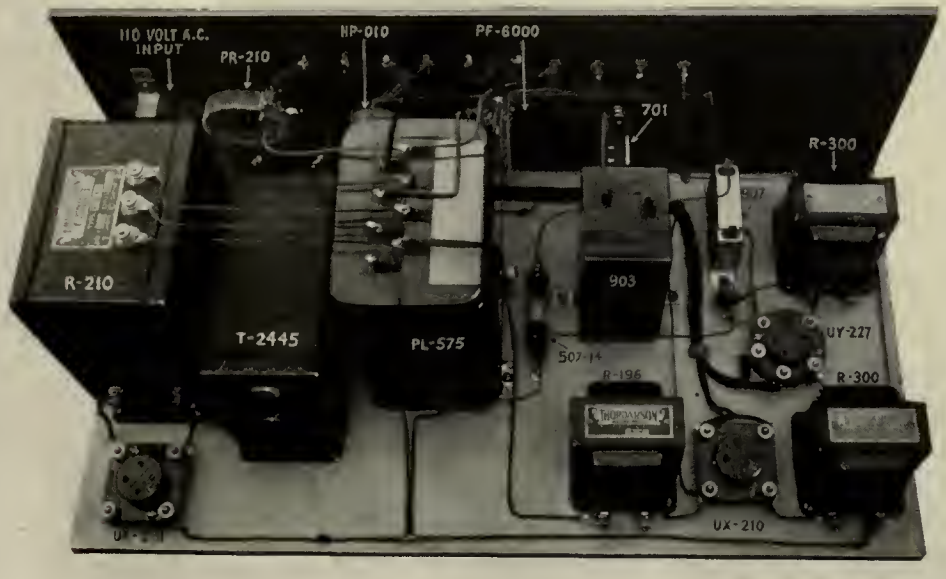


FIG. 2
Rear view showing layout of parts on baseboard

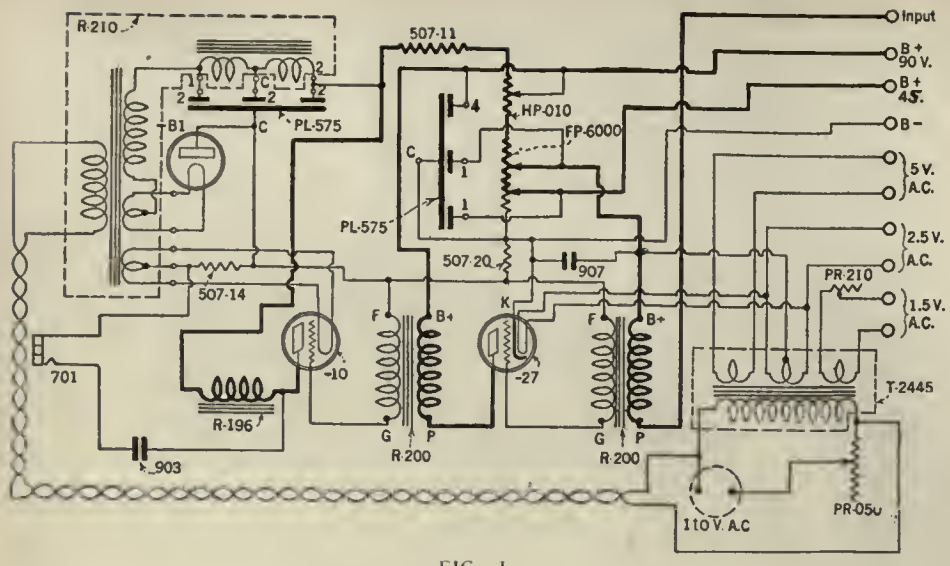


FIG. 1
Schematic diagram of Vivetone Power Unit

the meter registers approximately $2\frac{4}{10}$ volts (but not over $2\frac{1}{2}$ volts).

The meter is then disconnected from the detector socket and temporarily connected to the filament terminals of one of the r.f. sockets. Then the position of the secondary rheostat, PR-210, is corrected until a reading of approximately $1\frac{1}{2}$ volts is obtained. With this done the meter is connected permanently to the heater terminals of the detector socket. The setting of the secondary rheostat is then permanent and is not to be disturbed.

To complete the regulation process, the proper B voltages are to be determined. To accomplish this a high-resistance voltmeter would greatly simplify matters but for the benefit of those who have no meters the position of the arm of HP-010 on the power unit should be approximately halfway between both end terminals, whereas the arm of HP-6000 should be approximately three quarters of the way to the right (farthest from the negative end). The fourth terminal of PP-6000 should be approximately $\frac{1}{4}$ of an inch from the negative end terminal. This completes the regulation of voltages.

Now if a line variation occurs it will be indicated by the a.c. voltmeter, and only the voltage control rheostat, PR-050, need be manipulated to compensate for the line variation. In other words, by increasing or decreasing the resistance of this control all the voltages, a.c. and d.c., will increase or decrease respectively. By keeping the a.c. meter at approximately $2\frac{4}{10}$ volts all these voltages will be permanently correct.

In tuning the receiver there is really nothing difficult. After the current has been turned on, the tubes should be given at least a minute to heat up; then signals should come in with great volume and without hum. Should there be any noticeable hum it can be eliminated by correcting the arm position of the potentiometer, PP-015, on the receiver chassis. It should be remembered that the arm of the resistor, PP-2000, on the set chassis should be approximately one third of the way from front end terminal when the condenser plates are completely meshed.

Should the reader desire complete constructional blueprints or detail information concerning the function of the receiver they may be obtained by addressing the writer in care of this magazine. The blueprints are priced at $1.00 and are sold at their actual cost, including postage. They consist of complete full-size wired layout drawings, schematics, panel layouts, etc. of both Vivetone receiver and power unit number one. Blueprints describing another power unit have also been prepared. This unit consists of a push-pull 310 power amplifier utilizing a 327 in the first stage, as in power unit number one, and a full-wave rectifying system using two 381 rectifier tubes. This unit is suggested for those who require tremendous volume and wish to use more than one speaker.

LIST OF PARTS

[The list below gives the parts used in the unit described by the writer. Since all the parts are of standard design, the substitution of mechanically and electrically equivalent parts can be made by the experienced set builder.—THE EDITOR.]

Cost of Parts—Not over $95.00

1 Thordarson filament-supply transformer type T-2245
1 Thordarson power pack, type R-210
1 Thordarson choke coil, type R-196
2 Thordarson audio transformers, type R-300
1 Dubilier condenser block, type PL-575
1 Dubilier condenser, 1.0 mfd., No. 907
1 Dubilier condenser, 2.0 mfd., No. 903
1 Centralab heavy-duty potentiometer 10,000 ohms, type HP-010
1 Centralab fourth-terminal potentiometer, 6000 ohms, type PF-6000
1 Centralab power rheostat, 50 ohms, type PR-050
1 Centralab power rheostat, 0.2 ohm, type PR-210
1 Ward Leonard resistor, 10,000 ohms, No. 507-11
1 Ward Leonard resistor, 1000 ohms, No. 507-14
1 Ward Leonard resistor, 225 ohms, No. 507-20
1 Benjamin five-prong, green top socket, No. 9036
1 Benjamin four-prong, black top socket, No. 9040
1 Benjamin four-prong, red top socket, No. 9040
1 Yaxley junior jack, No. 701
1 roll flexible "Braidite" wire
1 roll Solid "Braidite" wire
10 Eby Binding posts
1 Westinghouse Micarta panel, $1\frac{1}{2}$" x 11"
1 Westinghouse Micarta panel, 1" x 2"
1 Westinghouse Micarta panel, 20" x 8"
Nuts, screws, etc.

For operating the unit in conjunction with an r. f. tuner, the following accessories are required:
1 Cunningham CX-381 rectifier tube
1 Cunningham CX-310 power tube
1 Cunningham CX-327 tube

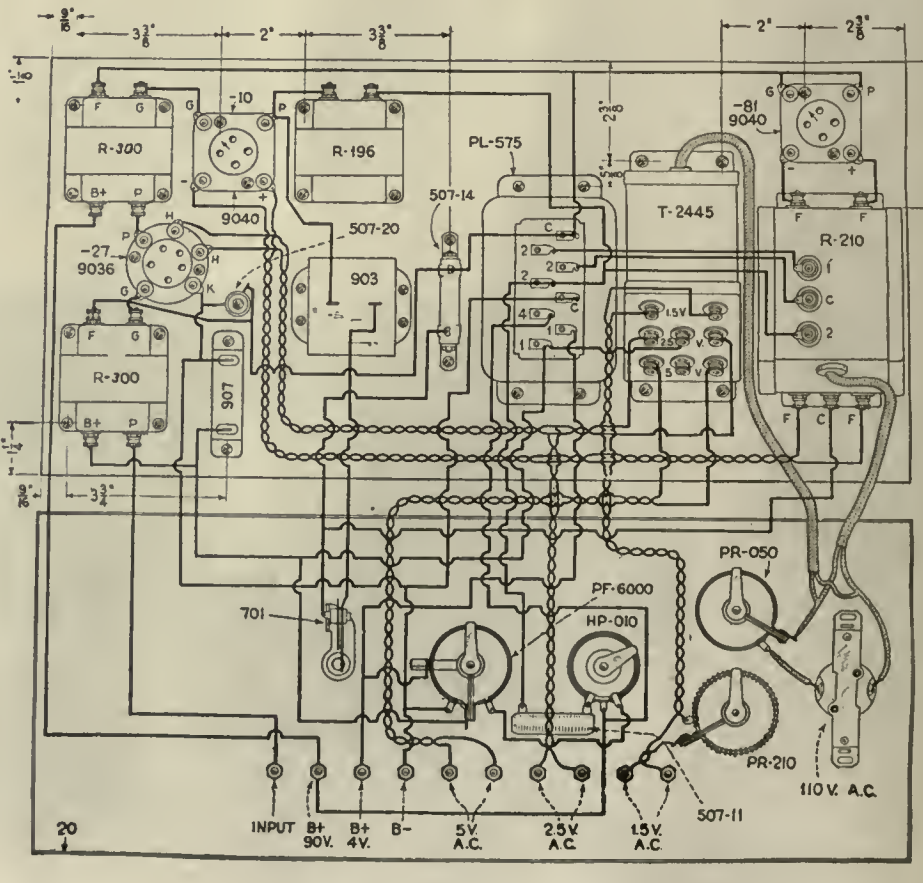


FIG. 3
Complete picture wiring diagram

"Our Readers Suggest—"

"OUR Readers Suggest" is a clearing house for short radio articles. There are many interesting ideas germane to the science of radio transmission and reception that can be made clear in a concise exposition, and it is to these abbreviated notes that this department is dedicated. While some of these contributions are from the pens of professional writers and engineers, we particularly solicit short manuscripts from the average reader describing the various "kinks," radio short cuts, and economics that he necessarily runs across from time to time. A glance over this "Our Readers Suggest" will indicate the material that is acceptable.

Photographs are especially desirable and will be paid for. Material accepted will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas.

—THE EDITOR.

Short-Wave Plug-in Coils

THE idea of using "dud" tube bases as a mounting for short-wave coils is certainly a good one, but some fans seem to have difficulty in making a really rigid job. The method illustrated in Fig. 1 has been in use in the writer's set for some time, and although the coils are subject to a lot of rough usage, they are just as strong and rigid as when first made.

The solution to the difficulties associated with these coils is found in winding the coils themselves on separate forms rather than on the tube base. This also provides greater latitude in winding specifications.

The coils are wound on a piece of thin bakelite tubing somewhat larger in diameter than a tube base. Holes $\frac{5}{32}$ inch in diameter are drilled 120° apart around the bottom edge of the tubing to admit a $\frac{6}{32}$ machine screw. Holes are also drilled and tapped 120° apart about $\frac{1}{4}$ inch from top edge of the tube base. The tubing is supported from the base by small collars made of brass tubing, and cut just long enough to fill the space. The whole is held together with $\frac{6}{32}$ round-head machine screws, as illustrated in Fig. 1.

After the coils are wound, they are given a coat of cement made of celluloid dissolved in amyl acetate which insures the wire remaining tight. The number of turns to use is not specified, as this information has appeared several times in RADIO BROADCAST and of course varies with the tuning condenser and also with the diameter of the coil. The reader is referred particularly to the description of the Cornet receiver of Lieutenant Wenstrom, which appeared in September RADIO BROADCAST.

Some readers may find difficulty in removing the vacuum tubes from their bases. The easiest method seems to be to pour a little wood alcohol through a small hole drilled in the base. After standing awhile the cement will be softened enough to pull the tube and base apart, when the solder is melted from the prongs.

C. S. TAYLOR, Ft. William, Canada.

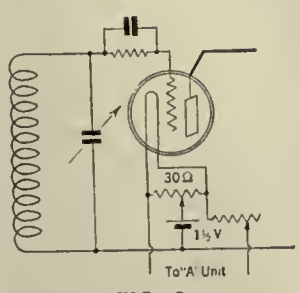


FIG. 2

When a.c. tubes are used this simple circuit will often effect a marked reduction in hum.

Receiving Without an Aerial

THE writer has discovered that his particular Atwater-Kent receiver functions quite satisfactorily when operated without an aerial, the ground wire being connected to the antenna post, and the ground post left unconnected. Operation is more selective and good volume is had on fairly distant stations. Occasionally a variable condenser, in series with the ground lead, is effective.

GEORGE N. COOK, Allenwood, Pa.

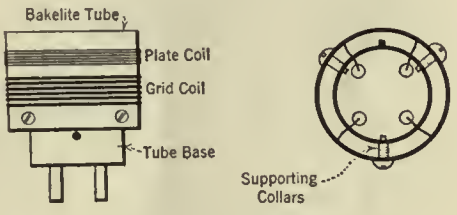


FIG. 1. COIL KINK

Tube-base plug-in coils of very rugged construction may be made by mounting a bakelite tube on an old tube base.

Polarity Indicators

IT IS often necessary to find the polarity of a line or pair of wires from a battery. In the absence of a meter the following methods may be used to determine the polarity of a source of direct current.

A small section of blueprint paper, such as is used in reproducing mechanical drawings, should be moistened and the two leads brought into contact with the surface. For voltages up to one hundred, the leads should be separated about one-half inch; for higher potentials this distance should be increased correspondingly. When the two leads are removed there will be a small bleached section where the negative lead touched the paper.

Another simple test for polarity can be made with a potato. The potato is cut in half. Stick the two wires to be tested into the freshly cut surface, about one inch apart. In a short time you will find that the potato has turned green around the negative wire.

J. B. BAYLEY, Jersey City, N. J.

STAFF COMMENT

The blueprint paper should be partially exposed before being used for the test. The potato idea is an old one but worth reprinting for the benefit of the new fan. The salt-water test is also simple and definite. Place two leads from the doubtful d.c. source into a glass of salt water. Bubbles will rise to the surface about both leads, but more bubbles will surround the positive wire.

Reducing Hum in the Detector

WHEN a combination of A and B socket-power units is used with d.c. tubes, a slight amount of a.c. hum generally is present in the loud speaker output. This hum can be reduced materially, if not eliminated, by connecting a 30-ohm potentiometer across the filament terminals of the detector tube. The grid return is then connected to the slider contact of the potentiometer, instead of to one side of the filament. When the potentiometer is adjusted to its mid-position, or approximately so, practically all trace of a.c. hum should disappear. A 1.5-volt flashlight cell, connected as in the diagram, Fig. 2, will provide the positive or negative grid bias required for the operation of 201A- or 200A-type tubes respectively.

CHARLES D. SAVAGE, Portland, Ore.

Reducing Hum in A.C. Sets

A GREAT deal of the hum in an a.c. home-constructed set comes from parallel leads and leads placed too close to the power transformer. A simple way to overcome this difficulty is to use the conventional automobile "BX" cable for all filament wiring and then ground the metal casing on these leads as well as the transformer shell. This trick has cured more than one baulky set.

J. B. BAYLEY, Jersey City, N. J.

STAFF COMMENT

The remedy suggested by Mr. Bayley will be effective in many cases. Shielding of the type he suggests should always be used, as a precaution, in wiring a.c. amplifiers for television reception. Small size BX cable can be obtained at any automobile-supply store or large garage.

Improving Capacity Feed-Back Regenerative Circuits

I HAVE just built the adapter described in your July issue and, while I think it provides the last word in satisfactory performance, I observe the presence of the familiar trouble of jumping suddenly into oscillation. The setting of the plate condenser is too critical for voice. It follows the tuning condenser too closely, to say nothing of the fact that the dial setting of the tuning condenser is affected by changes in the coupling condenser. This is an objection I have noted in all receivers employing this system of oscillation control.

However, as soon as a universal-range Clarostat was connected across the tickler, these objections disappeared. The variable resistor be

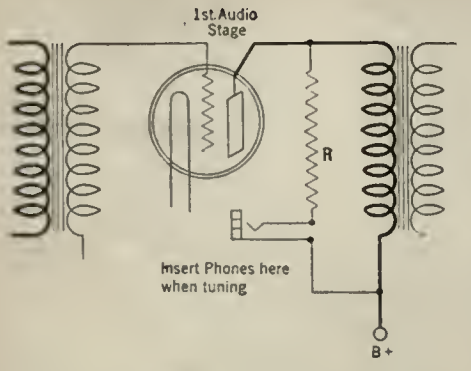


FIG. 3. SIMPLE OUTPUT CIRCUIT

With this arrangement it is possible to change from phones to loud speaker without disturbing the tuning adjustments.

comes the main control and should be mounted on the panel and the midget condenser, now an auxiliary, is relegated to the sub-panel. The over-all flexibility, ease of tuning, and reduction of body-capacity effects show a marked improvement.

E. W. MATTHEWS, Augusta, Ga.

STAFF COMMENT

The control of regeneration by means of a variable resistor connected across the feed-back coil is not new, but it seldom is employed in capacity-controlled circuits. However, as a matter of general principle, the use of a continuously variable resistor, so connected in any regenerative circuit, will provide the smoothest possible regeneration. The resistor, as suggested, is connected directly across the terminals of the tickler coil.

Tuning-in With a Distant Loud Speaker

REGENERATIVE detectors, followed by two audio stages, are found in many modern and ancient receivers. When the speaker is moved to some remote point, the operator is confronted with the problem of tuning the set by the phones. This is easy enough to accomplish in itself, simply by plugging into the detector jack, but it will be found, as a rule, that when the phones are removed, the constants of the plate circuit are so changed that the point of optimum regeneration is passed, and the set may even break into oscillation. If we plug into the loud-speaker jack, we get unbearably loud signals which may injure the phones, to say nothing of the ears!

There are many what might be called "orthodox" ways of overcoming this difficulty, probably the simplest of which is shown in Fig. 3. The value of the resistance R depends upon local conditions. Between 5000 and 10,000 ohms will fit most cases, but the best way, if you have a Clarostat or Royalty or other make of variable high resistance handy, is to connect it at R, set it to a comfortable volume of an average signal, measure the resistance and buy a cheap power-unit resistor near the value found, which is wired into place permanently.

W. BRUCE ROSS, Westmount, P. Q.

STAFF COMMENT

A perhaps more universal and equally simple arrangement for tuning with the telephone receiver, is to shunt a Centralab modulator plug (or any variable resistor having a range between one hundred and two thousand ohms) across the telephone receivers and plug the phones into the loud speaker jack. The volume can be adjusted, to a comfortable degree, by means of the resistor, and the set always is tuned to approximately the same volume.

Home-Made I.F. Transformers

IN THESE days of cheap retail radio prices, there are few pieces of apparatus that the fan will find it worth while to make. However, the intermediate r.f. transformers for a super-heterodyne are an exception. Efficient transformers may be made easily at a considerable saving by the super-heterodyne enthusiast. The following notes describe an intermediate transformer, designed for 201A or similar tubes, having a natural wavelength in the circuit of about 2000 meters—giving a wide separation between repeat tuning points on the oscillator dial.

Two discs of wood $\frac{1}{4}$ inch thick by $1\frac{1}{4}$ inches in diameter and a wooden core $\frac{1}{4}$ inch thick by $\frac{1}{2}$ inch in diameter are required for each transformer. These pieces are assembled as in Fig. 4.

Small wire brads may be used to fasten the discs to the core. Before winding, two holes should be drilled in each disc, near the outside for connecting terminals.

The windings consist of 200 turns for the primary and 800 for the secondary of number 32 s.c.c. or enameled wire. The wire should be wound haphazard fashion. First wind the primary over which place a layer of thin paper and then wind on the secondary in the same direction as the primary. Boil the completed unit in paraffine (make sure that the paraffine is not hot enough to smoke) for about a half hour. Terminal posts may now be inserted in the four holes drilled in the discs and marked PRIMARY, Plate and B plus, and SECONDARY, Grid and Filament. The start of the primary is connected to the B plus and the finish to the plate. The start of the secondary goes to the filament and the finish to the grid.

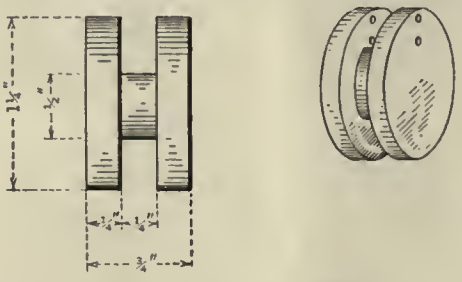


FIG. 4. DETAIL OF SPINDLE

The coils of an intermediate-frequency transformer may be wound on this simple spindle. Heavy cardboard may be used for the end pieces if desired.

No matching of the transformers is necessary as they were found to tune close enough.

No filter circuit is required as the combination of two or three of these transformers provides a band-pass of about the correct width.

R. W. TANNER, Springfield, Ohio.

Prolonging the Life of the 171A

THE Laboratory Information sheet number 204, appearing in July issue of RADIO BROADCAST contained information concerning the short life of the 171-type tube, used in a.c. sets.

As a radio service man with considerable experience in servicing electric sets, I can name two causes for the trouble, other than fluctuating line voltage.

I believe that the greatest source of difficulty arises from using 171A-and 371A- type tubes in sets which were designed for the 171 or 371 types. As these newer tubes draw only one-quarter ampere filament current, naturally the filament-supply winding on the transformer, which has been designed for a one-half ampere load, will provide an increase in voltage, and soon ruin a quarter-ampere filament. This same effect has also been found in battery sets where the audio tubes are controlled by a fixed resistor.

The remedy is extremely simple. Shunt a 20-ohm resistor across the filament terminals of the tube sockets, thereby adding another quarter-ampere load to the circuit, and the tube will then have a normal life.

Another trouble which I have run across is due to a low value of grid voltage on the tube. This is sometimes caused by a variation in the resistor which provides the voltage drop for the negative bias. When this grid voltage is low, the tube draws an excessive plate current, which soon lowers its electron-emitting characteristic.

This can be prevented by adding sufficient resistance to the C-bias resistor, to bring the grid voltage up to the proper value to balance the plate voltage, which figure may be determined from the tube chart, supplied by the manufacturer of the tube. Probably an additional 100-ohm unit would be good as a trial resistance.

I cannot recall a single instance of power tube failure, where the tube itself has been at fault.

A. H. GOUD, S. Portland, Me.

STAFF COMMENT

If it is possible to locate conveniently the resistor through which the filament current to the power tube is fed (in the case of d.c. sets designed for the 171 tube), this can be replaced by a 4-ohm resistor, or any quarter-ampere ballast resistor, with the same result.

Special Soldering Irons for Difficult Jobs

SET-BUILDERS and repairmen are running continually into odd soldering jobs which require a great deal of valuable time and are very trying on the patience. A set of irons similar to those illustrated in Fig. 5 will make soldering less troublesome.

The general type, shown in diagram A, is followed by the manufacturers of both electrically and externally-heated irons.

Mounting the heads at right angles to the shafts as shown in drawings B and C greatly facilitates working in out-of-the-way places. Drawing D shows a third modification with the head at a forty-five-degree angle to the shaft making an arrangement that should do the trick when all others fail.

A copper bar, one-inch square, was used for all the irons mentioned and found to be quite satisfactory.

GEORGE W. LINN, New York City.

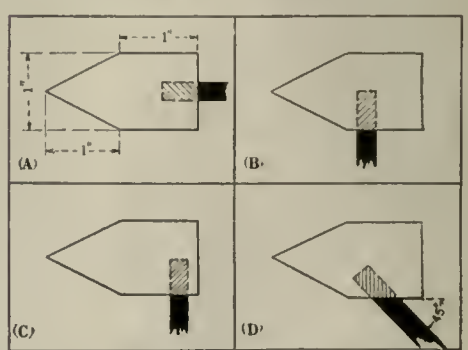
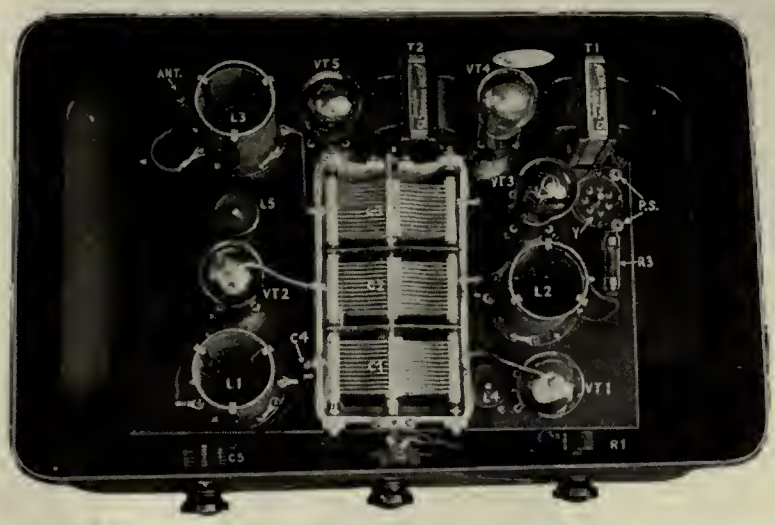


FIG. 5. SPECIAL SOLDERING IRONS

Difficult soldering jobs are greatly facilitated by using home-made irons of special design.



THIS PICTURE SHOWS THE ARRANGEMENT OF APPARATUS ON THE CHASSIS OF THE RECEIVER

The "Chronophase" Screen-Grid Receiver

By BERT E. SMITH

Aero Products, Inc.

WHEN the course of research, which was undertaken for the purpose of determining the best type of circuit arrangement, as well as coil construction for the screen-grid tube, left no doubt that the final method evolved gave the optimum results not only with this tube but also with standard a.c. and d.c. tubes, it was decided to proceed with the construction of a receiver utilizing this arrangement which, from its characteristics of adjusted phase relations, was called the "Chronophase."

Inasmuch as the "Chronophase" receiver was being planned to secure "DX" reception, through strong local interference, it was decided that a signal strength of one per cent., fifty kilocycles on each side of the resonant frequency, was the maximum allowable. With an experimental set-up entirely unshielded and with the coils separated by eight inches, it was found that such selectivity was secured by the use of two stages of radio frequency utilizing a 200-foot antenna approximately 50 feet high.

Next came the question of audio-frequency amplification. The most powerful audio equipment which can be built into a receiver, in most instances, will employ a 171-type tube which has an amplification factor of about three. With this tube in the last stage 650 milliwatts of undistorted output is obtained under proper load conditions when an alternating potential having a value of 28½ volts r.m.s. is impressed on the grid. A transformer recently has been made available of a type with a much flatter curve over the audible range than is ordinarily obtainable and continuing the flat portion of this curve out beyond the audible range so that there will be no loss of overtones and harmonics. These transformers give a voltage amplification of 3, so if we use a 201A-type tube in the first stage of the audio amplifier, we have an amplification factor between the detector output and the input to the grid of the last audio tube of 3 x 8 x 3 or 72. Since our tube required a maximum voltage of 28.5 r.m.s. to secure its greatest possible output, the corresponding detector output would have to be about 400 millivolts which is readily obtainable following two stages of r.f. amplification with a voltage amplification of about eleven per stage, which is provided by the "Chronophase" stages.

MECHANICAL DESIGN

HAVING both the audio-frequency and radio-frequency amplifiers determined, it was now only necessary to design the receiver in such a way that no serious losses would result in the layout and construction.

Always presuming that the coils and condensers of a radio-frequency amplifier are of the best quality obtainable, one of the most prolific sources of difficulty has been found to be in long leads, particularly in the grid circuits which are prone to pick up unwanted signals. The plate leads come next in sensitivity to external influences. In order to keep both of these as short as possible, the arrangement of parts indicated in the picture was employed. Stators of the condensers, which perforce must be in the grid circuit anyway, are used as grid leads, allowing the placing of each tube very close to the subsequent radio-frequency transformer, and permitting extremely short leads. A triple condenser with trimmers for compensating any slight differences in capacity is used to tune the amplifier. It was deemed advisable because of antenna variations to put the midget condenser, used as a vernier for the first stage, on the panel. A variation of this was required on both sides of the normal capacity of the condenser.

The illustration shows the complete layout finally adopted for the receiver. The Central Radio Laboratories manufacture a special stepless variable resistance for the stabilizing control which can be adjusted to hair-line accuracy. The Allen-Bradley grid leaks used are built from a solid block of non-hygroscopic carbon this unit is unaffected by weather changes, making it possible to solder the grid leak permanently into place without using the ordinary grid-leak clips which are a fertile source of trouble, due to oxidized and poor connections and consequent noisy operation.

The fixed condensers were also selected with great care, since they are in such a position in the "Chronophase" system that too great a phase-angle difference in the dielectric would seriously affect the operation of the circuit.

An inspection of the picture will show that there are practically no connections on the top of the subpanel other than those running from the stators of the variable condensers to the No. 6 terminals on the coils. The coils are mounted with three machine screws, and the 0.001-mfd. condensers between the plates of the tubes and the taps on coils are connected to the mounting screw between terminals 3 and 4 on the underside of the panel. A piece of flexible wire is attached to the top of this screw, the other end of which can then be connected to whichever terminal of the coil gives the desired results as will be explained later.

WIRING THE RECEIVER

AFTER making these connections, wire up the filament circuit, twisting the leads into a cable which more or less follows the outside lines of the sides and back of the panel. All filament, B-plus, and C-minus wires can be twisted into the cable wherever convenient, but the plate and grid leads should always be kept free, with the exception of the audio output lead which can be cabled with everything else.

When the wiring job is completed the set can be tested out before being put into the cabinet by placing an old dial on the condenser shaft and attaching the oscillation control and midget condenser with flexible leads. The circuits should be balanced, as will be explained in another paragraph, after it is mounted in the cabinet by attaching the mounting pillars to the screws in the subpanel in such position that they will be exactly over the bottom holes in the cabinet. Lower the set into the cabinet with the front end down and start the condenser shaft into the dial, and then dropping it back in until it fits into place. Now connect the flexible leads which were left for the midget condenser and resistance, tighten up the screws in the holes in the bottom of the cabinet and the set screw binding the dial to the shaft, and the set will be ready for operation.

The matter of balancing up the set is not at all difficult but will require quite a bit of time. In most cases, regardless of the type of tube used, the set will be found to operate to the best advantage with the antenna on tap No. 2, the first radio-frequency coil connected to tap No. 3, and the second radio-frequency coil at tap No. 1 or tap No. 2. For a comparatively short antenna, it may be desirable to put the tap on the antenna coil on No. 3 or No. 4, and for maximum selectivity with a long antenna, tap No. 1 should be used.

BALANCING PROCEDURE

A SUGGESTED method of procedure for balancing is as follows:

After connecting the taps as suggested, tune-in a station which will give a fairly weak signal when the set is not oscillating. Turn up the stabilizer until the set oscillates. Then, with the set in oscillation, adjust the trimmer units on the two rear sections of the multiple condenser until maximum volume is obtained, retuning to a weaker station if necessary, so that while adjusting, the volume is always kept at a comparatively low value. When perfectly balanced, the set should go into oscillation with the stabilizer about one third of the distance from minimum resistance, and should go in and out of oscillation at the same point; that is, it should be unnecessary after the set breaks into oscillation to retard the control beyond the point where it went into oscillation to clear it up again. If the set does not oscillate easily enough, raise the tap on the detector input coil. If it oscillates too easily, reduce this to tap No. 1. If insufficient selectivity is obtainable even with the antenna coil at tap No. 1, reduce the tapped portion of the middle coil. With everything properly adjusted, the removal of the cap from either of the screen grid tubes should practically stop the set from operating, although if it is tuned to a strong local station, the removal of the cap from the second tube may leave a trace of signal. Touching the first section of the tuning condenser should completely stop operation. Touching the second section should almost stop operation and touching the third stage, should reduce the volume considerably.

If the set is lacking in volume, or if a continuous high-pitched whistle or growling note is heard, a 1.0- or 2.0-mfd. condenser should be connected across the B minus and B plus 180-volt taps.

Using the particular receiver described in the article, on a 200-foot antenna, sufficient selectivity was obtained to bring in WOC while WEBH and WBBM were both in full operation, although WEBH is located within a mile of the point where the set was tested. With the same adjustments exactly, and during the same evening, the set brought in stations over a thousand miles distant with full loud-speaker volume. Over a short period of testing, stations on both coasts were received.

The need for careful adjustment of both taps and trimmers on the multiple condenser cannot be too strongly emphasized. If either adjustment is not correct, there will be a pronounced lack of selectivity and the receiver will probably bring in nothing but local stations.

OUTPUT DEVICE NEEDED

IT PROBABLY will be noticed that no provision has been made on this receiver for an output device. Many of the modern types of dynamic speakers contain a transformer and, accordingly, it is unnecessary or desirable to have an additional transformer built into the receiver. Furthermore, some builders prefer a choke and condenser output coupling, while others are strongly in favor of an output transformer. So with the idea of leaving the receiver as versatile as possible, the matter of output device was left to the builder.

Under no circumstances, however, should the set be used without some kind of satisfactory device to keep the direct current from the loud speaker windings.

[NOTE: The voltages suggested by the author for use on the screen-grid tubes are higher than those recommended by the manufacturers of these tubes. Normal screen-grid, control-grid, and plate potentials are 45, 1.5 and 135 volts, respectively. The simplest way to get such voltages to the proper places within the set is to connect the screen-grid leads to the blue 45-volt lead which at present is connected only to the primary of the first audio transformer. To get 135 volts on the plates of these tubes it will be necessary to run a separate lead to a 135-volt source, or to operate the power tube at this voltage when no change in the wiring will be necessary. The 10-ohm resistor R_4 should be connected in the plus filament lead to the two screen-grid tubes instead of in the negative lead.

In the Laboratory the difference between operating the receiver at normal voltages and those recommended by the Aero Products Company was hardly noticeable, although this is evidently not true in all cases, since the Aero Company advises that they obtained much better results with higher voltages. The disadvantage of using higher than the rated voltage is that shorter tube life results.—THE EDITOR.]

LIST OF APPARATUS

THE following is the list of parts recommended by the author of this article. Other parts of similar characteristics may be used if the constructor desires. The coils are 2" in diameter, wound with 90 turns of No. 22 B & S d.c.c. wire air spaced .005 inches and tapped as shown on the circuit diagram. The list price of the parts in kit form is $74.50.—THE EDITOR.

C_1, C_2, C_3—1 Aero gang condenser, .00035-mfd., Type AE-2155
C_5—1 Aero midget condenser, No. 940
C_6, C_7, C_{10}—3 Aerovox mica condensers, .001-mfd.
C_8—1 Aerovox mica condenser, .003-mfd.
C_9—1 Aerovox mica condenser, .00025-mfd.
L_1, L_2, L_3—1 Aero coil kit, No. U-203
L_4, L_5—2 Aero NoSkip chokes, No. C-60
R_1—1 Aero variable resistor, Type AE250
R_2—1 Bradley Grid leak, 3-megohms
R_3—1 Daven ballast, No. 5
R_4—1 Yaxley resistance, No. 810
T_1, T_2—2 Aero audio-frequency transformers, Type AE770
Y—1 Yaxley cable connecter, No. 669
A—Aero split-brass bushings, Type S-1
1 National dial, Type E
3 Kurz-Kasch walnut knobs, No. 98
2 Carter screen-grid connecters, No. 342
1 Eby Junior binding post
1 Aero cabinet, Type 400
1 No. 20 drilled Formica base-panel with all sockets, grid-leak clips, etc. mounted
9 Kellogg solder connecters, No. 2
50 ft. Rubber-covered stranded hook-up wire
4 ft. Rosin-core solder
5 Aero S4 mounting posts
3 Aero S3 bakelite bushings
1 Aero No. 3 screw assortment
Brass machine screws R. H., N. P., $5\frac{7}{8}$" x $\frac{6}{32}$"

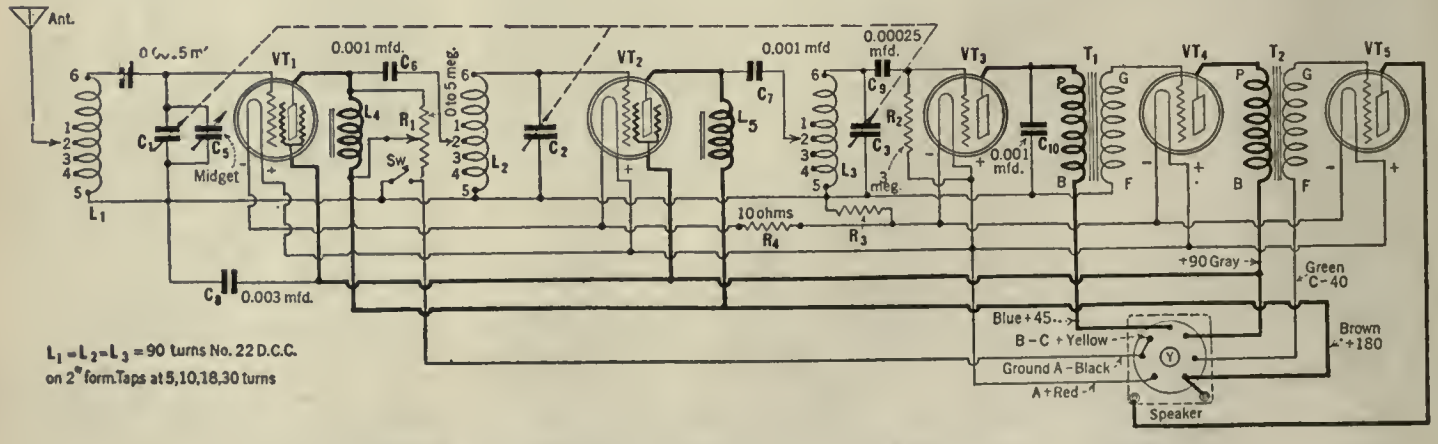


FIG. 1. COMPLETE SCHEMATIC DIAGRAM OF THE "CHRONOPHASE" RECEIVER

Who Are the Fellows of the Institute?

BY CARL DREHER

A FEW years ago, before industry deprived me altogether of leisure, I was returning by train from a walking trip in the country which had lasted several days and left me with a coat of tan and a considerable growth of beard. The train boy, happening to speak to me when I purchased some of his wares, began a sentence with the words, "All right, sir," but, glancing up at me as his lips formed the sibilant of the respectful title, and beholding my sweater and beard, he changed it hurriedly to "Feller." He was a class-conscious train boy. I reflected that the word Fellow has numerous meanings, and I could not tell whether he intended the one numbered in Webster 2. *A companion; comrade; associate; contemporary* or 3, *An equal in power, rank, character, etc.;* or perhaps even 6, *A man of low breeding or of little worth;* but I bought the lemon drops anyway.

Little did that snobbish youth know that the term which he used disparagingly also has learned associations, and, in scientific circles, entitles one to all the honors of a bishop among the men of God. Nevertheless, it is so, as he would see were he to consult the 1928 Year Book of the Institute of Radio Engineers. Of a total of 4200 members on December 1, 1927 (it is probably thirty or fifty per cent. greater by this time), 3543 were resident in the continental United States, the Canal Zone, Philippine Islands, and Alaska, and of all these radio engineers and aspirants under the flag of the United States only 74, I ascertained by a statistical investigation, are Fellows. It is easy, if one is of normally good character, to become an Associate Member. Full Members, although not born, may be made. But a Fellow! He is one of the 2 per cent., and a rare zoological specimen even at a meeting of the Institute. Contrary to the advertisements celebrating the prevalence of a certain affliction, four out of five cannot even hope to get it, and most of the remainder are turned down by the Committee on Admissions, of which Dr. Frank Conrad was Chairman in 1927, while Mr. R. A. Heising holds the helm this year. In 1927 10 Members had the temerity to seek admission to the Fellow grade; six were admitted, while four applications were denied. One Fellow was elected directly.

The Constitution of the Institute provides that a Fellow shall not be less than thirty years of age. He may be elected under one of several provisions. If he is a radio engineer by profession, "he shall be qualified to design and take responsible charge of important radio work; he shall have been in the active practice of his profession for at least seven years, and shall have had responsible charge of important radio work for at least three years." As a professor of physical science or of electrical engineering he is subject to equally severe requirements, if he seeks the honor in that section. By "notable original work in radio science," inventions, or contributions to literature giving an applicant 'a recognized standing at least equivalent" to the above he may also hope to become a Fellow. Under these provisions noted radio executives, like Mr. Sarnoff and Mr. Young, are admitted to the august company of their own chief engineers, and, like them, pay annual dues of $15, but they don't have to read the *Proceedings* unless they want to.

Moved by a perhaps unseemly curiosity, I recently read through the list of members of all grades published in the 1928 Year Book to see what the 74 indigenous Fellows did during their business hours. Thirteen, I found, are engineers employed by Radio Corporation, General Electric, and Westinghouse, and two are non-engineering employees of this group of companies. Ten are engineers for the American Telephone and Telegraph Company. Seven are engineers for miscellaneous radio concerns. Six are consulting engineers. Eleven are executives. One is in the sound-movie business. Two are definitely outside of radio in their business connections. Professors of engineering or allied subjects at universities number 6. There are 3 army or navy officers, and 5 in civilian government positions. In 6 cases no vocational information is given.



CHIEF OF THE INSTITUTE
Dr. Alfred N. Goldsmith, president, the Institute of Radio Engineers

My object in printing this is to render some of the impassioned opponents of the big corporations privy to the hitherto unrevealed fact that over a third of the leading radio engineers of the country are already in the hands of these octopi, and all of them may be swallowed unless Congress does something about it.

Other interesting facts may be gleaned from the Year Book. As they are published for all to see, I may be permitted to comment on them without scandal. Note, that Major E. H. Armstrong, indubitably one of the genuinely great men of radio, did not become a Fellow until 1927. He could have been one any time after he wrote his classical paper on the vacuum tube, in 1915, or as soon thereafter as he became 30 years old. Why didn't he bid for the honor sooner? Maybe he just didn't give a damn; that would be like Armstrong. W. R. G. Baker, Managing Engineer of the Radio Department of General Electric, is still down as an Associate; he has since come up for the grade of Fellow, however. More than one of the luminaries skip the Member grade, apparently. Stuart Ballantine became a Fellow in 1928, also, rising from Associate; he must be one of the youngest among the Fellows, but his recondite and brilliant researches deserve the honor. Harold H. Beverage remains a Member in the 1928 Year Book. Mr. H. O. Boehme is also down as a Member ('15). If you don't remember him, you don't remember the Atlantic Communication Company either, and if you don't remember the A. C. C. you are no radio man. But where is the name of George H. Clark? He doesn't seem to be a member of the Institute at all, these days. John M. Clayton, the Secretary of the Institute, is a Member. Powell Crosley, Jr. is a Member. H. P. Davis, the Vice-President of the Westinghouse Company, who is probably responsible in greater measure for the existence of broadcasting than any other man and who is an engineer to boot, is not listed. Dr. J. H. Dellinger was elected a Fellow in 1923 and became President of the Institute in 1925. Carl R. Englund of the Bell Telephone Laboratories, one of the most brilliant controversialists in the Institute, was only an Associate in 1927; he has since been elevated to the Fellow grade. C. L. Farrand seemingly has no desire to rise above the Member degree. A. H. Grebe, although a Manager for three years, remains an Associate. Similarly David Grimes. And ditto Charles A. Hoxie. So does Edward J. Nally, the first President of the Radio Corporation of America, modestly remain an Associate. Hudson R. Searing, an electrical engineer who was one of the pioneers among the New York amateurs, and Harry W. Secor, who was writing radio articles during the years of radio antiquity, are both associates, Mr. Secor since 1912, when the Institute was founded. Hendrik J. Van Der Bijl, the author of the well-known text on vacuum tubes, is a Member in South Africa. Irving Vermilya is a Member also; ten years before there were broadcast listeners to be annoyed, he was a master of spark sets from one end of Long Island Sound to the other.

On the same page of the Year Book one's eye strikes the name of Manfred von Ardenne, the German baron who, as a radio engineer and mathematician, was able to hold his own with some of the Fellows of the Institute during his visit a year ago, but who is so young that he can only qualify as a Junior. Finally, among the Z's, just before the name of Prof. Jonathan Zenneck, the Fellow who came from Germany this year to receive the Institute's Medal of Honor, there is Harold R. Zeamans, who ranks among the Associates, for he is a lawyer and not an engineer, but for all that he is one of the oldest members of the organization and has been presenting it with legal counsel since 1912.

Thus there are great and prominent men on the lower ranks of the hierarchy, as well as among the Fellows. Prominent or not, they can vote, speak their minds at the meetings, and preserve the *Proceedings* in their libraries. There are, however, privileges which they do not enjoy. Only the Fellows have the right to wear badges with blue lettering on a gold background, only Fellows may aspire to election to the offices of President and Vice-President, and only Fellows are *ipso facto* famous.

New Apparatus

PRODUCTS of radio manufacturers whether new or old are always interesting to our readers. These pages, a feature of RADIO BROADCAST, *explain and illustrate products which have been selected for publication because of their special interest to our readers. This information is prepared by the Technical Staff and is in a form which we believe will be most useful. We have, wherever possible, suggested special uses for the device mentioned. It is of course not possible to include all the information about each device which is available. Each description bears a serial number and if you desire additional information direct from the manufacturer concerned, please address a letter to the Service Department,* RADIO BROADCAST, *Garden City, New York, referring to the serial numbers of the devices which interest you, and we shall see that your request is promptly handled.*—THE EDITOR.

Two-Stage Power Amplifier for A.C. or D.C. Operation

X71

Device: NATIONAL PUSH-PULL AMPLIFIER. This is a complete two-stage transformer-coupled power amplifier. It does not contain any power supply, but it may be light-socket operated by the use of a 227-type tube in the first audio stage and two 210- or 250-type tubes in the output stage, which is push-pull. An extra socket is provided so that those who desire may use a 112A-type tube in the first stage and operate the amplifier from a storage battery. Resistances are contained within the device so that the proper C-bias potential is supplied automatically to the tubes. The unit is wired completely.

Manufacturer: National Company, Inc. Price: $40.00 completely wired but without tubes.

Application: The amplifier may be used readily in conjunction with radio tuners or it may be used with a phonograph pick-up for the electrical reproduction of phonograph records. It may also be used to replace poor audio systems in old sets, thereby improving the quality of the reproduction.

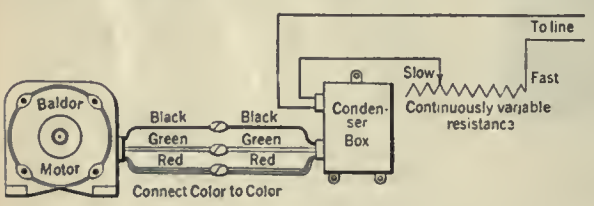


FIG. 1.

Diagram shows method of connecting Baldor motor with condenser block and a.c. line

Improved Motor for Television

X72

Device: BALDOR BALL-BEARING MOTOR. These motors are intended for use in television receivers for driving the scanning disc. Two types are available.

Type Y1V is a $\frac{1}{8}$-HP, 110-Volt, 60-cycle, single-phase, 1800-RPM motor designed for receiving sets using a 24-inch scanning disc. It is designed to maintain a constant speed between 750 and 1700 RPM with a 5- to 45-ohm variable resistance. Price: $30.00.

Type M2V is a $\frac{1}{15}$-HP, 110-Volt, 60-cycle, single-phase, 1800-RPM motor for receiving sets employing 9- to 18-inch aluminum scanning discs. The motor revolves 1750 RPM at full load and a variable speed range of 750 to 1700 RPM is obtained with a 60-ohm rheostat. Price: $23.00.

Machined flange for scanning disc for all motors. Price: $3.00.

Rubber-cushioned base. Price: $2.50.

Manufacturer: Interstate Electric Company.

Application: This motor is of the induction type, not relying upon a commutator either for starting or running. Because of the fact that the motor is placed in close proximity to the television amplifier, tiny sparks, such as are produced by brushes sliding over the surface of a commutator while the motor is running, would create disturbing electrical waves, which if picked up by the amplifier may cause distortion or fogging to such a degree that the sought for picture would be a failure. This motor is silent in operation and free from hum, either of which affects the amplifier because of distortion and lack of clearness. The circuit is given in Fig. 1.

The following excerpt from one of the engineering Test Department Reports of the Interstate Electric Co. is of interest: "The scanning discs as used to-day for television reception are anywhere from 9 to 24 inches in diameter, and $\frac{1}{16}$ or $\frac{1}{8}$ inch thick, usually of aluminum. These discs, may be driven by an M2V, $\frac{1}{15}$HP; Baldor motor, which has ample power for this purpose. As a matter of fact, with a 15-inch disc the motor may run up to within 50 to 75 revolutions of synchronous speed which is 1800 RPM. In order to reduce this speed to what is required it is only necessary to place a series resistance in the circuit with a means of short circuiting about 15% of the total resistance in the form of a key. For example, for a disc 15 inches in diameter, $\frac{1}{8}$ inch thick with a required speed of 1080 RPM there is required a fixed resistance of 160 ohms with a key shunting around 25 to 30 ohms.

"There is a means of obtaining somewhat more stable operation, which is to load the motor in some way (a flat disc is practically a frictionless load), as for example, by a fan. If we place six small blades, 1 by 2 inches on the side of the scanning disc, we will have accomplished the result we are looking for; namely, a slight load on the motor, enabling the operator to hold the speed of the disc more nearly constant. The motor now requires only a 30-ohm fixed resistance with approximately 5 ohms short circuited with a key, assuming a 15-inch diameter disc is used and a speed of 1080 RPM is desired."



THE NATIONAL TWO-STAGE POWER AMPLIFIER



NEW PORTABLE METER MADE BY WESTINGHOUSE

High Grade A.C. Meters

X73

Device: PORTABLE ALTERNATING-CURRENT INSTRUMENTS FOR LABORATORY USE. The Westinghouse Company have recently developed a new line of portable alternating-current instruments for laboratory use. These instruments are operated on the electric-dynamometer principle, containing two stationary coils and a moving coil. The unit shown on this page is a single-phase wattmeter. The unit illustrated has a case made of wood. However, they are now being manufactured with cases of built-up sheet micarta. This construction of case is novel and gives the units a great many advantages which wooden cases do not possess. The finish on the micarta case is that of burl walnut and is very hard, not easily scratched or marred like the finish on the wooden case instruments. The dials of the instruments are metal under which is a mirror so as to prevent parallax reading of the knife-edge pointer. The scale is $5\frac{1}{2}$" long with quite uniform markings throughout. Although the design of these instruments is primarily for alternating current use they can be used on direct current and are just as accurate as on alternating current when the average of the direct and reverse readings are taken. The instrument element has an iron shield around it so as to make it immune from external stray magnetic fields. The accuracy of the instrument is $\frac{1}{4}$ of 1 per cent., of full scale deflection. The terminals supplied on the instruments are non-removable, engraved with the scale value and have large contact surface.

Ammeters are made in double-scale ranges from $\frac{1}{2}$ to 30 amperes in capacities multiple of 2. The voltmeters are also made in double ranges of multiples of 2 capacities, from 3 volts to 600 volts. The double range 0-3 and 0-6 volts or 0-$7\frac{1}{2}$ and 0-15 volts are particularly desirable for measuring the filament voltages of the radio tubes in laboratory testing. The instruments are also provided in single-phase wattmeters with voltages as low as 30 volts up to 600 volts and currents from $\frac{1}{2}$ ampere up to 30 amperes.

Manufacturer: Westinghouse Electric and Manufacturing Company.

Application: The usefulness of such instruments in any electrical laboratory is obvious. The

ranges being manufactured cover all values of current, voltage, and wattage ordinarily dealt with in radio work.

An Adjustable Resistor Network for B-Power Units

X74

Device: TRUVOLT DIVIDER. A compact unit consisting of a network of resistances mounted in a small nicely finished container and designed for use in conjunction with all types of B-power units delivering voltages not in excess of 220. It permits one to obtain readily output voltages of various values between 0 and 180 and to also obtain two values of C voltage. It can be used with any type of rectifier or filter circuit.

Manufacturer: Electrad, Inc. *Price:* $12.50.

Application: The problem of obtaining from the output of a B-power unit the correct voltage for application to any given receiver is a serious one. Fixed resistances across the output of a B-power unit have the disadvantage that the voltage which will be delivered from the various taps varies considerably according to the amount of current drawn from these taps. The use of variable resistances for each tap has the disadvantage that the range of voltage which can be delivered from each resistance is very wide and therefore rather difficult to adjust accurately. A compromise between these two is probably the best. We therefore make use in the Truvolt Divider of the combination of fixed and variable resistances so that the voltage from each tap is approximately fixed but can be varied over a range sufficiently wide to adapt the unit to practically any receiver. This might be called a universal divider since it can be used interchangeably with any receiver and any power unit and can be adjusted to supply the correct voltages to the set. The unit will find application not only in the construction of new power units but in conjunction with old power units which perhaps deliver incorrect voltages or have not sufficient voltage taps. Also by using the Truvolt Divider we can obtain from a power unit that ordinarily delivers only B voltages two values of C voltages as well as the B voltages.

The Truvolt Divider is designed to supply four B voltages and two C voltages. The voltage obtained from the B1 tap is the maximum voltage from the B-power unit. Tap B2 supplies an average voltage of 135 but this voltage can be adjusted to any value between 110 and 160 volts. Tap B3 supplies an average of 90 volts which can be adjusted between the limits of 65 and 110 volts. Tap B4 is the 45-volt tap capable of supplying a range of voltages from 20 to 55. Tap B5 is the negative B. Tap C6 is the low voltage C terminal and it will supply a grid bias from minus 1 to minus 20 volts. For higher C biases tap C7 is used. It supplies voltages from minus 20 to minus 40. The connection of this device to a typical B power unit is indicated in Fig. 2.

Because the resistances used in this divider are of a type which can be accurately calibrated it is possible by the use of either tables or curves to adjust the various controls to give the proper voltages without the use of a voltmeter. If a voltmeter is available, it of course affords a simple, rapid, and certain method of adjusting the unit. The voltmeter is shunted between that particular tap which is being adjusted and the negative B and the control varied until the correct voltage is supplied. This test is, of course, made with the receiver connected to the unit.

Many experimenters desiring to use this device will probably not have available a high-resistance voltmeter; for them it would be helpful to have the booklet supplied with the divider, which describes in detail how to adjust the resistors for any given receiver. This booklet, which is called the Truvolt Divider Manual, is not only very helpful in adjusting this device, but also contains a great deal of excellent information in connection with the output circuits of a B-power unit.

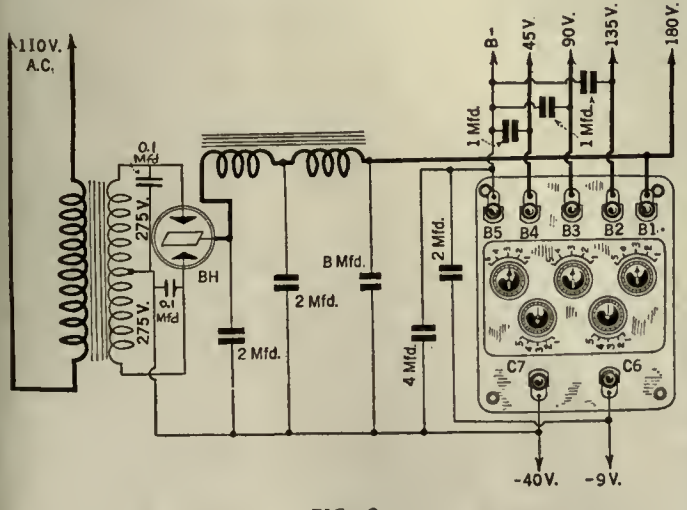


FIG. 2.

Method of connecting Truvolt divider in a B-power unit

Useful Tester for Radio Sets

X 75

Device: SET TESTER. This tester is designed to aid in servicing all types of a.c.- and d.c.-operated receivers. The following paragraphs indicate some of the tests which may be made.

In balancing the various tuning condensers in a single-control receiver the tester is very useful. This test is made by placing a tube in one of the sockets of the tester and inserting a plug into the power-tube socket of the receiver, thus converting the tester into an oscillator. When these connections are made, and the set is turned on, it will be found that the milliammeter in the tester will jump as the set is tuned to resonance with the oscillations produced by the tester. Each individual tuning condenser is then adjusted to resonance, as indicated by the movement of the meter.

The tester will measure the normal emission, and the emission when oscillating, of all types of tubes. In addition it will indicate the plate voltage, grid voltage, and filament voltage of each tube of a set, both under load condition and with no load. Another important application is the detection of open, short, and high-resistance joints in any parts of the circuit.



RADIO TEST SET MADE BY SUPREME INSTRUMENT CORP.

The instrument contains a complete set of tools with space for spare tubes. The supplies include a ratchet screw driver, soldering iron, hook-up wire, various adapters, test leads, etc.

The instruments in the tester are: a double-range milliammeter, 0-50 and 0-100; a triple-range voltmeter, 0-10, 0-50, and 0-250, and a triple-range a.c. voltmeter, 0-3, 0-18 and 0-150.

The photograph illustrates the Model 100A instrument priced at $108.50.

Manufacturer: Supreme Instrument Corporation.

Application: Indicated above. It should prove invaluable to service men.

Hook-up Wire for Various Uses

X76

Device: CELATSITE HOOK-UP WIRE. The following kinds can be obtained.

1. Celatsite Flexible Wire. A flexible hook-up wire consisting of tinned stranded copper wire covered with a non-inflammable insulation. Available in the following colors and wire sizes.

No. 22—$ .70 per 25-ft.
No. 20— .75 " "
No. 18— .80 " "
No. 16— 1.00 " "
No. 14— 1.00 " "

Colors: Black, Yellow, Red, Green, Brown, Slate, Blue, White, Maroon.

2. Celatsite twisted wire for a.c. filament circuits. One strand of Red and one strand of Black No. 18 Flexible Celatsite twisted together. The two colors are used so that, if desired, the same sides of all filaments can be maintained at the same relative potential. Packed in 25 ft. coils. *List price:* $1.75 per carton.

3. Solid Celatsite wire. Bus-bar made of tinned No. 14 copper wire and covered with a non-inflammable insulation. Strips easily for soldering. Available in same colors as the flexible wire. *Price;* $.09 per 30-inch length.

Manufacturer: Acme Wire Company.

Application: The above material has been used in the Laboratory for some time in constructing receivers and power units and has been quite satisfactory.

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on this page. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. 192B revised booklet, with circuit diagrams of popular kits. RADIALL COMPANY.

5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNOUM COMPANY.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RAOIO COMPANY.

17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

32. METERS FOR RAOIO—A catalogue of meters used in radio, with diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

37. WHY RADIO IS BETTER WITH BATTERY POWER—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.

46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.

47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.

48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.

53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.

56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.

57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.

58. HOW TO SELECT A RECEIVER—A common-sense booklet describing what a radio set is, and what you should expect from it, in language that anyone can understand. DAY-FAN ELECTRIC COMPANY.

67. WEATHER FOR RADIO—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. TAYLOR INSTRUMENT COMPANIES.

69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit; list of American and Canadian broadcast stations. RADIO CORPORATION OF AMERICA.

72. PLATE SUPPLY SYSTEMS. Technical information on audio and power systems. Bulletins dealing with two-stage transformer amplifier systems, two-stage push-pull, three-stage push-pull, parallel push-pull, and other audio amplifier, plate, and filament supply systems. AMERICAN TRANSFORMER COMPANY.

73. RADIO SIMPLIFIED—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. CROSLEY RADIO CORPORATION.

76. RADIO INSTRUMENTS—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. JEWELL ELECTRICAL INSTRUMENT COMPANY.

78. ELECTRICAL TROUBLES—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. BURTON ROGERS COMPANY.

81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

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The author, **C. E. Sterling,** is Radio Inspector and Examining Officer, Radio Division, U. S. Dept. of Commerce. The book has been edited in detail by **Robert S. Kruse** for five years Technical Editor of QST., the Magazine of the Radio Relay League. Many other experts assisted them.

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Since they began, in June, 1926, the popularity of the Information Sheets has increased so greatly that it has been decided to reprint the first one hundred and ninety of them (June, 1926–May, 1928) in a single substantially bound volume. This volume, "Radio Broadcast's Data Sheets" may now be bought on the newsstands, or from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Inside each volume is a credit coupon which is worth $1.00 toward the subscription price of this magazine. In other words, a year's subscription to RADIO BROADCAST, accompanied by this $1.00 credit coupon, gives you RADIO BROADCAST for one year for $3.00, instead of the usual subscription price of $4.00.

—THE EDITOR.

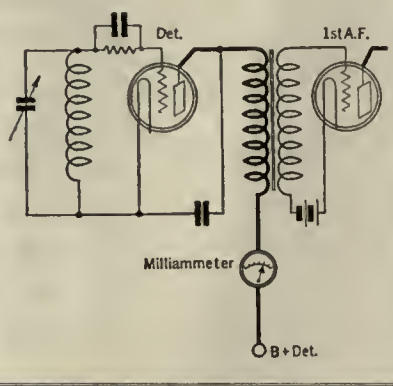
No. 233 RADIO BROADCAST Laboratory Information Sheet November, 1928

Balancing Radio Receivers

AN EASY METHOD

THE change in the plate current of the detector tube, when a signal is being received, may be utilized to balance the various tuned circuits in a single-control receiver. If the several tuned circuits in a multi-stage r.f. amplifier are not properly ganged, the set will be insensitive and the selectivity will be poor. It is essential, therefore, that the various stages be accurately aligned. How this can be done is the subject of this Laboratory Sheet. The method used is simple and is based on the action of a detector when a signal is being received.

If a milliammeter with a range of about 2 milliamperes is connected in series with the B-plus lead to the detector, as indicated in the diagram, it will be found to read about 1 mA. if the detector is of the grid leak and condenser type and about 0.2 mA. if a C-battery type detector is used. If a station is tuned-in, the plate current of the detector tube will decrease if the former arrangement is used and increase with a C-battery detector circuit, the amount of the increase or decrease being proportional to the strength of the signal—the stronger the signal the greater the change in current. Therefore, when the set is accurately tuned and all of the condensers are perfectly aligned the deflection of the meter—and therefore the output of the set—will be greatest.



Balancing therefore becomes a matter of tuning in some station, preferably one operating on a short wavelength, and then adjusting the various condensers, by whatever means are provided by the manufacturer, so that the greatest change is indicated on the meter in the plate circuit of the detector. When circuits have been adjusted so that the greatest current change is obtained, the set is balanced. It is best to make this adjustment with the set tuned to a short wavelength, for it is in this part of a receiver range that the greatest lack of balance is liable to occur.

No. 234 RADIO BROADCAST Laboratory Information Sheet November, 1928

The Audio Transformer

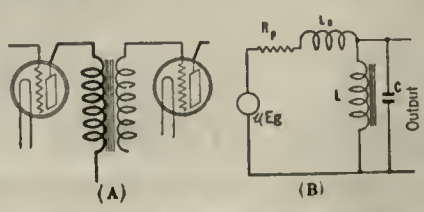
OPERATION AT HIGH AUDIO FREQUENCIES

IN LABORATORY Sheet No. 227, in the October number, we studied the characteristics of audio transformers and pointed out that the lowest frequency response depends upon the ratio of the reactance of the transformer to the plate resistance of the tube. Here we will consider the high frequencies. For convenience we have reprinted here the diagram from Sheet No. 227.

At high frequencies the reactance of L is very large in comparison with C, and it may therefore be neglected. Essentially, we then have a circuit consisting of R_p, L_a and C in series. As L_a and C come into resonance, the impedance of the circuit will decrease and more current will flow, thereby tending to increase the voltage across C, which is the voltage applied to the grid of the next tube. However, the voltage across C, for a given current, is inversely proportional to the frequency, and this will tend to lower the voltage across it at high frequencies. In some transformers, however, there is a marked peak at about 6000 cycles, corresponding to the resonant frequency of L_a and C in series, the output falling off rapidly beyond the point.

If this upper resonant peak is very pronounced the gain of the entire amplifier will increase greatly at this point, tending to make the amplifiers oscillate. Good design requires that the peak be kept as small as possible.

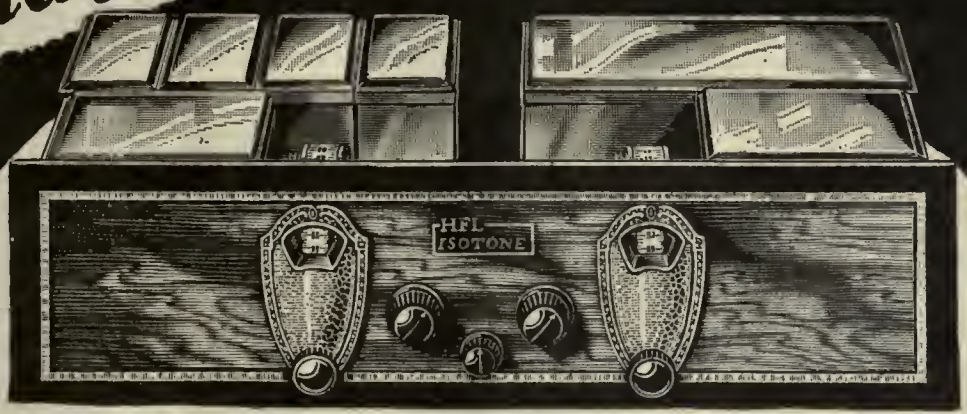
At frequencies higher than that at which L_a and C resonate, the reactance of L_a continues to increase, and the reactance of C to decrease; therefore, the voltage across C rapidly falls. If some transformer curves are examined, it will frequently be found that the curve drops rapidly beyond the upper resonant point.



The problem of design is to adjust the leakage inductance, L_a, and the effective capacity, C, so as to give satisfactory high-frequency response.

HFL

Distance Range That Staggers the Imagination! With the Wonder Receiver of the Century



The Model 10 HFL Isotone

SCREENED GRID . . . CUSTOM BUILT . . . RADIO PHONOGRAPH

THE HFL Isotone is unquestionably the most sensitive receiver that the world has ever seen. It will absolutely out-distance all other receivers regardless of price or type of construction. The amazing sensitivity of the HFL screened grid amplifier remains unequalled. No other commercial amplifier permits a gain of 65 per stage *under actual operating conditions.* The HFL Isotone is the supreme radio achievement. It's position has been definitely established in radio laboratories the country over.

2000—3000 Mile Range

So sensitive is the HFL Isotone that stations over 2000 miles away *have to be turned down.* Tremendous volume is obtained from stations all over the North American continent. The HFL Isotone will receive any station in the world that is putting enough signal voltage into the antenna to actuate the first tube in the receiver.

One Spot Tuning

The 450 kilo cyle screened grid amplifier allows absolute one spot tuning. Extreme selectivity is gained by hand tuning each transformer with a small variable condenser. An entirely new method of control permits the tubes to be operated in their most sensitive condition — just below the oscillating point. The HFL Isotone will actually select an *8 kilo cycle band* when the amplifier is worked at maximum. Dual detection (an exclusive H F L development) allows reception of the weakest signals and still permits the undistorted handling of powerful locals.

A.C. or D.C. Operation

Through the use of an ingenious system of filament control, the HFL Isotone operates perfectly with batteries or the special HFL—A.C. power supply. The same tremendous reserve power is available with batteries. The same crystal clear tones are developed with A. C. Only 30 mils. of plate current are required by the entire receiver *including the two power tubes.*

Phonograph or Radio

A special method of switching and ballasting allows an instant choice of phonograph or radio music by simply throwing the master control switch on the front panel. Both kinds of music are so amazingly realistic that no human ear can discern the difference between an original selection and an H F L reproduction. An automatic ballasting shunt—another exclusive H F L feature—prevents audio tube overloading when the six radio frequency tubes are *disconnected during phanagraph operation.* The three stage, push pull audio amplifier is a marvel of electrical design. Not only does it faithfully reproduce every musical frequency, but it actually corrects the flaws in broadcast transmissions and phonograph records.

45 Minute Construction

The HFL unit method of construction is the sensation of the 1929 radio season. Every item necessary to build a perfect Isotone comes in a factory sealed carton. Each of the three main units is wired and laboratory tested at the factory. *Only ten wires* are connected by the set builder. An exact, progressive method of assembly eliminates every chance of error. We stand ready to prove, at any time, that a standard HFL Isotone can be fully constructed in less than forty-five minutes.

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We guarantee, absolutely, that a standard HFL Isotone receiver operating under favorable conditions will receive over a distance of not less than 1500 miles. We guarantee every HFL unit to be mechanically and electrically perfect. Any unit believed defective will be immediately replaced at no extra charge. We reserve the right to select a location and *prove by demonstration* that it will receive over 1500 miles.

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The new A. C. Shield Grid Browning-Drake assembly is a combination of all the most modern and advanced ideas of receiver construction. The famous Kit has been designed this summer by Professor Browning for assembly with shield grid tubes, both A. C. and D. C. For the first time this well-known circuit has been reduced to single control, while the tickler feedback control is retained for the exceptional sensitivity for which it is noted.

Complete parts list at only $59.50, the lowest list price yet reached by a kit assembly of the highest quality. Full constructional details including full scale picture wiring diagram may be obtained free on request.

We have some territory open for exclusive distributors and authorized dealers handling factory-built Browning-Drake receivers. Write for our proposition on this line which brings both profit and prestige.

BROWNING - DRAKE CORP.
Cambridge, Mass.

BROWNING-DRAKE RADIO

No. 235 RADIO BROADCAST Laboratory Information Sheet November, 1928

Television

FREQUENCY BAND REQUIRED

IN TELEVISION transmission a problem which must be given careful consideration is the width of the band of frequencies which must be transmitted to reproduce at the receiver end, with good quality, the scene being scanned by the television transmitter.

Theoretically, a television signal contains components of all frequencies from zero to infinity. In practice the frequency band is much more restricted and depends upon various factors.

The width of the band of frequencies which must be transmitted is a function of the number of elements scanned per second at the transmitter. For example, if the number of lines into which the picture is broken—which is equal to the number of holes in the scanning disc—is 50, then the number of elements into which the picture will be broken will be 50 times 50, or 2500. If we transmit 20 pictures per second, the total number of elements transmitted per second will be 50,000. The highest frequency which must be transmitted, to get good quality, can be taken as equal to half this figure, or 25,000 cycles. The table given herewith shows how the value of the highest frequency which should be transmitted varies with the number of scanning lines and the number of pictures per second. For example, a 50-line picture sent 15 times per second requires up to 19,000 cycles.

No. of lines	*No. of pictures per second*		
	10	15	20
25	3,100	4,700	6,000
50	12,000	19,000	25,000
75	28,000	42,000	56,000
100	50,000	75,000	100,000

A station transmitting within a broadcast band is limited to 5000-cycle modulation. Therefore, any broadcast station transmitting television programs and using a number of lines and number of pictures per second such that requires a frequency band greater than 5000 cycles must either modulate above the legal limit or suppress in the amplifiers the frequencies above 5000 cycles.

No. 236 RADIO BROADCAST Laboratory Information Sheet November, 1928

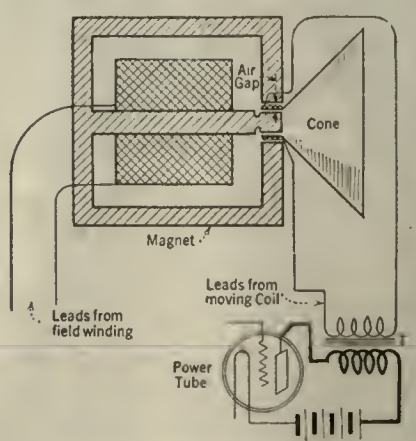
Moving-Coil Loud Speakers

THEIR OPERATION

THE important characteristic of the dynamic or, more properly named, moving-coil type loud speaker is the fact that it has a coil fastened directly to the cone, which is caused to move back and forth in an air gap in a magnetic circuit, the movements being in accordance with the frequencies flowing through the coil.

The moving coil is mounted at the apex of the cone, as indicated in the diagram, and connects to the secondary of the transformer, T, the primary of which connects to the plate of the power tube. The moving coil of a well-designed unit has a fairly constant impedance over the entire range of audio frequencies and the transformer, T, is designed to "match" the coil's impedance to the output impedance of the tube. So long as the power tube works into an impedance about equal to or somewhat greater than twice the tube's plate impedance, satisfactory power transfer from the tube to the moving coil will be obtained. The instructions covering the use of one of these loud speakers should indicate what tubes or combination of tubes are recommended for use with the unit.

The term "dynamic loud speaker" is not a very accurate description of a type of loud speaker whose distinguishing feature is that it has a moving coil. The word "dynamic" is defined as "mechanics treating of the motion of bodies and of the action of forces in producing or changing their motion." Since all loud speakers move they can all be called "dynamic." We have seen descriptions and advertisements of "dynamic" loud speakers which consisted mainly of an ordinary electromagnetic unit coupled to a cone. This term used to describe such loud speakers is probably misleading to some although technically it is not incorrect.



No. 237 RADIO BROADCAST Laboratory Information Sheet November, 1928

Power Output

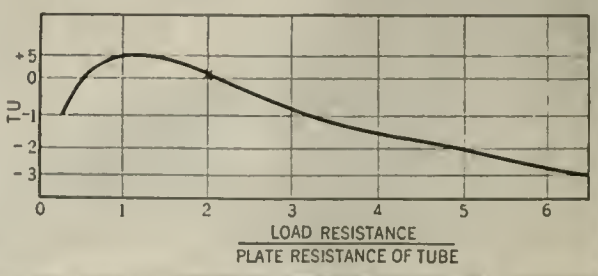
HOW IT DEPENDS UPON IMPEDANCE RATIOS

IT HAS been proved mathematically and experimentally that a tube delivers the maximum amount of *undistorted* power when it works into a load resistance equal to twice the plate resistance of the tube; maximum power output, however, is obtained when the load resistance equals the tube's plate resistance. The curve on this sheet indicates relatively in TU how the power in the load varies with the ratio of the load resistance to the tube's plate resistance (sometimes called plate impedance). The X on the curve indicates where a tube is normally operated, the load resistance at the point being twice the tube resistance.

We frequently see statements to the effect that the loud speaker we use must be matched to the tube to get the largest amount of undistorted power into the loud speaker. Such is the case, but the curve indicates that there can be considerable mismatching without serious loss of power. For example, even when the load resistance is about five times greater than the tube's resistance, there is only a 2 TU loss—a loss which would hardly be noticeable to the ear.

It is unwise, however, to work a tube into a load resistance less than its own resistance, because under such conditions the tube's characteristic is curved (see Laboratory Sheet No. 124) and this curved characteristic introduces distortion.

In cases where the element of the loud speaker has a low impedance, for example, it is necessary to use a transformer between the tube and the loud speaker to compensate the differences in impedance. A moving-coil type, i.e., dynamic loud speaker, might have an impedance of, say, 20 ohms at some frequencies, and if it is to be used with a 2000-ohm tube (171A) which requires a load impedance of 4000 ohms to get maximum undistorted power, then the coupling transformer would have an impedance ratio of 4000 divided by 20, or 200, corresponding to a turns ratio of the square root of 200, or 14.



ELKON REPLACEMENT RECTIFIERS Are Saving Radio Fans MILLIONS of DOLLARS



Type BNK for replacing the acid jars in Balkite Types N and K Trickle chargers



Type BJ for replacing the acid jars in Balkite Type J chargers





Type V-4 for replacing the rectifiers in 6 makes of Trickle chargers

Millions of dollars are invested in radio chargers, eliminators, etc. which would be lost if it were not possible to replace the rectifying units when their life has been exhausted. All Elkon Rectifiers are replaceable.

HOW TO TELL IF YOUR RECTIFIER NEEDS REPLACING?

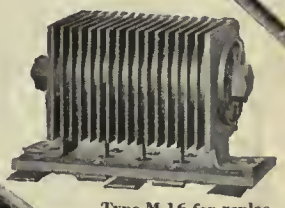
If your trickle charger no longer keeps your storage battery up the way it did when it was new, you need a new rectifier.

If your set has not the same pep as it did when you installed your "A" Eliminator, you need a new rectifier.

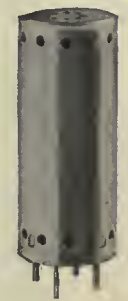
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No. 238 RADIO BROADCAST Laboratory Information Sheet November, 1928

A Hook-up for Short-Wave and Broadcast Receivers

A METHOD FOR SWITCHING OVER

IT IS general practice in constructing short-wave adapters to arrange them with extension leads so that they may be plugged into the broadcast set in the detector socket in place of the regular detector tube. This practice is all right when one is building an adapter that perhaps will not be used continually, but when both the broadcast and the short-wave tuners are going to be used frequently, it is better to arrange the circuit as indicated in the diagram on Sheet No. 239, which permits one to change from broadcast to short waves by a simpler means than taking out a tube and plugging in an adapter.

The diagram shows the detector of the broadcast receiver and the detector of the short-wave receiver. They are both wired to the same A and B voltages, and either set is thrown in or out of operation by simply turning the proper filament switch, S_1 or S_2; S_1 turns on and off the broadcast receiver and S_2 similarly controls the short-wave set.

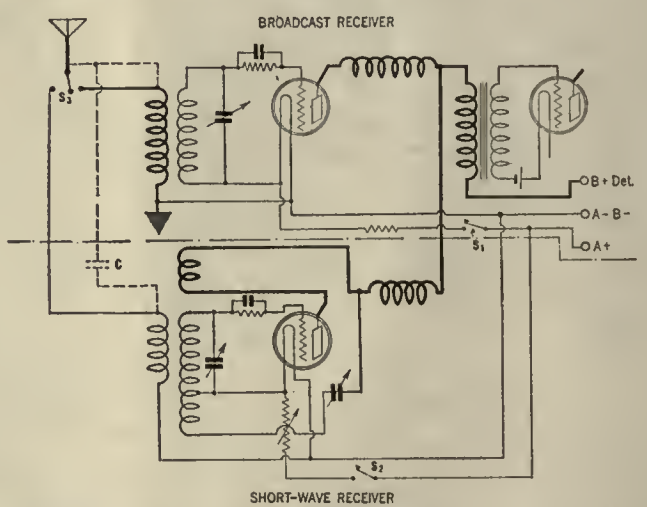
The two plates are permanently wired together, and for this reason the arrangement we have indicated should only be used when the two sets are located close to each other (which is usually the case) so that the plate lead running from one set to the other is not more than 1 or 2 feet long.

Most of us have available only one antenna to use with both sets. To use it with both receivers a single-pole double-throw switch, S_3, can be placed in the antenna circuit; thrown to one side it connects the antenna to the broadcast set, and thrown the other way it connects the short-wave receiver.

An easier arrangement, which works well in practically all cases (how well it works depends upon the characteristics of the two receivers) is indicated by dotted lines. The antenna is connected directly to the broadcast set and through a 50-mmfd. condenser, C, to the short-wave set. This small condenser will block the broadcast signals from the short-wave set but permit these latter currents to pass quite readily.

No. 239 RADIO BROADCAST Laboratory Information Sheet November, 1928

Circuit for Short-Wave and Broadcast Reception



No. 240 RADIO BROADCAST Laboratory Information Sheet November, 1928

Television

DATA ON THE BELL TELEPHONE LABORATORIES' METHOD

THE demonstrations of television given by the Bell Telephone Laboratories, associated with the American Telephone and Telegraph Company, rank higher, in our opinion, than any of the other demonstrations so far given, in quality of the results. In the following paragraphs are summarized some of the most important elements of the apparatus used by these Laboratories.

(a) The scanning discs contained 50 holes and revolved at a speed of 1062.5 revolutions per minute, giving 17.7 pictures per second.

(b) The output voltage of the photo-electric cells at the transmitter was about 10 microvolts.

(c) The range of frequencies decided upon as being essential for good quality extended from 10 to 20,000 cycles. Overall measurements on the final amplifier indicated a frequency characteristic constant within plus or minus 2 TU over this range.

(d) The signals from the transmitter were amplified and delivered to the transmission line at a level of 10 milliwatts. The amplification from the photo-electric cell to the line was 130 TU.

(e) Synchronization was accomplished by the use of synchronous motors containing 120 poles and having a synchronous speed of 1062.5 r.p.m. The angular phase displacement was above 0.07 degrees. This magnitude of phase displacement corresponds roughly to the angular twist in a steel shaft 6 feet long of 1 inch in diameter, operated at full load.

(f) With regard to the effect of extraneous currents due to noise, it was found that satisfactory results were obtained if the average picture currents were 10 times greater than the average noise currents.

This corresponds to 20 TU, or a power ratio of 100. In ordinary sound broadcasting the noise in the telephone lines is kept at a level 60 TU below 10 milliwatts, giving a power ratio of 1,000,000. It is evident that it is permissible to have the noise level much higher in television reception than in sound reception.

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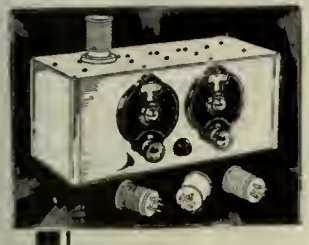
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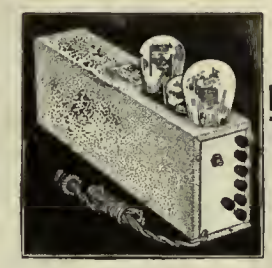
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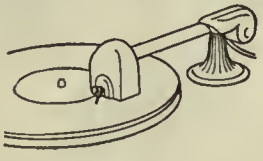
Listen-In on London with the Round-the-World Four

NOT with any ordinary radio receiver, of course—the Atlantic is too wide for regular broadcast receivers to bring you London programs. But turn on your S-M "Round-the-World" set some night. Don't be surprised if the language you hear is a foreign one, or if the announcer mentions "Paris" or "Amsterdam," or "London" instead of the cities you are accustomed to hear from. Call your neighbors to listen if you want to—but be cautious about calling anyone who has already explored the mysterious short-wave channels with an S-M set—your wonders might sound very tame to him. Perhaps by this time he is only interested in New Zealand and Japan! For in short-waves *almost anything is possible*; amazing feats of distant reception are becoming a matter of common knowledge. (See prices on opposite page).

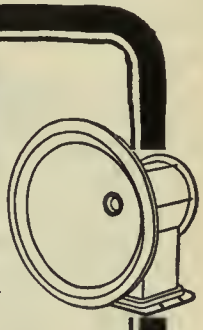
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The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. . .

WITH this issue, we start the promised department for radio service men. The service man is a most important element in the present radio structure but for some reason or other he has been inarticulate. We know that a great many readers of RADIO BROADCAST are doing service work, either on whole- or part-time and we hope that those who are doing this work will write us, telling of their problems, how they are being solved, and of topics they would like to see discussed. Incidentally, the head of one of the largest New York organizations specializing in this work, Mr. John S. Dunham, writes: that although he believes service articles are of real value that "the average service man could derive far greater benefit by painstaking, thorough study of RADIO BROADCAST's Data Sheets from the beginning and the very excellent series of Home Study Sheets, recently inaugurated. From our own experience, we believe that service men generally need to increase their basic knowledge." With this, we agree, but we are certain that the experiences of service men are of deep interest to others working in the field. It certainly goes without saying that no service man can really do his work intelligently unless he has a thorough background in fundamentals.

THE application of power amplifiers, microphones, moving-coil loud speakers and similar apparatus for so-called public- or group-address work seems to be increasing rapidly. This development is a natural and fortunate one and in our opinion due largely to the increasing appreciation of what good radio apparatus can do. The question which most frequently comes up is not the simple one of how to connect or to operate the gear but what power output is essential for a given service. RADIO BROADCAST Laboratory Data Sheets Nos. 245 and 246 in this issue discuss this interesting question.

EARLY in 1926, Mr. Howard E. Rhodes joined the staff of RADIO BROADCAST and since that time, his excellent articles have added much to the interest and technical value of our pages. The popular Laboratory Data Sheets are Mr. Rhodes' work. We are pleased to announce that effective November 1st, Mr. Rhodes was appointed Technical Editor of this magazine.

THE current issue contains many articles on subjects of great interest to many radio folk. Notable among these are the following: the article on cutting and grinding quartz crystals, the data on underground antennas in "Strays from the Laboratory," the references to sources of information on sound movies, the article on experimental band-pass filters, the discussion of moving-coil and "magnetic" type loud speakers, Mr. Kruse's article on amateur experimenting and finally Boyd Phelps' description of his ingenious work in television synchronizing which is found on page 123.

THE January issue will contain the long-promised article on moving-coil speakers and is worth waiting for. Constructional stories on interesting receivers, and power amplifier units are promised as well as more useful data for the experimenter and service man.

—WILLIS KINGSLEY WING.

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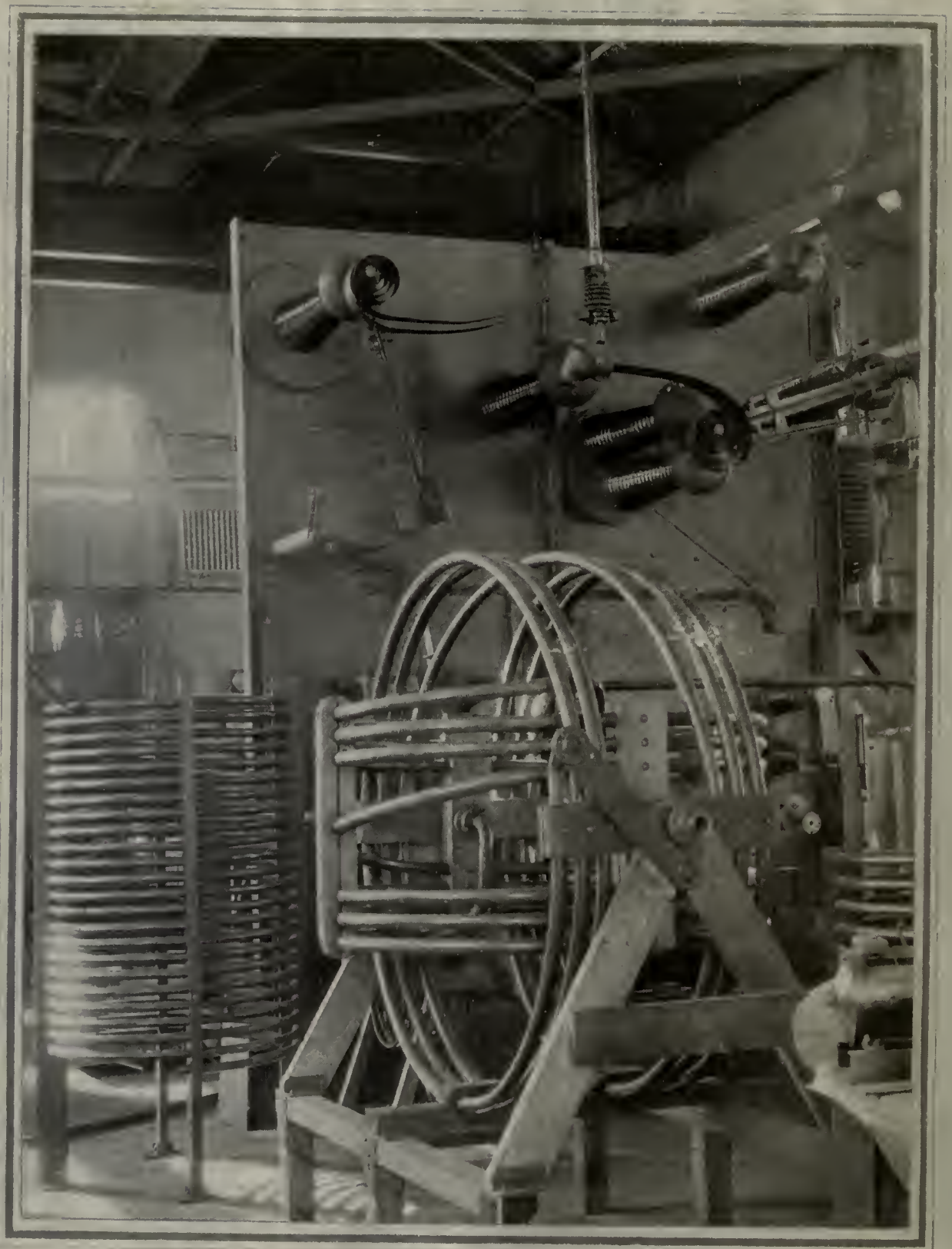
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Old Sayville Station Returns to Limelight

Herman P. Miller, chief transmission engineer of the Federal Telegraph Company, is stationed at Sayville, Long Island, for the purpose of reconditioning the once-famous radio transmitter which was built there by the Germans in 1912. This station was taken over by the U. S. Navy during the World War and abandoned in 1925; however, it may soon be one of the most powerful marine stations in the world. This interior view shows a portion of the transmitting equipment. The remotely controlled switching apparatus is mounted on the large panel in the rear, on the left is the adjustable inductor for tuning the counterpoise, and the variometer in the foreground is connected in the antenna circuit.

QUARTZ CRYSTALS

How to Cut and Grind Them

By R. C. HITCHCOCK

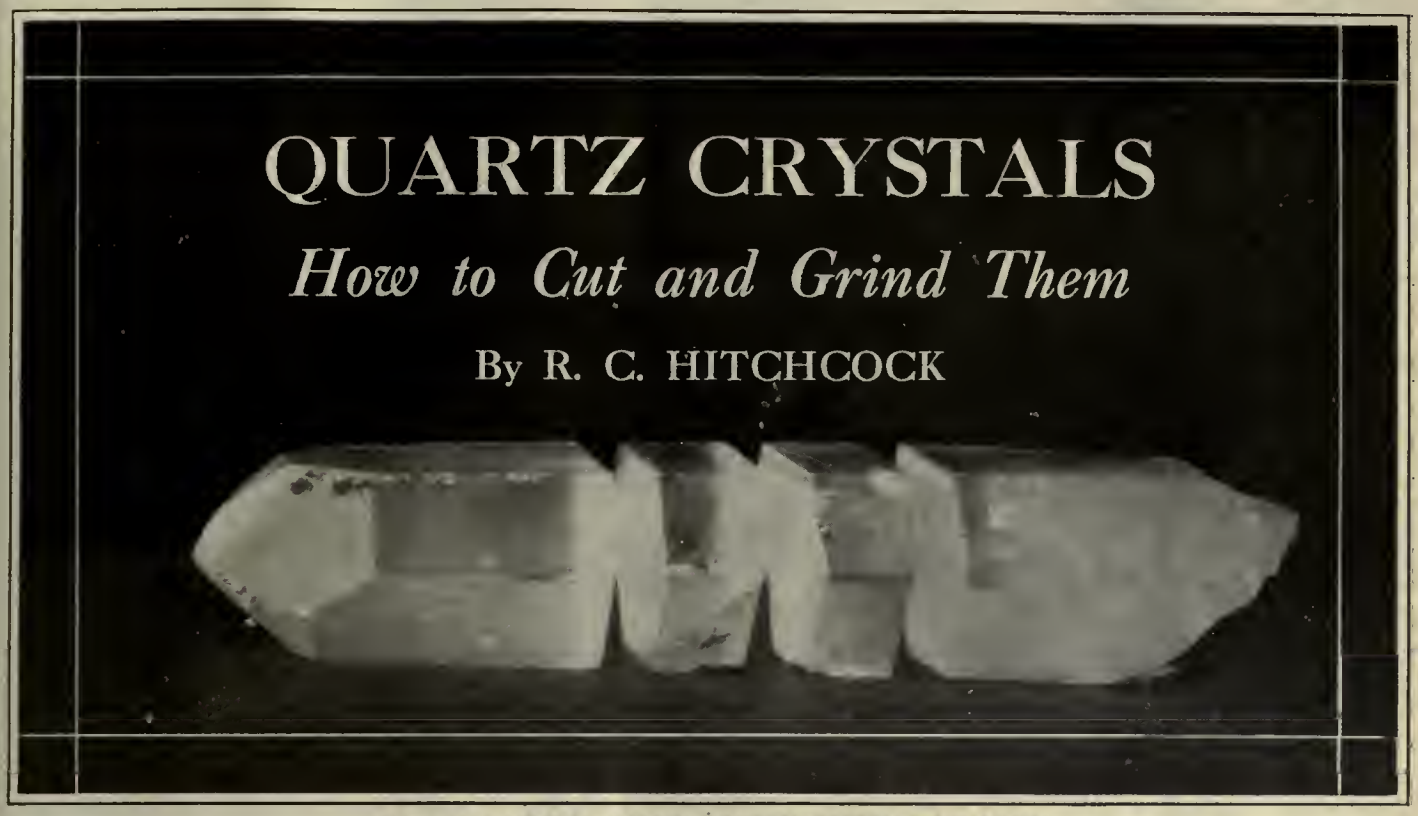


FIG. 1. A NATURAL QUARTZ CRYSTAL CUT IN FOUR PARTS

MOST radio experimenters are now familiar with the advantages of using a quartz crystal to control a radio-frequency transmitter. Although many articles have been written on the use of a crystal oscillator, the actual procedure of cutting a proper plate from a crystal of quartz has received relatively little attention.

This article is concerned mainly with the actual operations and calculations used in cutting and grinding a quartz oscillator plate from a quartz crystal. It should be noted that a quartz-crystal oscillator does its most reliable work when certain factors are kept constant. These are plate and filament voltages, plate and "tank" circuit tuning, and most important of all, the temperature of the crystal.

Assuming the tuning to remain fixed, when a crystal temperature is maintained constant, the ordinary plate and filament voltage variations cause only small frequency changes in a crystal-controlled circuit. The frequency of such a crystal-controlled circuit varies about one five-hundredth as much as that of a similar tuned grid-oscillator circuit with the same plate and filament voltage variations.

SELECTING THE RAW MATERIAL

A PERFECT quartz crystal is rare, but fortunately a perfect crystal is not required for an oscillator. There are a few simple tests for determining the suitability of a quartz crystal, which require only the unaided human eye. A good quartz crystal may be rough and dirty on the outside, but generally is clear inside when viewed by the naked eye, showing no colors or dark regions. It also must be free from bubbles and cracks. Quartz is often cracked mechanically during mining. This of course would make it unsuitable for oscillator use, as a crack would lengthen into a complete break.

The optic axis of the quartz crystal, so called because of the unique optical effects obtained in this direction, is located parallel to the edges formed by adjacent hexagonal crystal faces. It is in the direction of the dimension W in Fig. 3.

For reference in cutting as well as convenience in clamping, a crystal should have at least one of its natural hexagonal faces present. An ordinary crystal has all six hexagonal faces, and a pyramidal point on one end. The end opposite the point is generally full of flaws and is broken off in mining. Fig. 1 on this page shows a natural quartz crystal, with the first three cuts made for crystal oscillators. The left section contains the point, and is of a quality suitable for oscillator use. The right-hand section is full of bubbles and other flaws which make it unsuitable for an oscillator.

CRYSTAL-CONTROLLED transmitting stations are rapidly becoming the rule rather than the exception. The new amateur bands which become effective in 1929, and the insistent demand for greater frequency stabilization among broadcasting stations, make it imperative that transmitters use quartz plates which will hold the frequency of the station within very close limits. These plates must be sawed from quartz crystals, and then ground to the desired thickness. This article, by R. C. Hitchcock, of the Westinghouse Electric & Mfg. Co., gives the details of the modern technique of crystal grinding, and should appeal to amateurs and broadcast station engineers alike.

—THE EDITOR.

Although the pyramid at the point of a quartz crystal is bounded by true planes, the hexagonal sides are seldom planes, their faces more often showing striations. These striations resemble steps, the crystal cross-section being gradually made smaller by these definite steps in the direction of the point. Striations are sometimes closer than $\frac{1}{16}$ inch and quite deep, and others may be over an inch apart and so shallow that the crystal must be examined closely to distinguish them.

The striations, if they are present, are useful as reference marks, as the first cuts are to be made in exactly the direction of the striations, that is, perpendicular to the hexagonal faces of the crystal.

The usual specifications for a good quartz crystal, or rock crystal, for oscillator cutting are that it should be free from twinning, have no flaws, and be of optical quality. It is true that sometimes a crystal plate is a satisfactory oscillator while all the other properties mentioned above are lacking. But in general, until one has had experience and is willing to risk cutting plates with the certainty that some will not oscillate, the best recommendation is that the proper quartz crystal be secured from a reputable dealer in minerals.

The cost of a quartz crystal depends on its size and quality. For the quality specified above the usual price is about five dollars a pound. A crystal $2\frac{1}{4}$" across the hexagonal flats, and 3" over all in length, weighs about a pound. For larger crystals the price per pound increases. Clear quartz crystals having dimensions all less than one inch are quite cheap, but are not large enough for quartz oscillators. These tiny crystals can be used in fused quartz work and for ceramic glazes, and are sold for a few cents a pound.

CUTTING QUARTZ

QUARTZ is very hard and some form of machine for cutting is advised, although for grinding quite satisfactory work may be done by hand. Fig. 2 shows how an inexpensive polishing head may be arranged for cutting a quartz crystal. A lathe could also be used for this work, but special precautions would have to be taken to prevent the grinding compound from ruining the bearings and the ways.

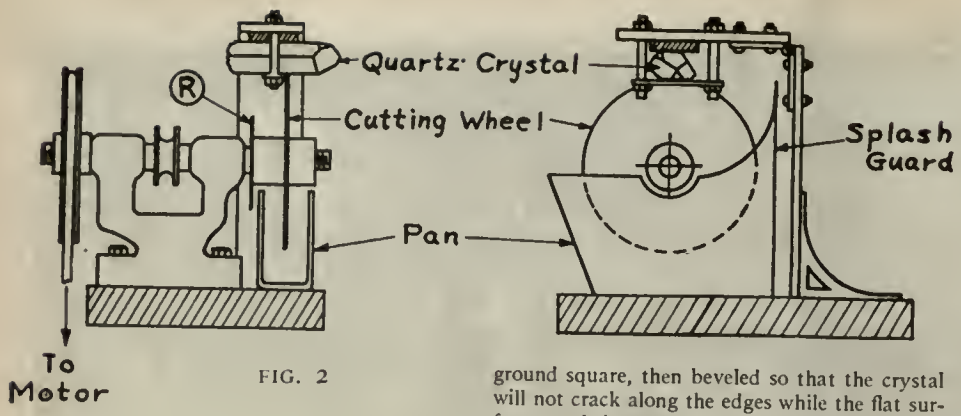


FIG. 2

A copper or brass disc $\frac{1}{16}$" thick and 6" to 8" in diameter revolves in a pan nearly filled with No. 150 carborundum and water. More of this cutting compound has to be added as the cutting progresses, as a good deal of the material splashes out. Shields should be placed to prevent the spattering of walls and floors if the cutting apparatus is set up at home. A splash guard should also be provided as shown in Fig. 2, and a ring, R, put on the shaft to prevent the compound from working into the bearings. During cutting, the compound in the pan should be stirred so that the carborundum is kept in suspension.

The crystal is bolted to a hinged piece as shown in the figure. A thin wooden block is placed on top of the crystal so that the crystal will be cut clear through before the cutting wheel reaches the hinged piece. The cutting speed should be 250 r. p. m. or slower. If an 1800 r. p. m. motor is used, the pulley on the polishing head should be 1800/250 = 7.2 times as large as that on the motor. A motor of $\frac{1}{4}$ h. p. is about the right size when the crystal rests on the cutting wheel of its own weight, as shown in Fig. 2. About twenty minutes will be taken to cut through a two-inch crystal. If a weight is added to the crystal to make it feed faster, a more powerful motor will be required.

As shown in the picture in Fig. 1, the first cuts are to be made perpendicular to the crystal's hexagonal faces, and the section cut will be a right prism. These cuts should be 1.25" apart so that the finished size can be made 1.10" or 28 mm. This width dimension is called W in Fig. 3.

METHODS OF SLICING QUARTZ CRYSTALS

TWO methods of slicing an oscillator crystal from the right prism are shown in Fig. 3. The original method, given in 1880 by the Curies, is still used for all low-frequency crystals, and sometimes for high radio-frequency crystals. This is shown as Method 2. For frequencies higher than 600 kc. (less than 500 meters wavelength) a Method 1 crystal controls more power, is easier to make oscillate, and uses less quartz. For a given frequency a Method 1 crystal is about two-thirds as thick as a Method 2 crystal.

Fig. 3 shows clearly how the slices are made; a Method 1 plate has its faces parallel with the crystal hexagonal faces; a Method 2 plate has its faces at right angles to these faces. The dimensions L and W are not critical but good results will be obtained if L is about 1" or 25 mm, W being about 1.10 inch, or 28 mm.

The quartz prism is bolted to the hinged piece and slices made according to Method 1 or 2 are cut. The cutting disc wastes material and does not cut squarely, so a larger slab should be cut than is needed for the actual crystal size. For frequencies above 600 kc. a slice $\frac{3}{8}$" to $\frac{1}{2}$" thick should be made.

The edges of the L and W dimension are ground square, then beveled so that the crystal will not crack along the edges while the flat surfaces are being ground.

The distance T is the oscillating dimension and Fig. 5 gives the value of T for frequencies between 600 and 4000 kc. The frequency and wavelength are given in the left column, and the oscillating dimension in both millimeters and inches is given in the right column. The short center column is a constant K, called the "meters per millimeter," meaning that for each millimeter of a quartz oscillator there is a definite electromagnetic wavelength. The larger T is, the longer is the wavelength, λ, the relation being

$$\lambda = K\,T \qquad (1)$$

The "meters per millimeter," or K, is found by

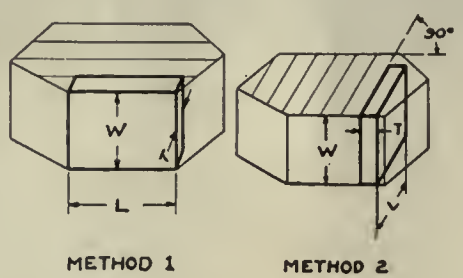


FIG. 3

dividing both sides of equation (1) by T, so that

$$\frac{\lambda}{T} = \frac{\text{meters}}{\text{millimeter}} = K \qquad (2)$$

For Method 1, K varies from 140 to 150 meters per millimeter, while for Method 2, K is 100 to 110 meters per millimeter.

To use Fig. 4, line up the frequency at the left column, with K in the center column, finding T in the right hand column.

To be on the safe side, it is best to use the smaller value of K for preliminary work so that the crystal will be thick enough to allow for a final adjustment. For precision better than 10 per cent. a wavemeter or some source of standard frequency should be used. Fig. 5 gives only approximate values of T. A more exact method of figuring T and how to find the proper K for a given piece of quartz will now be given.

CALCULATING K FOR A CRYSTAL

QUARTZ crystals have different values of K, as noted above, and the only sure way to know the frequency is to measure it. However, a fair determination of K can be made for a given crystal, if the frequency is measured. Suppose a Method 1 crystal for 1800 kc. is wanted, and the value of 140 meters per millimeter for K is used. This shows T to be 1.19 mm. When T is ground to 1.19 mm. the frequency is measured to be 1760 kc. sec. Using equation (4), to be derived later, it will be found that the correct K for this piece of quartz is.

$$K = \frac{300{,}000}{T\,F} = \frac{300{,}000}{1.19 \times 1760} = \frac{143 \text{ meters}}{\text{millimeters}}$$

Putting this value of K in equation (4), the correct T is

$$T = \frac{300{,}000}{K\,F} = \frac{300{,}000}{143 \times 1800} = 1.166 \text{ millimeters}$$

The thickness measurement is used for convenience in grinding, and is not as reliable as a measurement of the frequency. The final adjustment of a crystal for frequency should be made with a wavemeter or some known standard of frequency.

For testing, the oscillator circuit of Fig. 4 is suggested. A 10,000-ohm wire-wound resistor and C battery provide grid bias. The use of a grid choke coil should be discouraged; a good crystal does not need it, and a crystal which will not oscillate without a choke should not be depended on for control. At 1000 kc. over 50 watts can be obtained from a single crystal-controlled tube using only a grid resistor, and no grid choke. For power work, from 20 to 50 watts, the crystal must be kept at a fairly low working temperature to prevent overheating.

For frequencies below the broadcast band, and as low as 25 kc. / sec., crystals are cut by Method 2, oscillating along the L dimension, T being from 2 to 4 mm. K has the same meaning for these low frequencies as for the regular Method 2 crystals oscillating in the T dimension.

NECESSARY PLANENESS OF CRYSTAL PLATES

THE faces of an oscillator plate should be as nearly flat and parallel as possible. That is, T should be the same throughout the crystal in order to have the whole crystal oscillating usefully as a unit. Tests have shown that the best crystals have variations in T such that the corresponding natural frequencies are not more than .5 kc. different. For instance, a 1000-kc. crystal may have thicknesses corresponding to frequencies ranging from 999.75 to 1000.25 kc. This makes it necessary to grind a high-frequency crystal very accurately plane and faces parallel, the accuracy required increasing as the square of the frequency.

If λ is the wavelength in meters, and F the frequency in kc. sec., the well-known relation is

$$\lambda = \frac{300{,}000}{F} \qquad (3)$$

Eliminating λ between equations (1) and (3),

$$KT = \frac{300{,}000}{F} \text{ or, } T = \frac{300{,}000}{K\,F} \qquad (4)$$

To find the relation between small changes in T and F, equation (4) is differentiated, giving

$$dT = \frac{-300{,}000}{KF^2}\,dF$$

For frequencies from 600 to 4000 kc. the curves of Fig. 6 give the thickness variation, dT, for a frequency variation dF = .5 kc. To take a particular case, a Method 1 crystal of 3000 kc. should have a thickness variation of only 8.5 ten ten thousandths of a millimeter, or 3.3 hundred thousandths of an inch, if the .5-kc. variation is allowed. From Fig. 6 it will be seen that Method 1 crystals must have only two thirds as much thickness variation as Method 2 crystals of the same frequency. This offsets to some extent the

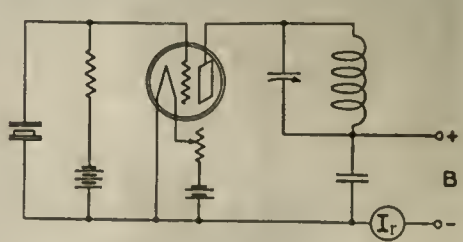


FIG. 4

advantage of using less quartz for the Method 1 crystal. However, the advantage of greater power still favors the Method 1 plate.

Accuracy as great as given above is impossible by ordinary grinding but indicates the desired goal. Crystals with thickness variations twenty times as great as given by Fig. 6 are often good enough, even though their frequencies are 10 kc. different at various points. If a crystal is ground with two frequencies nearly the same —for instance, one half the crystal at 1000.0 kc. and the other half at 1000.5 kc.—an audible beat note of .5 kc. will probably be produced and the crystal will not be satisfactory for control. This will not occur if the two thicknesses are irregularly spaced over the whole crystal.

For very high frequencies, due to the difficulty in making crystals plane enough, it is recommended that a low-frequency crystal be used in a circuit whose harmonics are amplified to obtain the desired high frequency.

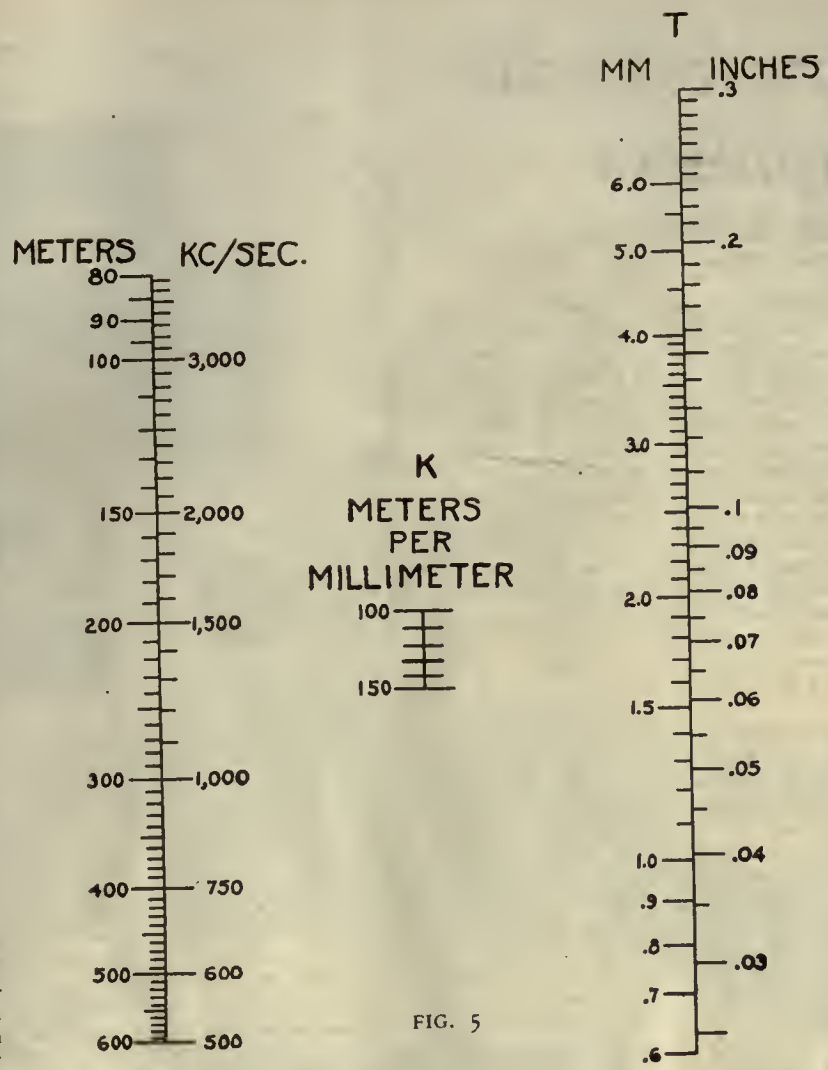


FIG. 5

GRINDING QUARTZ

THE thickness grinding may be done by hand, using a micrometer to measure the thickness. Crystal plates should be ground with their faces oriented as nearly as possible like the plate shown in Fig. 3. However, if a crystal has its faces quite accurately parallel, a change of a few degrees in having the crystal plate line up with the one shown in Fig. 3 is not serious except as it changes the value of K. As this factor varies for different crystals, and has to be determined for each one by a frequency measurement, the important thing is to have the faces parallel.

Gasoline or benzol should be kept handy to clean the grinding compound from the crystal before measuring or testing in a circuit. After cleaning, a crystal should be handled as little as possible to prevent getting grease on it from the fingers.

For the first stages of grinding an ordinary piece of glass is flat enough. First use No. 150 carborundum, then 302½ and 303½ emery. Pour the powder upon the glass, adding a few drops of water, and mix it with the powder to make a grinding paste. Move the crystal plate around in circles, holding it with the finger tips. If desired, the crystal may be fastened to a block of metal with low melting wax, and the metal block held by hand.

During grinding the thickness should be measured from time to time; be careful not to grind down the edges too far. If a certain spot is too high, a small brass piece charged with the grinding compound should be rubbed over it.

When approximately the right thickness by micrometer, a crystal should be tried in its circuit and the frequency measured. If the frequency is much too low, a new calculation of T should be made, as already mentioned.

Sometimes a crystal jumps abruptly to a higher frequency during grinding, just before the calculated thickness is reached. This does not necessarily mean that this crystal is useless, as often the frequency will jump lower by grinding either L or W a little, of the order of 0.020 inch. If a crystal refuses to oscillate when thin, although it oscillated well when thicker, this is due to irregularities in the T dimension, and a grinding off of the high spots will cause the crystal to oscillate.

When using a micrometer as the sole means of testing a crystal plate thickness the plate often deviates from a plane, the reason being that a hollow on one side and a high spot on the side corresponding can not be detected by an ordinary micrometer. When grinding very thin crystals this is especially likely to happen, and often prevents the oscillation of an otherwise satisfactory crystal plate. One remedy is to use a metal straight edge as a reference in keeping the crystal plate flat and free from high or low spots. The crystal is held up to the light, and the straight edge moved slowly over the surface. The high spots will be seen to touch the straight edge, and cracks of light will indicate low portions.

Polishing with rouge may be done with a leather surface, but if the thickness is nearly as good as the 0.5 kc. variation of Fig. 6 gives, no great increase in power or other advantage will be gained by polishing the faces of the quartz crystal.

It has been shown that high-frequency crystals must be very accurately flat and parallel. The grinding of the thickness is by far the most important item of the whole operation of grinding a crystal. A few hours spent in careful and painstaking work in grinding the thickness will be repaid by the successful operation of the quartz oscillator crystal plate.

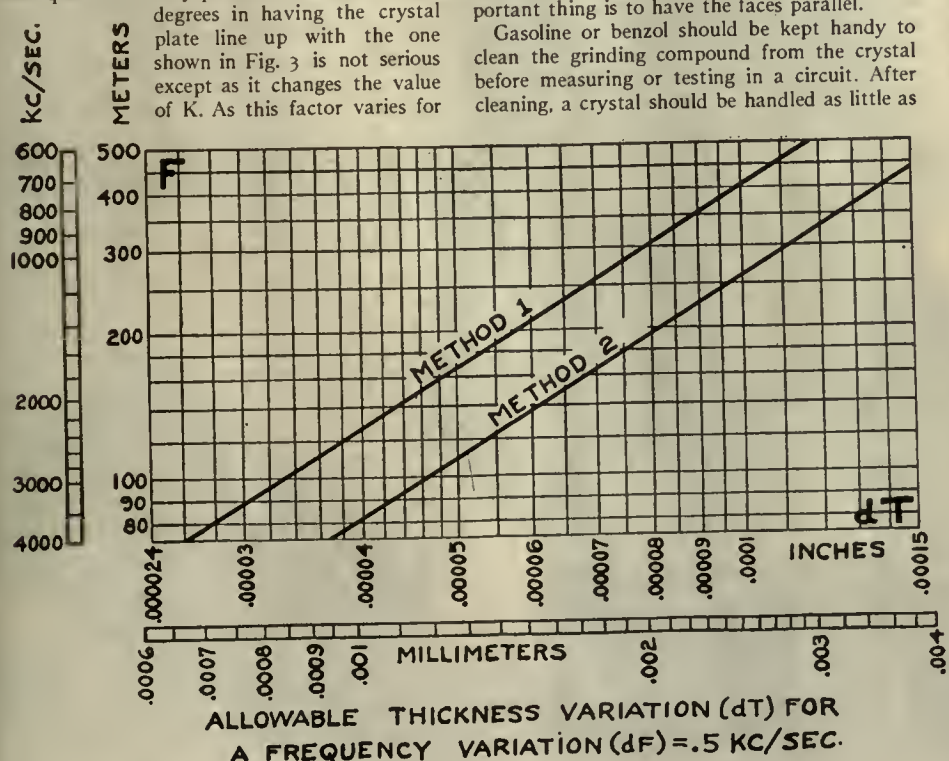


FIG. 6

Phonograph-Radio Amplifiers

HOWARD E. RHODES
Technical Editor



FIG. 1. THE PLATTER PHONOGRAPH-RADIO CABINET WITH AN AMPLIFIER AND REPRODUCER IN THE LOWER COMPARTMENT

THERE is a natural link between the phonograph and the radio, for they both constitute means of bringing entertainment into the home. In a sense neither is quite complete without the other and both may be combined advantageously into a single instrument. There are many commercial examples of this—Victor, Columbia, etc.—with which the reader is probably familiar. From a small but carefully selected group of records one can obtain a great deal of pleasure, and, when the radio program becomes tiresome (as it frequently does), it is convenient to be able to turn on the phonograph and listen to one's favorite selection. The pictures in this article illustrate some apparatus, both home-constructed and manufactured, that can be utilized readily in assembling a phonograph-radio combination.

What apparatus do we need? For the radio set we require a tuner with which we may select and detect the radio signal, an audio amplifier, and finally a loud speaker. For the phonograph we require an electrical pick-up unit an audio amplifier and a loud speaker. The audio amplifier and loud speaker may be arranged so that they may be used interchangeably with either the radio or the phonograph; these two sections will differ, therefore, only in the first part, a tuner being used for radio and an electrical pick-up for the phonograph. This article is devoted to a description of an amplifier and loud speaker combination designed to fit into the lower compartment of a cabinet which also contains space for a radio receiver; located in the top of the cabinet is a phonograph turntable. All of the apparatus may, of course, be light-socket operated. The choice of apparatus should be limited only to the extent that good parts must be used. The apparatus can be arranged in any fashion suiting the desires of the individual constructing the set.

The picture, Fig. 1, is typical and shows the installation of an audio amplifier in the bottom compartment of a cabinet designed to house a phonograph and radio. The loud speaker is placed on the baseboard on which the audio amplifier was constructed. The inside of the cabinet has been lined with a layer of porous material so as to prevent to some extent cabinet resonance which tends to make some loud speakers boom at the low frequencies. The blank space at the upper part of the cabinet is for the radio tuner; we have not shown a receiver in this position because we wish to make it quite evident that any good tuner may be used, be it tuned r.f., superheterodyne or any other type. The lid on the cabinet, shown in a slightly opened position, closes down on the compartment holding the phonograph turntable. There is ample room in this compartment to permit placing the electrical pick-up in the correct position relative to the turntable.

In front of the loud speaker is placed a baffleboard shown in the picture lying against the left door. This baffle should preferably be constructed of a piece of board about 1 or 1½ inches thick of such dimensions as to fit into the opening in the cabinet. To hold the baffleboard in place it may be screwed to the front of the baseboard on which the amplifier is constructed. There is supplied with this cabinet a decorative screen which fits in front of the baffle and helps to improve the final appearance of the instrument.

The amplifier, shown in Fig. 2, constructed in the laboratory to give the reader an idea of the kind of apparatus which may be utilized (any good amplifier may, of course, be used), employs an a.c.-operated two-stage transformer-coupled circuit. A 227-type tube is used in the first stage and a 250-type power tube in the output stage. The output of this tube—about 4.5 watts—is more than enough for all purposes.

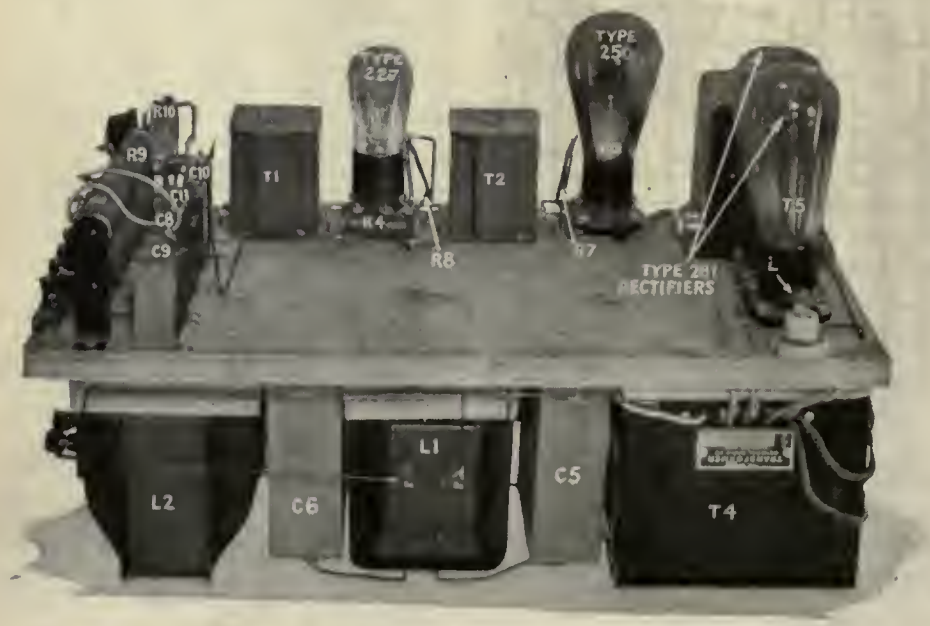


FIG. 2. THE PHONOGRAPH-RADIO AMPLIFIER CONSTRUCTED BY THE WRITER

LIST OF PARTS

THE circuit diagram of this amplifier is given in Fig. 3, and those who have had experience in the home construction of such units will obtain the information they require from the circuit diagram and the pictures. Those who haven't had such experience will do better, we feel, to buy a complete amplifier or a complete kit of parts, which can be assembled very easily. The parts used in the amplifier are listed below. Other makes of parts electrically equivalent may, of course, be used.

The following is a list of the apparatus used in the power amplifier constructed in RADIO BROADCAST's Laboratory:

C_1, C_2, C_3, C_4 Four Acme Parvolt by-pass condensers, 1-mfd., 400-volts;
C_5, C_6 Two Acme Parvolt filter condensers, 2-mfd. 1000-volt;
C_7 One Acme Parvolt filter condenser, 4-mfd., 600-volts;
C_8, C_9, C_{10}, C_{11} Four Acme Parvolt by-pass condensers, 1-mfd. 400-volt;
L One dial light, 5-volt;
L_1, L_2 Two Samson filter choke coils, type-312, 30-henry;
R_1, One Ward Leonard fixed resistors, 5000-ohm;
R_3 One Ward Leonard fixed resistor, 2000-ohm;
R_2 One Polymet metallized grid leak, 25,000-ohm, type G-1303;
R_4 One Ward Leonard resistor, 5000-ohm;
R_5 One Polymet metallized grid leak, 25,000-ohm, type G-1303;
R_6 One Polymet wire-wound resistor, 1500-ohm, type, W-1702;

R_7 One Electrad Truvolt resistor, 50-ohm, type V-50;
R_8 One Electrad Truvolt resistor, 10-ohm, type V-10;
R_9 One Ward Leonard resistance bank, type 507-6;
R_{10} One Centralab power potentiometer, 175-ohm, type PF-175;
T_1, T_2, Two Sangamo audio transformers, type A;
T_3 One National filament-lighting transformer;
T_4 One General Radio power transformer, type 565-B;
T_5 One General Radio loud-speaker filter, type 587-B;
Three Benjamin sockets, UX-type;
One Benjamin socket, UY-type;
Belden Hook-up wire;
Eight Eby binding posts;
One Platter orthophonic cabinet, type PR-918.
The following tubes are required:
One power tube, 250-type;
Two rectifier tubes, 281-type;
One tube, 227-type.

The input to the amplifier is through leads Nos. 1 and 2 which form a complete circuit for the audio-frequency currents, these currents being kept out of the B-supply unit by the resistor R_1. Filter systems, consisting of resistors and by-pass condensers, are used in the grid and plate circuits of the 227-type tube, and also in the grid circuit of the 250-type tube, for the purpose of keeping all of the audio-frequency currents out of the B supply. The filter in the grid circuit of the 227-type tube consists of R_2, C_2, the plate-circuit filter is R_4, C_3 and the grid-circuit filter of the 250-type tube is R_6, C_4. The output of the amplifier feeds into the choke-condenser unit T_5.

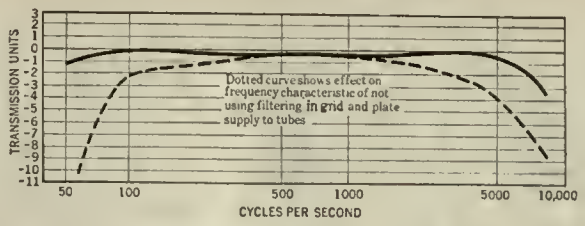


FIG. 4. RESPONSE CURVE OF THE AMPLIFIER DESCRIBED IN THIS ARTICLE

The B-supply unit for the amplifier is conventional, consisting of two 281-type tubes in a full-wave rectifier system. In series with the output of the rectifier is placed a small 5-volt flash-light bulb, L. If a short circuit occurs in the filter system, or at any other point in the circuit, the current through this lamp will increase sufficiently to burn it out, thereby protecting all the apparatus from damage.

The excellent frequency characteristics of this amplifier are indicated by the solid curve in Fig. 4. To give an idea of the importance of the various filter circuits, mentioned in a previous paragraph, we have also shown in dotted lines the frequency-characteristic curve of this amplifier without the filters. The importance of such filtering is obvious.

The home experimenter who likes to construct his own gear may desire to build such an amplifier as we have described, but the professional set builder who has or hopes to get some orders for the construction of a phonograph-radio combination can do the job more quickly by buying a kit of parts or a completely wired amplifier.

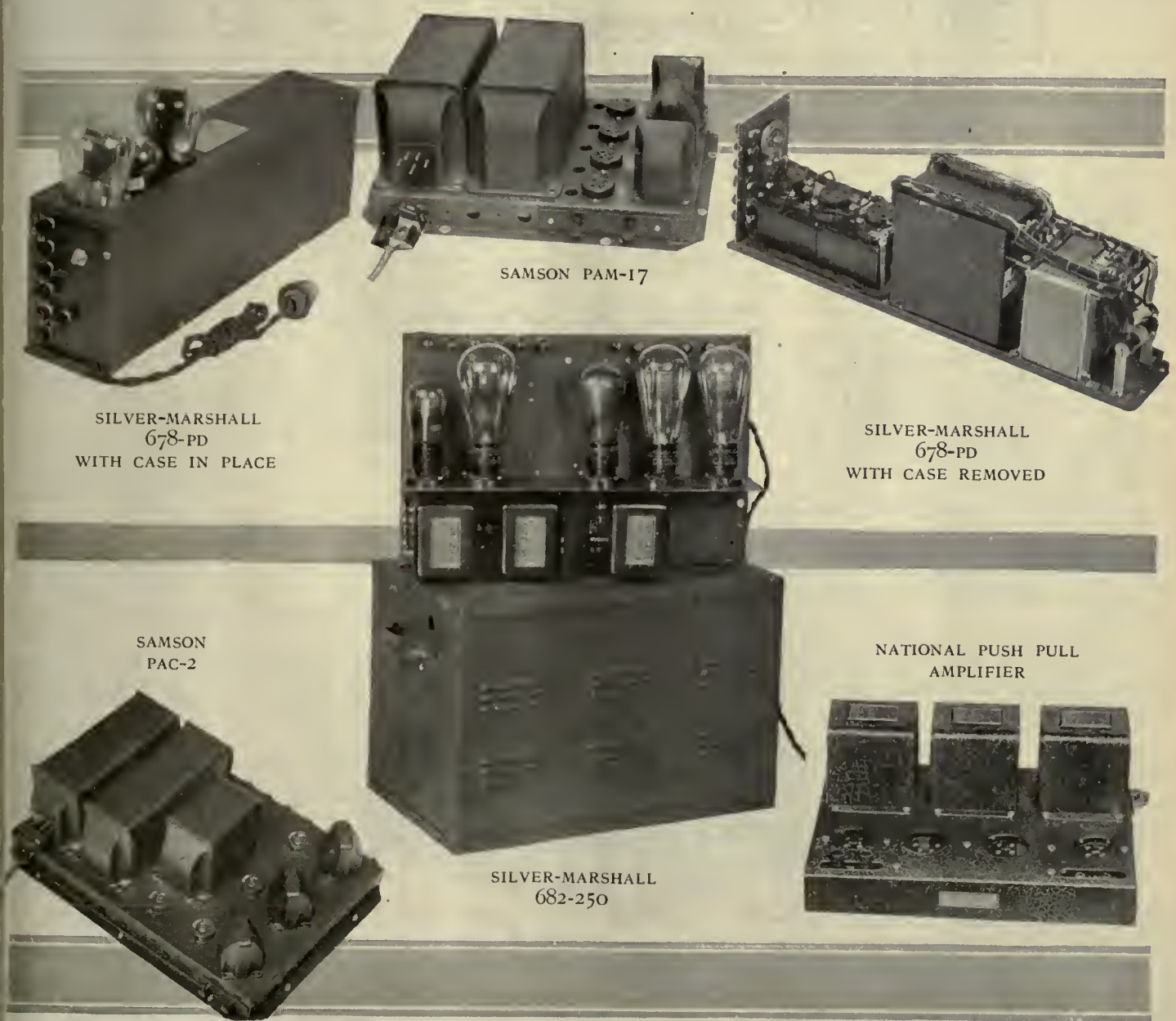


FIG. 5. A GROUP OF AMPLIFIERS SUITABLE FOR USE IN PHONOGRAPH RADIO COMBINATIONS

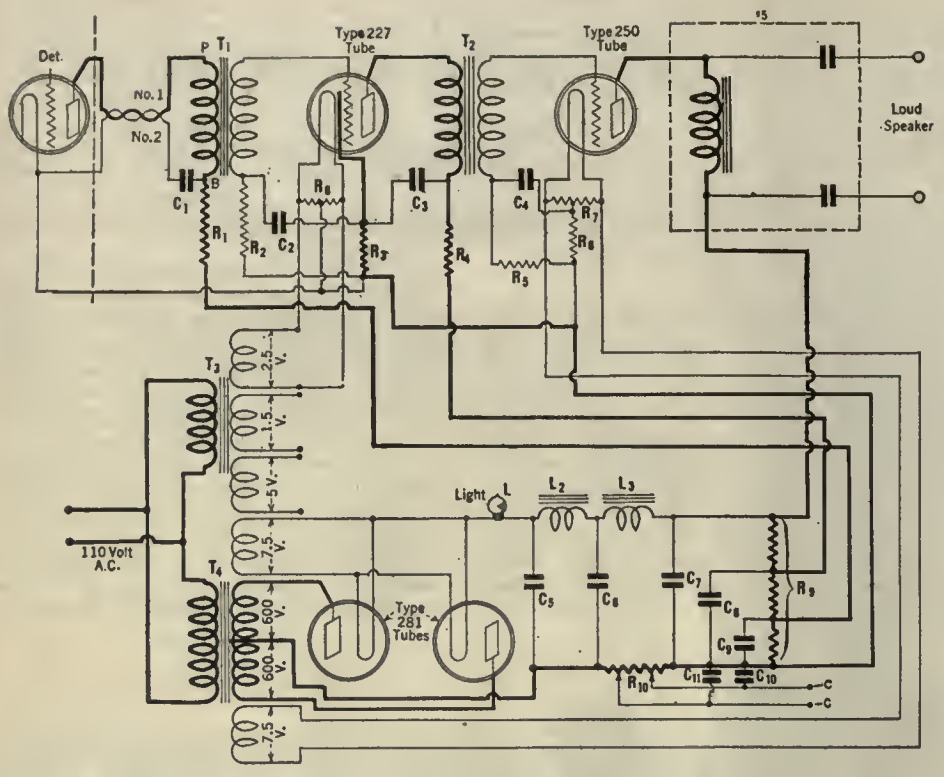


FIG. 3. SCHEMATIC DIAGRAM OF THE WRITER'S AMPLIFIER

necessary A, and B voltages to both the amplifier and the radio-tuner unit.

A large number of special amplifiers which, in some cases, may be adapted to phonograph-radio combinations, are also made by many manufacturers, including those mentioned in Table 1. As an example we might consider the installation of power-amplifier equipment in a hotel. In such a case one would require one or more amplifiers arranged in the form of a group, each amplifier supplying a certain portion of the power for the loud speakers. The utility of such an installation is, of course, increased if it is arranged so that music from either radio stations or phonograph records can be transmitted throughout the system. When this arrangement is employed it is necessary to connect the input posts of all the amplifiers to the same set of terminals, and a switching system is needed to connect either the output of a radio receiver or the output of a phonograph pick-up to these terminals. Any readers interested in the details of such amplifiers will do well to write the manufacturers mentioned in this article for complete descriptions of this equipment.

An excellent power amplifier which, unfortunately, is not illustrated in this article, is the Amertran type 2-AP. This is a complete two-stage transformer-coupled amplifier, the output stage being push-pull. Either 171- or 210-type tubes may be used in the push-pull stage and the first audio amplifier tube may be either a 227- or a standard 201A-type tube.

Many such amplifiers are made—several are illustrated here—and a list of a few of the best units, with their characteristics, is given in Table 1.

COMMERCIAL POWER AMPLIFIERS

IN FIG. 5 are illustrated two Silver-Marshall "Unipacs;" both of them satisfactory for use in a phonograph-radio combination. Data on these and other S-M. amplifiers is given in Table 1. As indicated, these amplifiers may be obtained either completely wired or in kit form. The 678-PD amplifier is especially interesting in connection with this article since the circuit is arranged so that the field of the dynamic loud speaker acts as the filter choke and is energized by the d.c. current flowing through the filter circuit. This amplifier, with its 250-type output tube is capable of supplying up to 4.5 watts of undistorted audio-frequency power, to the loud speaker.

In Fig. 5 are illustrated also some of the power amplifiers made by the Samson Electric Company, which may be used in constructing a phonograph-radio combination, or any other unit from which high-quality reproduction may be desired. Data on the various models are given in Table 1. It will be noted that the amplifier PAM-17 is similar to the PAM-16 except that it supplies field current for a dynamic loud speaker. The type PAC-2 amplifier should be used where the unit is also to supply B voltages for the radio tuner. This amplifier, it will be noted, also supplies a C voltage of minus 4½ volts which may be used to bias the grids of the r.f. tubes in the receiving set.

The National Company also makes a power amplifier that may be used. This amplifier is also illustrated in Fig. 5, and Table 1 gives complete data on the various models. Model 8110 is a complete power amplifier and B-supply unit, but the Push-Pull amplifier does not contain any power supply and, therefore, must be used with a separate power unit designed to supply the

Table I—Data on Power Amplifier Units and Kits

Manufacturer	Type No.	Prices		Voltages Available for Receiver		Description of Amplifier
		Kit	Wired	B Voltages	A. C. Voltages	
Silver-Marshall	682-250	$96.50	$111.50	45, 90, 135	1.5, 2.25	Two-stage transformer-coupled. 226 in first stage and one 210 or 250 in output stage. Rectifiers are two 281 tubes. An 874 glow tube is used.
Silver-Marshall	682-210	$102	$117	45, 90, 135	1.5, 2.25	Same as 682-250 except that output stage is push-pull. Either 210 or 250 tubes may be used.
Silver-Marshall	678-PD	$66	$73	None	None	Two-stage transformer-coupled. 226 in first stage and one 250 tube in output stage. Rectifier is one 281 tube. This model supplies current for field excitation of a dynamic loud speaker.
Samson	PAM-17		$125	None	None	Two-stage transformer-coupled. 227 in first stage and 210's in push pull in output stage. Rectifier is one 281 tube. This model supplies current to the field winding of a dynamic loud speaker.
Samson	PAM-16		$125	None	None	Same as PAM-17 except that no provision is made for supplying the field of a dynamic loud speaker.
Samson	PAC-2		$175	45, 90, 135	1.5, 2.5	Two-stage transformer-coupled. 227 in first stage and 210's in push pull in output stage. Rectifier is one 281 tube. An 874 glow tube is used. This model also supplies a —4.5 volt C bias.
National	8110		$85	45, 67 (adjustable)	None	Three-stage resistance-coupled. Uses one 210 power tube in output stage. Rectifier is one 281 tube. One 201A and one 240 are used in the first two stages.
National	8050		$75	45, 67 (adjustable)	None	Same as type 8110 except that the output tube is a 250 and the rectifier is a type 280 tube.
National	Push-Pull Amplifier		$40	None	None	This unit is a two-stage transformer-coupled push-pull amplifier using type 210 or 250 tubes in the output. It does not contain a power supply and must therefore be used with a separate unit such as the National Type 250.
American Transformer Co.	2-AP		$60	None	None	Two-stage transformer-coupled. Either a 227- or 201A-type tube in the first stage and 171A- or 210-type tubes in the output stage which is push-pull. It does not contain a power supply.

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

Radio May Become the Cornerstone of the Amusement Industries

IT IS the privilege of all men to consider the age in which they live as the zenith of human progress. In our little world of radio, the last decade has been a kaleidoscope of evolution and to-day we stand at the brink of a titanic realignment of the communication and entertainment worlds, with the versatile vacuum tube as its cornerstone. We cannot escape the conclusion that this decade will prove the most significant in the history of the stage, the screen, the phonograph, and the broadcasting industry.

Radio has grown from a humble sideline of the electrical industry and a pursuit of the former amateur experimenter, who refused to abandon his hobby, to the position of key industry of the entertainment world. The application of vacuum tube amplification to practically every phase of aural and visual entertainment promises to make broadcast reception only one phase of the many-sided business which will constitute the radio industry of the future.

Five years ago, the prostrate phonograph industry was revitalized by adopting the methods of the broadcast studio in recording and the audio system of the radio receiver for reproduction. More recently, the motion-picture industry, by an almost identical process, has incorporated sound entertainment as an integral part of screen reproduction and is, in consequence, enjoying an amazing revival.

Slowly but surely, drama, concert, vaudeville, motion pictures, phonograph, and broadcasting are being drawn into the vortex to form a huge, unified entertainment business, destined to reach staggering proportions in volume of business and to achieve undreamed of heights in the character of entertainment and education which it brings to the home. By this process, also, the economic problems of broadcasting will be solved definitely and the spasmodic character of production in the industry significantly readjusted.

SOME PREVIOUS PREDICTIONS

IN THE January "March of Radio," we ventured some predictions as to an ultimate home-entertainment machine, comprising broadcast receiver, phonograph reproducer, radio picture recorder, film projector and, some day, television reproducer. Nebulous as this conception then appeared, it seemed to us inevitable because of the natural technical and artistic alliance of these once separated fields. In June, we were able to chronicle the first practical step in this direction, the rumored merger of the Radio Corporation of America and the Victor Talking Machine Company. To-day, all the important phonograph companies are in the radio business. Concurrently, came the talking-movie boom, utilizing many of the inventions developed for radio. More recent developments are providing the structure for the actual manufacture of such a device.

The principal motion-picture producers are licensed already by the Bell System to use one or both of their two methods of sound synchronized film systems. Vitaphone uses phonograph records mechanically synchronized with the film; Movietone records sound impressions directly on the edge of the film by means of a light shutter system. These light impressions are converted into sound at the motion-picture theatre by passing light through the sound track, upon a photo-electric cell.

The R. C. A. more recently entered the field by exploiting a system developed by the General Electric Company, using the oscillograph principle to make the sound record on the film. Having entered the field later, there are, as yet, only a few Photophone licensees, as the R. C. A. system is termed, but with the prospective alliance with the Keith-Albee-Orpheum circuits and the Film Booking Offices of America, a huge number of theatre installations by Photophone are in prospect. Several other systems are soon to appear. Acute shortage of equipment exists and there is a feverish rush to speed theatre installations for the reproduction of sound pictures.

At the present time, the R. C. A. and the Bell System are in competition in the sound-picture field. If the precedent of broadcasting is followed, a combination of these rival interests will be effected ultimately. Five years ago, the Bell System laid the foundations for the National Broadcasting Company by operating the first chain of stations with WEAF as the key, while the Radio Corporation and its associates maintained WJZ as the competing key station to a chain connected through telegraph lines. Intense competition proved uneconomic, with the result that the National Broadcasting Company was formed as a merger of the two systems.

UNIFICATION INCREASES EFFICIENCY

FROM the standpoint of efficient and economic operation, unification of broadcast studio management, concert bureau direction, recording of musical accompaniment for sound pictures, phonograph recording and vaudeville management is a natural alliance. The operation of broadcast input amplifiers, of electrically operated devices for phonograph recording and of sound-film recording devices, as well as of reproducing equipment in theatres and public address systems, is technically similar. Nothing could be more natural and logical than the merger of these activities.

There are, however, some practical obstacles to the joining of so many forces. Political sentiment is against the concentration in a single hand of so many potent means of influencing public opinion as are presented by broadcasting and motion pictures. The leaders in the radio field have, at no time, been in greater need of unified public support and of intelligent management of their public relations. The very fact that all the prospective mergers are announced as being only in the negotiation stage is recognition of the need for public approval in advance of actual consummation.

The principle of unification and concentration in industry is founded upon efficiency in public service. So long as the policies of huge corporations are directed with impartiality, we not only tolerate, but encourage the unification of such important agencies of general welfare as the telephone service. Likewise, we may look forward to centralization of broadcasting, motion pictures, phonograph recording and ultimately television, provided that service to every element of the public, every taste, every strata of society, and every shade of religious and political belief is considered in proportion to their needs. The actual completion of such mergings may have to await additional legal safeguards but, more likely than not, the immense detail of negotiation is the only immediate problem to be met.

The merger of radio, phonograph, and theatre interests by a leading group of the industry will, undoubtedly, result in similar alliances on the part of the other radio manufacturers. There can be no practical monopoly of any artistic effort and, undoubtedly, in the prospectively combined fields, we



NEW SUPER-DIRECTIONAL HORN

The huge loud speaker illustrated above was developed by the Victor Talking Machine Company, Camden, N. J., and was designed to have marked directional characteristics. The horn is used to remove the hazards of landing dirigibles by providing a means of communicating directly with the ship while it is in the air. Successful results have been obtained in tests with the U. S. Navy Dirigible J-4 flying at 1500 feet over the Victor building.

will see competition of a character similar to that now applying in our more limited radio spectrum. The Radio Corporation activities, it appears to us, are only an example which will be followed by the entire industry in time. We also regard it as likely that, although patents may be an important part in the Radio Corporation structure, by the use of alternative methods or by licensing, a competitive field will be built up.

RESULTS OF UNIFICATION

TO THE radio manufacturer, the combination of these now separated industries promises an immensely increased volume of business and less seasonal fluctuation in production. To the home user of radio equipment, it will offer a more versatile source of entertainment of both aural and visual character. To the artist, it means greater opportunity to participate in a much wider range of activity, instead of restriction to a single field of entertainment, such as recording, radio, screen, or theatre. The unit of sale in radio equipment will rise manyfold, and a billion dollar industry will soon appear. Every element of the industry will enjoy greater prosperity, proportionate to the greater diversity and service which it renders.

WGY Protests New Allocation Plan

THE most vociferous objections to the allocation plan have been advanced by WGY, which has been allotted a "daytime only" channel, which it may use up to the point that it interferes with KGO. Under the Commission's definition of sunset, this is three hours after sunset in the East, limiting WGY to transmissions up to about eight P. M. in winter and nearly eleven P. M. in summer. If KGO stands by for one hour after sunset, WGY gains most of the important hours when it serves its more distant listeners. The Commission points out, in answer to WGY's protests, that the First Zone, and particularly New York State, has more than its share of powerful stations and that there is one station of 30,000 watts and one of 50,000 watts within a hundred and fifty miles of WGY. Certainly, if the principle of equitable division among zones and subdivision of zone quotas according to states by population is to be observed, there must be time sharing of one form or another on the part of at least one of the powerful stations in the First Zone with a station in another zone, so long as there are but eight exclusive channels per zone. WGY was selected for such sharing, no doubt, because it is not the original source of chain programs but acts principally as a relay station. Had WJZ or WEAF been selected for sharing with a Pacific coast station, the effect would have been a great hardship upon the largest broadcasting audience in the world.

WGY HAS NATIONWIDE POPULARITY

WGY has pointed out that it is one of the pioneer stations with the most widespread audience of any station in the United States. RADIO BROADCAST's questionnaires certainly support the contention that WGY has the most enthusiastic "distance" audience of any station in the country. The requirements of equitable distribution are, however, inescapable. The exclusive channels of the First Zone cannot be assigned exclusively to chain stations or only to those within service range of New York City. The only alternative offered the Commission is to suggest a time-sharing arrangement by WGY with one of the New York stations, either WJZ or WEAF. While this might be satisfactory to WGY, it certainly would be a blow of such serious proportions to New York listeners that it accounts for the fact that the Commission did not consider that course. The original engineers' plan, calling for fifty exclusive channels, provided room not only for WGY in the First Zone but better allocations for additional leading stations in all zones. Reduction of the cleared band to forty channels has complicated greatly the problem of providing adequately for all the good stations in all the zones.

One way out of the present situation might be a more liberal definition of "sunset." The Commission has ruled that daytime stations shall close down at the average time for sunset during a given month, at the point where the western station, subject to interference, is located. However, night broadcasting conditions do not prevail immediately upon the setting of the sun, but only after quite complete darkness. Therefore, the same sundown regulation as is used for the lighting of lights on motor cars may be more suitable for broadcasting regulation. The addition of an extra evening hour at such peak times as ten and eleven P. M. would greatly lighten the economic burden now placed upon stations limited to daytime broadcasting. We urge that experiments be made to determine the proper time for establishing an official broadcasting sunset, because we believe this offers a loophole for improving the position of the worthy stations, now compelled to sign off just at the hours when they begin to have a fighting chance to make enough revenue to meet their expenses.

The Chicago stations which protest and ask for better channel assignments do not receive much sympathy from the average broadcast listener. Chicago stations have dominated the dials for too long a time in the memory of the broadcast listener to cause anything but glee when it is announced that the Commission has somewhat reduced the proportion of ether territory assigned to stations in that city. Chicago has had its way about radio long enough and it will be a relief to listeners, who like dial twisting, to find something other than Chicago stations on the clear places.

Reasons for the 300-Mile Chain Regulation

THE regulation of the Commission, requiring that the same program shall not be duplicated in the exclusive channels by stations separated by less than three-hundred miles, has, for the time being, been waived, pending further investigation of the subject. Some months ago, in considering the problem of the frequent duplication of chain programs in the few clear channels, we pointed out that an ideal solution lay in limiting the nmmber of exclusive channels assigned to stations of the same chain to four or five widely separated points, requiring that the bulk of chain broadcasting be conducted on regional rather than nationally clear channels. In practice, however, such regulation leaves an insufficient number of high-grade, independent stations, now carrying non-chain programs, to fill the clear channels thereby freed.

Some form of regulation is necessary, however, if the real objective of the clear channel is to be accomplished. The distant listener, beyond the high-grade service range of any broadcasting station, depends upon the nationally cleared channels for his program service. If he finds all stations within his range on these cleared channels radiating the same program, the fundamental objective of giving the rural listener the best broadcasting service and the greatest variety through cleared channels is not achieved. It was such a consideration which caused the Commission to pass the 300-mile separation regulation. The principal reason that the regulation adopted failed is that there is an insufficient number of high-grade independent stations to fill the cleared channels; not that there is anything fundamentally wrong with the regulation itself.



VIEW OF SAN FRANCISCO RECEIVING STATION AT DALY CITY, CALIFORNIA, SHOWING ROTABLE LOOP AERIALS. THIS STATION IS OPERATED BY THE FEDERAL TELEGRAPH FOR THE RECEPTION OF MARINE SIGNALS

The Fight for Short-Wave Allocations

SECRETARY of War Dwight S. Davis has requested the Federal Radio Commission to set up a new amateur band between 5000 and 10,000 kc. This proposed band is to be used for amateur work in coöperation with Army radio stations. Oldtimers will remember that one of the first broadcasting stations in New York was WVP, operated under the supervision of the Army with the coöperation of a committee of amateurs. This station did its

share in the early days to introduce broadcasting to New York.

ONE of the more ambitious of applicants for short waves is the newly formed Universal Wireless Communication Company which wants no less than 116 short-wave channels. To begin its proposed service, it asks for an experimental license to operate a New York-Chicago circuit, to be followed, upon its success, by stations in fifty leading cities. There is no indication of the competence of the organization involved or its financial resources in the press dispatches. Certainly, its sponsors are not overburdened with modesty because they have the courage to ask for frequency space worth many millions of dollars.

A considerable number of non-communication companies have applied for short-wave channels. Perhaps one of the most interesting applications is that of the Montgomery-Ward Company, which wishes to link nine factory branches, three hundred existing stores, and ultimately 1500 stores by short-wave radio telegraphy. The means now used for communication purposes for this extensive group are the mails because telegraphy is too expensive for the purpose.

If a rental had to be paid the Government for the use of a channel, proportionate to its worth, it is unlikely that many of the private services now contemplated would be undertaken. The situation with respect to short waves is exactly similar to what would occur if we could have free telegraph lines, the only expense to the user being to furnish key and operator. Perhaps many of the Government's problems could be solved by turning over the channels in each class of service to the highest bidder. Such a process would be a shocking one to those who consider radio a democratic utopia, but it would eliminate a lot of the useless fighting now going on; limit the employment of radio to services in which it is truly superior and essential; avoid filling short-wave channels with private services, requiring discrimination against late but deserving applicants and, in addition, make radio a revenue producer for the Government.

IN SUPPORT of the Radio Corporation of America's application for 67 short wavelengths its representatives stated before the Commission that its principal purpose was to distribute 10,000 incoming transatlantic radiograms and 2000 transpacific radiograms daily. 95 per cent. of these messages are addressed to individuals and corporations in thirty leading cities, which it is proposed to link. The R.C.A.'s representative stated that Western Union, with its 25,000 offices, and Postal with its 2000, are unwilling to make satisfactory arrangements for handling these messages. The proposed radiogram forwarding business is not enormous and it seems unfortunate that a special system of communication must be set up in competition with existing nationwide systems of wire communication to handle such a reasonable amount of traffic. It is within the Commission's jurisdiction, in considering the merits of this application for short waves, to inquire why the wire facilities of the country are not available on satisfactory terms to handle the traffic involved.

With the Broadcasting Stations

A NEW departure in political programs was offered by the Democrats when they put on Irving Berlin, William Collier and Gene Buck on a coast-to-coast network, together with Fred Barrens' Democrat Orchestra. That political speeches require entertainment support has always been recognized, but this was the first political broadcasting accompanied by a goodwill, musical program.



THE RADIO OPERATOR OF THE COURTNEY FLIGHT AND HIS APPARATUS

Hugh Gilmour, the radio operator who accompanied Captain Courtney on his attempt to fly the Atlantic, is shown in his London home with the apparatus which he removed from the Dornier Wal flying boat when he was rescued by a life boat from the "Minnewaska" after floating in the ocean for fifteen hours.

WALTER DAMROSCH, the dean of American orchestral conductors, has always found the education of children in music his happiest work. Under the sponsorship of the Radio Corporation of America, he is now enabled to carry this out on a more extensive scale than he dreamed possible ten years ago. He is directing forty-eight school concerts in four series, each series designed for a different group of school and high-school students. The first series is for children of the third and fourth grades; the second for the fifth and sixth grades; the third for seventh grade and junior high school; and the fourth for high schools and colleges. In this series, Mr. Damrosch takes up each instrument and describes its part in the spectrum of music. He also analyzes various musical themes in a carefully worked out curriculum. Schools are actively taking advantage of this meritorious educational use of broadcasting.

THE Bureau of Standards is undertaking the calibration of crystal oscillators for broadcasting stations on a moderate schedule of fees. The tremendous volume of work entailed in preparing for the new allocation requirements is, no doubt, overwhelming the personnel of the Bureau. We can count on the customary faithfulness of Bureau of Standards employees to do the job with the utmost speed consistent with the standards of accuracy which they maintain.

AN IMPORTANT addition to the Columbia chain is WBBM of Chicago which, for its power, has extremely good coverage in the central west.

WLS, the famous Sears-Roebuck station in Chicago, has been sold to the publication, *The Prairie Farmer*. E. L. Bill has been retained as its director. Inquiring persons point out that the Commission is not required to approve this sale and that it is not under obligation to grant a license to the station under the new ownership.

BY INCREASING its power to 10,000 watts, KWKH becomes the South's most powerful station.

WLW of Cincinnati and WTIC of Hartford, Conn., officially have been granted 25,000-watt construction permits and may use an additional 25,000 watts experimentally.

THE Federal Radio Commission quickly yielded to the protest of Iowa, demanding an exclusive channel, to which it is entitled under the quota arrangement of the Davis Amendment. Because of congestion in Chicago, the Commission, in its original set-up, had borrowed a channel for that city from Iowa. This is the first, but not the last, example which will show how useless the borrowing clause will prove in practice. When there is a universal shortage of any commodity, it becomes impossible to find anyone who will loan freely to others. Certainly, nobody feels inclined to make any sacrifices so that Chicago may have additional stations.

AN OPINION by Federal Judge James H. Wilkerson confirmed the right of the Federal Radio Commission to regulate wavelengths and the power of broadcasting stations under the Radio Act of 1927. This decision was rendered in Chicago in the case of Stations WCRW and WEDC, which stated that the Commission's power reduction, required under the new allocation plan, represented confiscation of property without due process of law. The effect of the decision is merely to change the scene of argument from a Chicago court to one in Washington where, under the Radio Act, such appeals must be brought.

Progress in the Field of Aircraft Radio

THE first of a more powerful type of radio transmitter installations at an important aircraft junction point is to be completed at Cleveland, Ohio, in the near future. It is of 2000-watt power and promises to give reliable radio-telephone communication with aircraft in flight for a distance of a hundred miles and many times that distance by telegraphy. The standard aircraft frequency of 335 kc. will be employed. Eleven aircraft centers, other than Cleveland, are being installed at the present time, and all of them will be in operation within the next six months.

UTILIZING 500-watt high-frequency transmitters a complete chain of stations has been established as the communications network for the Chicago-Dallas air route. The cities at which the transmitters are located are Fort Worth, Oklahoma City, Wichita, Kansas City, Unionville, and Moline.

BELLEFONTE, PA., is the location of another radio aircraft installation. This important center for air mail service will have a directive radio beacon, somewhat similar to that installed at College Park, Md. Announcement is also made of a new type of vibrating reed which is used as an indicator on the plane, in which change in frequency with temperature is practically eliminated.

Radio Abroad

A VITALLY important patent decision was made by the Comptroller General of the Patent office in England when a compulsory license was granted to Loewe Radio Company. Under this compulsory license, the Loewe Company will make three- and two-element radio valves at license fees of 10 s. and 7 s. 6 d. respectively, instead of £1, 17 s. 6d. and £1, 5s., heretofore asked by the Marconi Company. In the decision of the Comptroller General, he stated that he was "satisfied that a case of abuse of monopoly rights had been established." The decision further states: "When we come to consider the scale on which the applicants hope to manufacture in this country, the Loewe valve will be recognized as offering a new advantage or utility for which it may be well worth sacrificing the superior sensitiveness which the use of reaction admittedly affords. Broadcasting has become a feature of our national life and a commercial policy which excludes large sections of the public from its full enjoyment is not, we think, a justifiable policy.

"The Marconi Company have secured a dominant position by gathering together in their own hands a large series of patents which, taken collectively, cover almost all broadcasting receivers of an efficient character. It is to be remarked that not one of the five patents now in question is for an invention originating with the Marconi Company. Three of them are American, one is French and one is German in origin.

"It is a kind of super-monopoly. The applicants cannot seek alternative terms from competing monopolists. They are absolutely in the hands of those who have gathered together this far-reaching aggregation of monopolies."

THE British Broadcasting Company's educational curriculum includes literary readings in French, German, and Latin from biographical sources, and a wide range of subjects presented in English on literary, historical, geographical, and musical subjects. This educational program is summarized completely in a brochure on the subject which should interest ambitious American program directors.

THE League of Nations announces that its plan of establishing a powerful radio-telegraph station has advanced to the point that it has now purchased a 50-kilowatt transmitter which will be operated, in normal times, by Radio Suisse. The station and its personnel may be taken over by the League, upon notice, in emergencies.

THE Government of Australia, under a new law, has taken over the ownership, equipment, and facilities of broadcasting stations of the Class "A" type. A system somewhat similar to that now established in New Zealand is being adopted for the control of broadcasting.

A COMMISSION has been appointed in Canada with a view to laying plans for the establishment of a national radio system, similar in character to the British Broadcasting Company. The commission will study the situation, not only in Canada but in Great Britain and the United States. Naturally, the owners of broadcasting stations are opposing the move.

In the Visual Broadcasting Field

COMMISSIONER H. A. LAFOUNT is reported as advising stations in his zone, interested in visual broadcasting, that, "In my opinion, the Commission will shortly issue orders for the regulation of television and picture transmission, particularly in the broadcast band. I, therefore, suggest that you defer the purchase of any equipment or the making of any investment until such action has been taken."

If restrictive regulation must be applied to this experimental art to the discouragement of those who are risking their time and money in so problematical a field, it would be a good idea to get it over with. There is no known reason for regulation at this time because picture broadcasting is causing no trouble of any kind, but the Commission has so often and so repeatedly thrown the shadow of threatened regulation upon it that progress in extending picture broadcasting has been totally stopped. If the new field must be stifled by the Commission, the sooner it is done the better, because all the money, so far courageously spent by experimenters, is practically a total loss should the Commission pass any serious restricting regulations. Further waste in experiments may as well be stopped, sooner rather than later, and protracting the agony is not in the least helpful.

A VERY fine publicity story emanated from WGY, following the broadcast, on the evening of September 11, of the radio play from their studio. The television transmitter was working on the occasion. The story stated that synchronization of speech and vision was perfect, but there were no comments as to the character of the images received. Those, technically acquainted with the subject, were inclined to smile at the statement that perfect synchronization was accomplished, not because there was any doubt that it had been done, but because it would have been wonderful if anyone discovered a practical means of transmitting speech and television out of synchrony under the conditions involved. A statement by Dr. Alexanderson, who is receiving WGY's transmissions at Lake George, a distance of two-hundred miles, reported trouble from a mirage or delayed image. Television may prove useful in securing data with reference to the heaviside layer.

THE Experimenter Publishing Company has sued a magazine which was to appear under the title *Television*. The application for the injunction was, of course, denied by the New York Supreme Court. Somebody ought to publish a list of patented words.

News of the Radio Industry

IN URGING industry support of the R. M. A. patent pooling plan, Le Roy J. Williams of that Association pointed out that the automobile industry, which solved its patent difficulties by means of an identical scheme, did not find a single patent basic. The R. M. A. plan, as our readers will remember, provides for the pooling of non-basic patents at the option of their holders, and permits patent holders to exempt so-called basic patents from the pool. The argument, however, does not hold good for the radio industry because there are many patents of a decidedly basic character still in force. The pooling of non-basic patents is of negligible importance.

A RECENT statement of the R. M. A. innocently rises to the point of humor when it seeks to throw aspersions on the accurate and comprehensive statistics which the National Electrical Manufacturers' Association has issued with the coöperation of the Department of Commerce. The R. M. A. now proposes to go into the statistics business also, utilizing agencies of a character undisclosed to assist it. "The study of available, but incomplete statistics, largely estimates, is being made by the Committee which will present recommendations to the R. M. A. Board of Directors for the development of real statistics which are reliable and may be of actual service to all branches of the radio industry." Silly publicity of this character certainly does not reflect glory upon those who issue it.—E. H. F.



NEW AUTOMATIC SOS RECEIVING APPARATUS

The S. S. "Cedar Bank" recently has been equipped with Marconi apparatus for automatically receiving SOS signals. The signals are received by the three-tube regenerative set shown on the left, and below the receiver is the selector relay which rings bells, in the radio room, on the bridge and in the operators' stateroom, whenever an SOS signal is picked up.



FRONT VIEW OF "SKYSCRAPER" RECEIVER

The "Skyscraper" Screen-Grid Receiver

By CLIFFORD DENTON

Ferranti, Inc.

FOR a long time the neutrodyne type of receiver, consisting of a two-stage neutralized radio-frequency amplifier using 201A-type tubes, a non-regenerative detector and a two-stage audio-frequency amplifier, justly has been considered an excellent set—sensitive, selective, and easily controlled. The receiver described in this article has these plus some additional good characteristics. This set uses two stages of r.f., detector and a two-stage audio amplifier, and to this extent is to be likened to a neutrodyne—but here the similarity ends.

In this receiver two 222-type screen-grid tubes are used in the r.f. amplifier and, as a result, it becomes unnecessary to neutralize the r.f. circuits and greater amplification is obtained. The use of the screen-grid tube in the r.f. stages makes it essential that shielding be used and that all the plate and filament circuits be bypassed and filtered to prevent common coupling between the various circuits, which would result in oscillation. As part of the shielding, it is recommended that Remler tube shields be placed over each of the 222-type tubes.

Starting with the antenna connection we will review the circuit arrangement used in this receiver, and in this way we will be able to bring to the attention of the reader the various interesting design features which the set possesses. The circuit diagram of the receiver is given in Fig. 1.

The input circuit to the receiver is arranged so that either an antenna or a loop may be used. The loop is connected to the two terminals marked "Loop" in which case no ground need be used, although a ground may be connected to the ground terminal if one desires. The antenna connects to the first coil L_1, through a small 0.0001-mfd. fixed condenser, C_1. The switch SW_2 adapts the set for use on either a short or a long antenna, and, when the set is put into operation, reception should be checked on both positions of the antenna switch. In locations where there are several near-by broadcasting stations and a selective receiver is essential, the antenna switch should be thrown to terminal No. 1. With the antenna switch in this position the set is very selective; if the switch is thrown to terminal No. 2 the volume will increase but the set will lose some selectivity. In out-of-town locations, where very sharp tuning is not required, the set generally will give most satisfactory operation with the antenna switch on terminal No. 2.

The output of the tuned circuit L_1C_2 feeds the grid circuit of the first 222-type tube which in turn feeds into the r.f. transformer consisting of L_2L_3. This transformer is wound on a threaded hard-rubber tube. The plate coil is wound first with a small-size wire in the bottom of the grooves and on top of this primary winding the secondary is laid, the secondary wire being of a size such that it lays on top of the groove. The turns ratio is 1 to 1. The coils are mounted on a standard four-prong base and plug into sockets mounted on the sides of the shields, as indicated in the picture of the receiver.

THE receiver described in this article is a development of Robert Arnold, in association with the laboratory of the Ferranti Company in the United States. The set was examined and tested in operation in New York City by a member of the staff of RADIO BROADCAST *Laboratory and it performed very satisfactorily. The set is quite selective and the fidelity is excellent.* RADIO BROADCAST *will be pleased to hear from those who undertake the construction of the set.*

Constructional data is not given in this article for complete information of this sort may be obtained directly from the Ferranti Company.

—THE EDITOR.

This secondary, L_3, of this transformer feeds into the second radio-frequency tube whose output circuit supplies energy to the next transformer consisting of L_4L_5; this transformer is similar in construction to the preceding one. A C-bias detector is used; the plate is supplied with 90 volts through the 50,000-ohm resistor, R_1, and minus 6 volts is used on the grid. The output of the detector goes to the first audio transformer, T_1, across the primary of which is connected a jack, J_1, to which a phonograph pick-up unit may be connected. The output circuit of the audio amplifier is push-pull with 171A-type tubes. The output transformer, T_3, should be of a type designed for use with the particular loud speaker which is to be used with the set. The designers of the receiver, feeling that many experimenters might have available an audio amplifier and, therefore, desire only to construct the radio-frequency and detector circuits, have shown the jack J_2 in the plate circuit of the detector. If a separate amplifier is to be used it should be connected to this jack.

As we mentioned in a previous paragraph all the battery circuits of the receiver have been filtered carefully in order to prevent common coupling which is often the cause of oscillations and motorboating. The screen-grid circuits of the two r.f. tubes are filtered by the 10,000-ohm resistors, R_2 and R_3 and the condensers, C_5 and C_6. The plate circuits of these tubes are filtered by resistors R_4 and R_5, each with a value of 50,000 ohms, and the by-pass condensers, C_7 and C_8. The detector circuit is filtered by the 4-mfd. condenser C_9 and the resistor R_1. Filtering in the detector circuit is especially important since even a small amount of coupling at this point will affect the characteristics of the audio amplifier and either make it distort or hum badly, and in some cases the coupling may be sufficient to make the audio amplifier oscillate.

Three filter circuits are located in the audio amplifier. The grid circuit of the first audio-frequency amplifying tube is filtered by a 2-mfd. condenser, C_{10}, and a 50,000 resistor R_7. The plate circuit is filtered by a 20,000-ohm resistor, R_8, and the condenser C_{11} with a capacity of 2 mfd. The third filter circuit is located in the grid circuit of the input push-pull transformer, T_2, and it consists of a 10,000-ohm resistor, R_9, and the condenser, C_{12}, whose capacity is 2 mfd. [Push-pull amplifiers frequently have a tendency to oscillate especially if the power tubes have slightly different characteristics. If the amplifier does oscillate it can be overcome by placing a 50,000-ohm resistor between the center-tap of T_2 and R_9, in the grid circuit of the input push-pull transformer. This resistor should *not* be by-passed. The use of this resistance will not in any manner adversely affect the quality. *Editor*.]

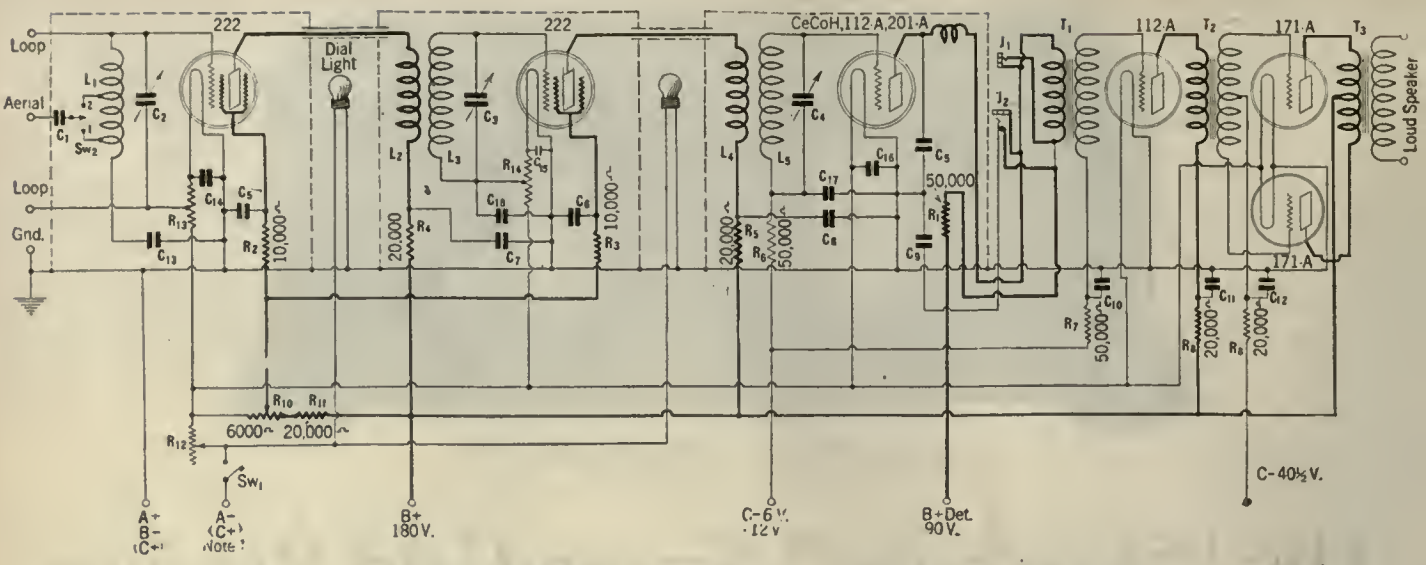


FIG. 1. COMPLETE SCHEMATIC DIAGRAM OF THE "SKYSCRAPER" RECEIVER

The values of resistance used in the filter circuits are such that both of the r.f. tubes and the first audio tube may be supplied with 180 volts from the power supply, and the filter resistance will reduce this voltage to the correct value for the operation of the particular tube. An example will make this clear. Consider the first audio stage, in which socket is recommended the use of a 112A-type tube. The d.c. plate resistance (*not* the a.c. plate resistance) of this tube is about 20,000 ohms. This 20,000-ohm plate-circuit resistance is in series with a 20,000-ohm filter resistance, R_8, across 180 volts. Therefore, half the voltage will appear across the tube and the other half across the filter resistance. Therefore, there will be about 90 volts on the plate of the 112A-type tube.

Volume is controlled in this receiver by varying the potential applied to the screen grids of the r.f. tubes, this adjustment being accomplished by R_{10}, a 6000-ohm potentiometer. In series with this 6000-ohm potentiometer is placed a fixed resistance, R_{11}, with a value of 20,000 ohms so that not more than the rated value of 45 volts can be applied to the screen grids.

On the front panel of the receiver are four controls, besides the on-off switch. The two small knobs at the lower-right and left-hand corners are the filament rheostat and the volume control, respectively. The drum dial on the left tunes the antenna condenser, C_2, and the right-hand dial tunes the other two condensers, C_3 and C_4, which are ganged together.

For the past several months development work on the "Skyscraper" receiver has been in progress in the laboratories of the Ferranti Company. For this reason the writer feels certain that those who construct the set will obtain as satisfactory performance as he has from the various models which have been undergoing tests. Optimum performance can be assured only by following as closely as possible the arrangement of apparatus illustrated in the pictures on these pages and in the wiring layouts supplied with the construction booklet. For this reason it is recommended that set builders, who contemplate building the receiver, send for this booklet. If, after the construction has been completed, the set does not perform in an altogether satisfactory manner the wiring should be checked carefully and the various tubes should be tested. It is also a wise plan to examine the B power-supply device, as poor results may be caused by incorrect plate voltages.

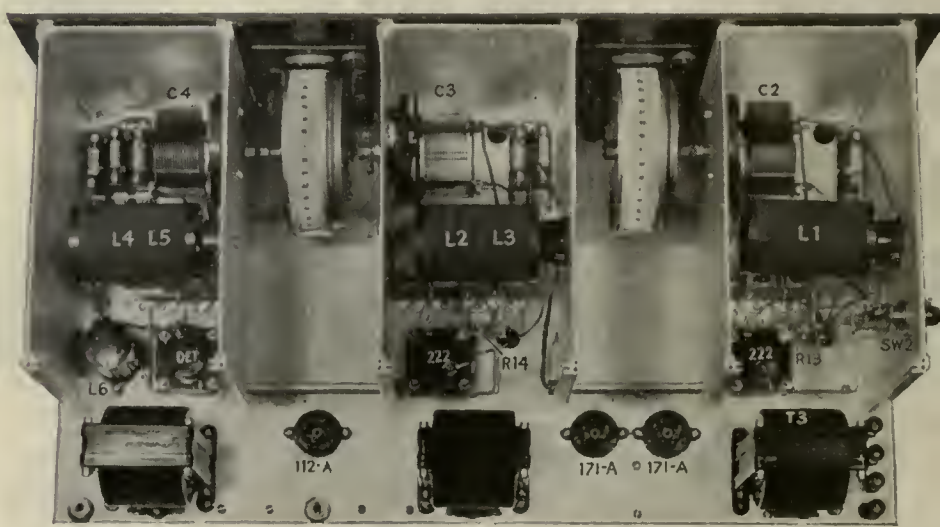
LIST OF PARTS

THE apparatus used in constructing the model of this receiver illustrated in these pages is given below. The total cost of the parts listed is $95.00. The builder may substitute electrically equivalent parts.

The last four items in the list, and also the tuning coils, are especially designed for use with this receiver, and may be obtained by writing directly to the Ferranti Company. Those who desire to construct this set can also obtain a booklet giving complete constructional data from the Ferranti Company for $1.00.

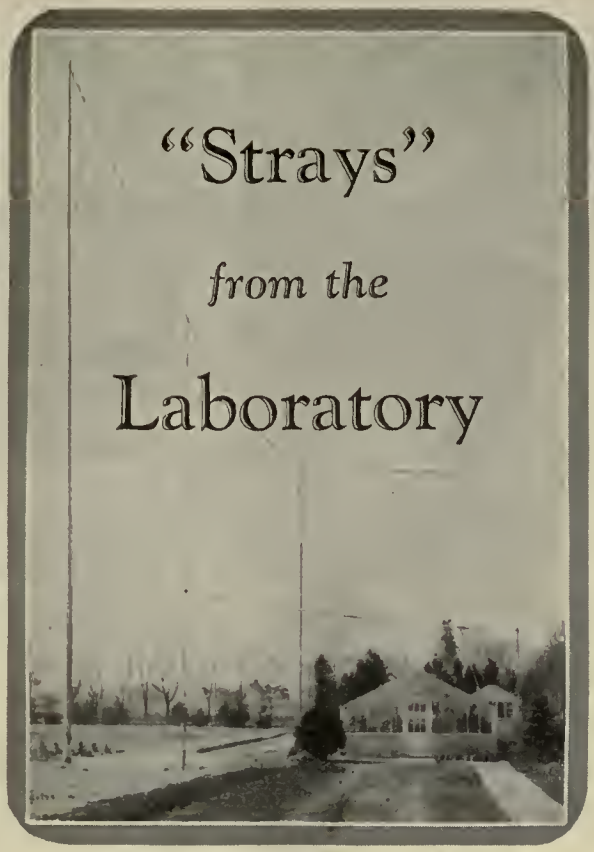
The list of apparatus follows:

C_1 One Tiny-Tobe fixed condenser, 0.0001-mfd;.
C_2, C_3, C_4 Three Remler SLW condensers, 0.0005-mfd.;
C_5, C_6, C_7, C_8, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18} Ten Tobe by-pass condensers, 0.5-mfd., type 300;
C_9 One Tobe condenser, 4-mfd., type 240;
C_{10}, C_{11}, C_{12} Three Tobe condensers, 2-mfd., type 202;
L_1, L_2-L_3, L_4-L_5 Three Ferranti tuning coils, "Skyscraper"-type;
L_6 One Hammarlund r.f. choke coil, type RFC-85;
R_1 One Tobe fixed resistor, 50,000-ohm, 2-watt;
J_1 One Yaxley jack, open-circuit;
J_2 One Yaxley jack, closed-circuit;
R_2, R_3, R_{13} Three Tobe resistors, 10,000-ohm, 2-watt;
R_4, R_5, R_8, R_{11} Four Tobe resistors, 20,000-ohm, 2-watt;
R_6, R_7 Two Tobe resistors, 50,000-ohm, 2-watt;
R_{10} One Carter midget potentiometer, type MW-6M;
R_{12} One Carter rheostat, 6-ohm, type 506;
R_{13}, R_{14}, Two Carter resistors, 15-ohm, type J-5-15;
T_1 One Ferranti transformer, type AF-5;
T_2 One Ferranti transformer, type AF-5C;
T_3 One Ferranti transformer, type OP-8C for magnetic speakers, type OP-4C for dynamic speakers;
Two Remler tube shields, type 56;
Three Hammarlund shaft couplers, type FC;
Three Na-Ald sockets, type 424;
Three Na-Ald sockets, type 428, for plug-in coils;
Three Benjamin sockets, type 9040;
One pair of Benjamin brackets, type 8629;
Two National drum dials, type VF with type-28 illuminators;
Two Carter screen-grid connectors; type 337
One Yaxley mounting plate and cable, 7-wire;
Four Eby binding posts, insulated;
Ten Lynch resistor mounts;
Acme flexible wire in colors to match Yaxley cable, for wiring;
One Aluminum base, 10-gauge; drilled;
One Bakelite panel, 8" × 24" × $\frac{3}{16}$", walnut finish, drilled;
Three Aluminum Co. of America standard shields, drilled;
Thirteen rubber insert rings, for feed lines through base.



THIS PICTURE SHOWS THE EXACT ARRANGEMENT OF PARTS ON THE CHASSIS

"Strays" from the Laboratory



Accuracy of the "Slide-back" Voltmeter

MANY engineers take the vacuum-tube voltmeter for granted, i.e., they seldom stop to consider its limitations and inaccuracies. Many times within the past two years we have seen described in more or less technical papers the "slide-back" voltmeter with a direct or implied statement that it is an infallible device for measuring voltage.

The circuit diagram for a "slide-back" voltmeter is given in Fig. 1. It consists of a vacuum tube biased so that the plate current is quite small and so that a.c. input voltages change this steady C bias, thereby changing the plate current. The plate current is then brought back to its original value by changing the steady C bias by means of the potentiometer. The difference between the two values of bias (with and without a.c. input) is the peak value of the input voltage. The negative halves of these cycles drive the grid more negative, but, since the tube is already overbiased, the plate current changes but little. The positive halves of the cycles, however, reduce the steady negative C bias, and the plate current increases. Then the potentiometer is varied and the steady C bias is "slid-back" until the same plate-current reading is obtained.

To test the accuracy of the instrument we used a Weston model 301 milliammeter with a full-scale reading of 1500 microamperes. With 45 volts on the plate and a C bias of minus 4 volts, the plate current was 200 microamperes. This steady current was balanced out of the microammeter by using the A battery voltage or by means of a "bucking battery" (B) as shown in dotted lines in Fig. 1. Now, when an a.c. voltage of 2.05 peak was placed on the input, the plate current increased, and we "slid-back" the potentiometer until the C bias meter read an increase of 0.35 volts. When an input of 4.0 volts was used a net change of 1.6 volts in the C bias was required before the current plate was the same.

Clearly the method fell down. A change of C bias due to a.c. voltages could not be balanced out by an equal change of d.c. voltage.

In the next test we put .33 milliamperes through the meter by means of the battery B, in Fig. 1, and the C bias on the tube was adjusted so that no change took place in the deflection of the plate-current meter when the plate voltage was turned on or off—in other words, we placed sufficient bias on the tube so that the plate current was zero. This point cannot be determined exactly, of course, but if the meter has an initial reading changes in this deflection are noted easily.

Now when an a.c. input voltage was placed on the tube, the C bias changed, the plate current changed and a deflection was noted. The steady bias was then increased so that turning on or off the plate battery to the tube made no change in the reading of the plate-current meter.

When an input peak a.c. voltage of 10 was applied to the tube a change of 9.5 volts steady bias was necessary to reduce the plate current to zero; other readings are noted in Table 1.

TABLE I

Steady current through 500 microammeter=331 microamperes. Steady bias to cause no deflection on meter=7.7 volts when E_p=45 volts

input a.c. peak volts	d.c. volts to reduce I_p to zero	accuracy
4.05	3.6	89%
6.1	5.8	95
8.2	7.5	92
10.1	9.5	94
14.5	14.3	99
16.3	15.6	96
18.3	17.5	96

Substituting a more sensitive meter, say a Westinghouse 500 microampere meter, or a Weston zero-center galvanometer with a sensitivity of 60 microamperes per division, increased the accuracy somewhat. But even with the 1500 microampere meter we could balance out an a.c. voltage with a d.c. voltage with an accuracy of about 90 per cent. Larger input voltages could be read more accurately.

When used in this manner the "slide-back" voltmeter is accurate enough for all ordinary measurements. The device is inaccurate when operated, as is often done, so that a fairly large steady current is obtained in the plate circuit, and the bias is so adjusted after an input is applied that the plate current returns to this value. The nearer one can get to the actual zero plate current point, the more accurate the instrument as a whole becomes.

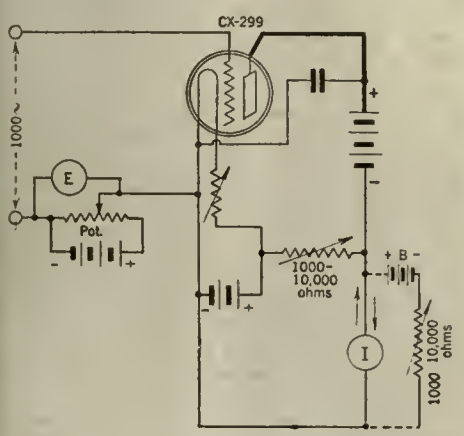


FIG. 1. SLIDE-BACK VOLTMETER

Hum in the "Lab" Circuit Receiver

FOR A long time we threatened to throw out our B-supply unit and build a new one. With the four-tube "Lab." circuit receiver (August RADIO BROADCAST) considerable hum appeared in the loud speaker in spite of rather thorough filtering in the B supply itself. We began to wonder where the noise came from; was it inductive pick-up from the power line running near the audio-transformers, or was it picked up in the first- or second-audio, detector or r.f. tube?

The audio amplifier of the receiver was perfectly quiet, as evidenced by shorting its input through a 10,000-ohm resistor. Running the detector from a 45-volt B battery helped a bit, but the hum was still too loud. Running the r.f. tube from a 90-volt B battery killed the hum completely. Larger filter condensers across the 90-volt B-supply lead did no good. What could be the trouble?"

Let us look at the r.f.-tube circuit in Fig. 2. Notice that the 90-volt lead from the power-supply unit—which has some a.c. in it no matter how well it is filtered—is connected directly to the detector input coil. This is a very high-impedance circuit, equivalent to Fig. 3, and any a.c. current flowing will build up a large voltage and subsequently will be amplified by this detector and audio tubes.

The first experiment was to wind a primary coil about the detector input coil, as in Fig. 4. The noise dropped out. The solution was then simple: isolate the primary winding of the coil from the secondary, as in Fig. 5, and ground the lower end of the detector coil. Now the power-frequency noise is effectively grounded as far as the detector input goes, and, therefore, no hum gets on to the tube's grid.

Figure 5, then, gives the circuit diagram of an r.f. amplifier and detector for the "Lab." Circuit which will iron out a.c. hum entering the receiver from the B-supply unit via the r.f.-amplifier plate circuit.

In the course of the experiment leading to the elimination of the hum from the circuit, the leads to the regeneration condenser were reversed. Considerable difficulty was experienced in "holding-down" the circuit, and it was impossible to neutralize the amplifier completely without placing a shield between the regeneration condenser and the detector tuning condenser. When, however, the regeneration condenser was connected correctly, that is, stator to the detector plate, all difficulty disappeared, and a high-gain stable amplifier resulted. Readers who have trouble with the circuit, evidenced by the detector or amplifier oscillating continuously, might try reversing the leads to this small condenser.

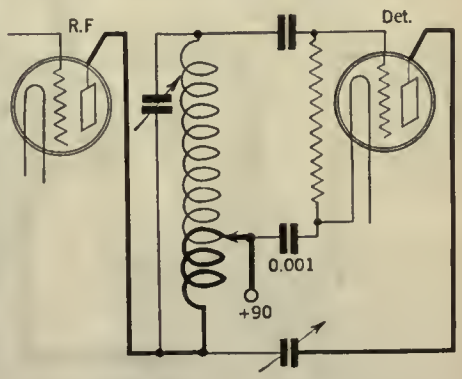


FIG. 2. ORIGINAL "LAB" CIRCUIT

More Data on Underground Aerials

SO FAR as we are concerned the following quotation from a letter from our good friend Dr. G. W. Pickard closes the subject of trick and underground antennas:—

"On page 259 of the September issue of RADIO BROADCAST I notice an appeal for definite quantitative data on the underground antenna. Probably by this time you have found the various references necessary, but in case you have not, I'll give some of the desired facts.

"As you know, there are underground antennas and antennas. Some of these consist of plates or coils of wire, variously insulated, but aside from the sucker type of radio fan, no one has taken them seriously, and so far as I am aware, no quantitative measurements have been made. But the real, more-or-less-useful type of underground antenna, consisting of a long, straight insulated wire buried at a slight depth in the ground, is the subject of a considerable technical literature, and its reception characteristics are quite well known.

"First, consider 'Short-Wave Reception and Transmission on Ground Wires (Subterranean and Submarine)' by A. Hoyt Taylor, *Proceedings* I. R. E. Vol. 7, No. 4, August, 1919. Taylor points out that the buried wire antenna is strongly directive, receiving signals best in the direction of its length, and but feebly from directions normal to the wire. He also explains that reception is possible because of a tilt in the wave-front, which gives a component of the electric vector parallel to the wire.

"Next, take my paper, 'Static Elimination by Directional Reception,' *Proceedings* I. R. E., Vol. 8, No. 5, October, 1920, wherein it is explained that if static and signal come from different directions, properly oriented directional aërials will eliminate more static than signal.

"Finally, consult 'The Wave-Front Angle in Radiotelegraphy' by L. W. Austin, *Washington Academy of Science Journal*, pages 101-106, March 4, 1921, wherein it is shown that waves are slightly tilted forward in the direction of propagation, this tilt being small and of the order of 0°-3°.

"It is obvious without going further into the literature of the subject that buried wires often give better signal-static ratios than does the conventional open antenna, simply because they receive directionally.

"Now for a numerical answer to RADIO BROADCAST's question; what is the relative signal strength of a fifty-foot wire in the open, and the same length of wire buried? If the wire in the open is truly vertical, and the earthed wire is horizontal and but lightly covered with earth, reception on the buried wire will be somewhere between 0 and 3 per cent. of that on the vertical wire, depending upon soil resistance and the consequent tilt of the wave. If the wire is buried quite deeply, both theory and Taylor agree that the wave tilt will increase, and hence a somewhat better signal will be obtained on the more deeply buried wire. If you really wish to pursue this matter to the bitter end, that is, literally run it into the ground, see *Wireless Telegraphy* by Zenneck, McGraw-Hill, 1915, particularly pages 260-262 and Figs. 310-317 showing examples of tilted waves for different soil constants.

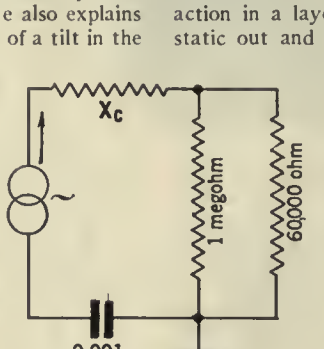


FIG. 3

"You see, there is no mystery, no magic about this matter. There is no division of the wave from the transmitter into two distinct parts, one traveling under and the other over, the earth's surface. There is no inexplicable filtering action in a layer of dirt which will strain the static out and let the signal through. A long buried wire is merely an inefficient but directional antenna, and, if it can be aimed at the signal and not at the static, it will give a favorable signal-static ratio.

"But more power to you in your attack upon the thousand and one fake contraptions which grow like weeds upon our unfortunate roofs, burrow foolishly in the ground and litter the tables of the uninformed fan. I am afraid an appeal to reason will not reach effectively the class you would protect, therefore, the best way would be to make fun of these fakes. With wire cones, triangles and other Euclidian-looking objects on the roof, weird tangles of wire in pits on the front lawn, Geppert and other dingusses guarding the radio receiver, a poor, puzzled radio wave must scratch its head and wonder how it would ever get in."

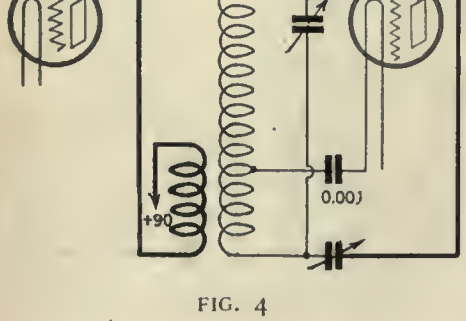


FIG. 4

Is a 112 Tube Needed in the First stage?

FROM time to time we see the statement in an article about high-quality audio amplifiers that it is a good plan to use a 112-type tube in the detector socket because of its low output impedance. The object is that under these conditions the first audio transformer works out of a tube whose impedance is, ostensibly, 5000 ohms, instead of 12,000 ohms for the 201-A. Therefore, the articles argue that the low-frequency response will be better. We have often suspected this to be a piece of nonsense, and recent tests made in the Laboratory by Howard Rhodes on a two-stage Sangamo amplifier have proved our contention.

Little or nothing has been said about what happens to the high-frequency response of an amplifier when the impedance out of which it works is changed. It seems to be assumed tacitly that nothing happens, or if it does, the difference does not matter. This may be part of the general negligence on the part of amplifier designers to consider the high frequencies as unimportant, occasioned without a doubt by the unreasonable demand on the part of listeners for low-frequency tones all out of proportion to their natural values. Mr. Rhodes's figures (Table II) show that working a good amplifier out of an impedance for which it was not designed may ruin its characteristic.

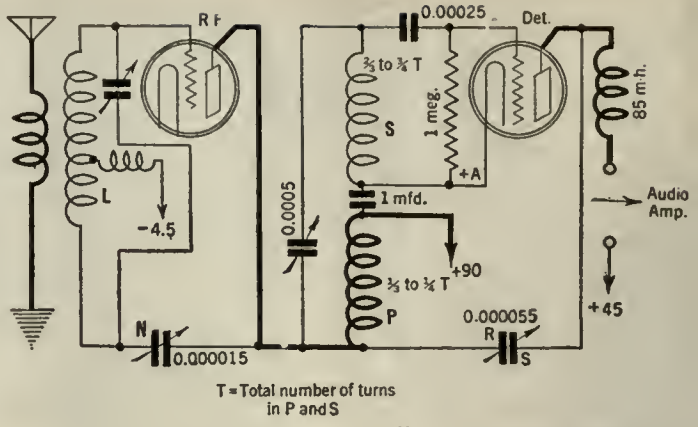


FIG. 5. THE IMPROVED "LAB" CIRCUIT RECEIVER

TABLE II

Rp ohms	Frequency cycles				
	60	1000	2000	4000	6000
5000	-1.7	0	+1.3	+2.8	+2.6
10,000	-1.7	0	+0.6	0	-1.3
20,000	-2.0	-0.5	-1.1	-3.5	-5.2
30,000	-2.3	-1.0	-3.2	-8.0	-8.6
			TU		

The amplifier consisted of two Sangamo type-A transformers, a CX-327 first-stage and CX-350 second-stage tube. The output device consisted of a General Radio Type 587-D which is made up of a 15-henry choke and two 2-mfd. condensers. The current into 4000 ohms was read while the input voltage was kept constant. The table gives the necessary data on the measurements. The current at 1000 cycles when the amplifier worked out of 10,000 ohms was taken as a zero level; all other adjustments of frequency and input impedance are compared to this value. Thus, at 60 cycles and worked out of 5000 ohms, the amplifier is down 1.7 TU compared to 1000 cycles when worked out of 10,000 ohms.

The amplifier has the best characteristic when worked out of 10,000 ohms, and it is assumed it was designed with this impedance in mind. Working it out of 5000 ohms causes a rise at the high frequencies where the secondary capacity begins to resonate with the leakage reactance of the transformer. Perhaps this is because lower input resistance is equal to lower reflected resistance in this resonant circuit so that the resonance becomes more pronounced. This theory is borne out by the fact that many amplifiers, which are perfectly stable when operated out of 10,000 ohms, begin to oscillate badly at 5000 or 6000 cycles when worked out of low impedances.

The Sangamo amplifier begins to fall off when worked out of 20,000 ohms but is still much better than many when worked out of the impedances for which they were designed.

The truth of the matter is that a well-designed transformer is engineered with some particular input resistance in mind. When worked out of this resistance the characteristic will be the best, if this resistance is something else the characteristic goes bad. If the resistance is 5000 ohms a 112-type detector tube will give better over-all frequency response; if it is 10,000 ohms a 201-A detector will be better.

The question remains, what is the output impedance of an average detector circuit? Who knows?—KEITH HENNEY.

A Test Set for the Radio Service Man

By B. B. ALCORN

THIS is the second article on practical service problems by Mr. Alcorn. In his first story, the author discussed what seemed to him the ten leading service troubles, analyzing some of them in detail. This one deals with short circuits and the "case histories" represent actual and most interesting experiences which should be useful not only to those who have occasion to service or use the particular sets referred to, but also to those doing service work on almost any set. Surprisingly little really helpful data has appeared in print on service problems. It is our hope that these articles by Mr. Alcorn, and other similar articles which we may publish, will in a measure fill this real need.

—THE EDITOR.

The second installment of a series of articles relating the experiences of a radio service man

IN SERVICING radio receivers repair men and radio dealers are confronted constantly with mystifying problems which tax their ingenuity to the extreme. In some cases several hours of experimenting may be necessary before it is possible to locate the trouble and start work on the repair, whereas other times an unusually baffling condition may be cleared up accidentally in a few moments. The writer does not wish to infer that he has found the solution difficult in all, or even a majority, of the problems in radio servicing, for this is not the case. On the contrary, the owner's description of the receiver's performance often permits one to diagnose the trouble, and other times it is possible to analyze the difficulty by merely turning the tuning controls for a few moments. However, there are a sufficient number of unusual ailments which a receiver is apt to contract to make this line of work full of interest.

In last month's article of this series the writer described several unusual experiences which he has had in locating troubles caused by open circuits. It is admitted that the difficulties cited were out of the ordinary, but they serve to point out the type of work a service man must be prepared to tackle. In all probability open circuits of the types described may never be experienced by the reader, but they are typical of the peculiar problems which present themselves every day. While on this subject there is one new case of open-circuit trouble which may be of interest.

The writer was called upon to repair an Atwater Kent Model 35 receiver, and after testing the various circuits it was found that there were a great number of open circuits. Both audio transformers were burned out, the grid suppressors were open, the primary windings of the radio-frequency transformers were defective and, in addition, several by-pass condensers were blown out; in fact the set was almost a total wreck. However, after all of these parts had been repaired or replaced the set still refused to function, although the usual tests showed the continuity of all parts to be in order, except that the B potential did not reach the plates of the tubes. After considerable checking, the trouble was located in the battery cable, but not in the place where one would normally expect to find it. The A+ wire in the battery cable of this receiver is fitted with a lug for connection with the storage battery, and the B— wire is connected with the cable in this lug. In some way the B— wire had become loose, and an oxide had formed which insulated the wire from the cable. When this difficulty was repaired no further trouble was experienced with the receiver.

GOOD EQUIPMENT NEEDED

IN THE servicing of radio receivers a repair man is lost without the proper tools and testing equipment. Both of these items are of equal importance and their selection deserves the most serious consideration. With a well-designed portable test set it is possible to locate most all causes of trouble in a fraction of the time that would otherwise be required, and, if a complete set of tools is available, the receiver often may be repaired in the customer's home. However, when equipping himself with tools and test apparatus the service man should always consider the equipment from the viewpoint of portability and convenience.

In addition to its utility value a service man's equipment accomplishes another very important result; namely, it creates a favorable impression in the mind of the client, and this is very important. Therefore, when building or buying portable equipment it is wise to consider its appearance as well as its usefulness.



THE AUTHOR'S TEST SET

There are a number of excellent test sets available on the market, and, if the service business will stand the strain on its pocketbook, one of these instruments is an excellent investment. Such apparatus is now being made by Hoyt, Jewell, Supreme Instrument, Weston, and other instrument manufacturers. The writer recently had an opportunity to experiment with the test set made by the Supreme Instrument Company, and, while it is rather expensive, it is as complete an outfit as could be desired. The set is designed especially for use in the field, but it is also excellent for work in the laboratory. It consists of an oscillator, a wavemeter, a calibrated variable condenser, and a power-supply circuit which operates direct from the a.c. line. The set is housed in a neat case which also provides space for carrying tools, tubes, and enough supplies to meet the usual requirements. It may be considered a portable laboratory.

Unfortunately most service men cannot consider purchasing elaborate test equipment of the type referred to in the above paragraph, because of the high cost of such apparatus. However, it is possible to build a very satisfactory set-checking device at a considerable saving in expense. It is true that such a set tester may not be quite as versatile as a commercial product, but it may be constructed so that it is satisfactory for most purposes. The set checker designed by the writer will indicate short circuits, open circuits, and the general condition of tubes in both a.c. and d.c. receivers, and it is made up of meters that every service man should own. Of course, if high-grade meters are used the cost may be as high as $40, but this is considerably less than the average commercial outfit.

PARTS NEEDED

A LIST of the apparatus required for the construction of the set checker is as follows:

One double-range panel-mounting high-resistance d.c. voltmeter, 0–8 and 0–200 volts;
One panel-mounting d.c. milliammeter, 0–100 milliamperes;
One portable triple-range a.c. voltmeter, 0–4, 0–8 and 0–150 volts;
Two Benjamin sockets, UX-type;
Nine Carter tip jacks;
Two single-pole, double-throw push-button switches;
One double-pole double-throw switch;
One double-pole single-throw switch;
One wooden case (large enough to provide space for accessories);
One bakelite panel.

The accessories used with the test set follow:

One set of test prods;
One socket adapter, UX199 to UV199;
One socket adapter, UV199 to UX199;
One socket adapter, UX199 to UV-201A;
One Jewell UY socket adapter, type-521;
One test cord (made by connecting two UX199 bases by six feet of four-wire battery cable).

The complete schematic diagram of the set tester is given in Fig. 1. The portable a.c. voltmeter is not

connected directly in the tester, but it is a necessary piece of equipment which should be on hand at all times. One of the sockets called for in the list of parts is connected in the position indiacated by the tube in the diagram; the four wires marked "test plug" are connected to the terminals of the second socket. The notations on the drawing indicate many of the ways in which the tester may be used, but a few additional pointers may be of interest.

In checking a battery-operated receiver with this set tester it is best to start hy removing each tube of the set in turn and inserting it in the tube sockets of the tester, the test plug socket of the tester being used for the test cord which is also plugged into the empty socket of the receiver. Next, throw the double-pole switch to one side, but change it quickly to the other side if the d.c. voltmeter is incorrectly connected, i.e., if the needle tends to move in the wrong direction. With the tester connected in this manner the milliammeter will indicate the condition of the circuit under test; if the deflection of the meter is correct for the tube used, it is necessary to assume that the circuit and tube are operating properly, but a large deflection indicates a short circuit and zero deflection indicates an open circuit.

After the above check has been completed it may be necessary to make further tests in order to locate the exact position of the opened or shorted circuit. In this connection it is interesting to note that tip jacks have been provided on the tester so that each of the meters may be used separately. When testing a.c. sets the portable a.c. voltmeter is used to measure the filament or heater potentials, and then the circuit is checked in the usual manner with the tester. It should be remembered that the d.c. voltmeter will not record the filament voltages of an a.c. set, and, therefore, the double-pole switch should be open when making the tests.

The tools and replacement equipment which it is necessary for a service man to carry with him in the field vary in different territories. In districts where it is necessary to travel a considerable distance from the shop it is essential that the equipment be very complete, and it should consist of a large assortment of tools as well as a number of replacement parts, such as transformers, condensers, etc. On the other hand, when working in a city a large kit of tools and parts is not essential. However, it is always advisable to carry a complete assortment of tubes and a few minor parts such as grid leaks, fixed condensers, amperites, etc. For city work the tools which the average service man considers it necessary to carry are a pair of long-nose pliers, a screw driver and an electric soldering iron.

AN EFFICIENT TOOL KIT

THE writer was once employed as field engineer for a well-known manufacturer, and, while acting in this capacity, he covered most of the southern states. In this work it was necessary for him to carry a very extensive kit of tools in order to be able to meet all conditions. In this particular case the tools were carried in a case with straps for each tool, thus making it difficult to lose equipment as each strap had to be filled before leaving the scene of work. A list of the tools included in this kit is as follows: flat-nose pliers, long-nose pliers round-nose pliers, diagonal pliers, slip-joint pliers, long-nose angle pliers, duck-bill pliers, ratchet screw driver with three blades, screw driver with screw-holding attachment, set of Stevens Spintite wrenches with detachable handle, Yankee push drill, American Beauty soldering iron, bits, reamers, and counter-sink bits. The miscellaneous equipment consisted of solder, soldering flux, tape, saddle tacks, lead-in strips, ground clamps, etc.



A HANDY A.C. VOLTMETER AND TEST PLUG

SHORT-CIRCUIT TROUBLES

TROUBLES caused by open circuits, which were discussed at length in last month's issue, are only one of the many types of difficulties experienced in the repair of radio receivers. Short circuits cause the service man nearly as much worry as the former, and they will be considered in the following paragraphs. Short circuits, it might be explained, occur in accessories as frequently as in the set itself, and they frequently are the result of carelessness or inexperience on the part of the person installing the receiver.

Short circuits due to carelessness or inexperience frequently are found in the Radiola Super Eights and the Radiola 20's. In these receivers six dry cells are connected in series parallel, and in installing these batteries a short circuit is often caused by two negative terminals touching each other, thus shorting one or more batteries and causing the set to go "dead." Much time is lost and often another set of batteries is ruined before the real cause of the trouble is discovered.

Another rather baffling short circuit, which is encountered frequently, is found in the older types of reflex receivers, such as the de Forest. Although there are few of these sets in city homes, many of them are still being used in outlying farm districts. This particular short manifests itself as an open circuit, and, when the set is tested with a set checker the results indicate a burned-out transformer. However, further testing will show that the transformer is perfect; the trouble being caused by a shorted condenser in shunt with the primary or secondary winding of the transformer. When the faulty condenser is removed the set will function but bad distortion will be experienced until the condenser is replaced.

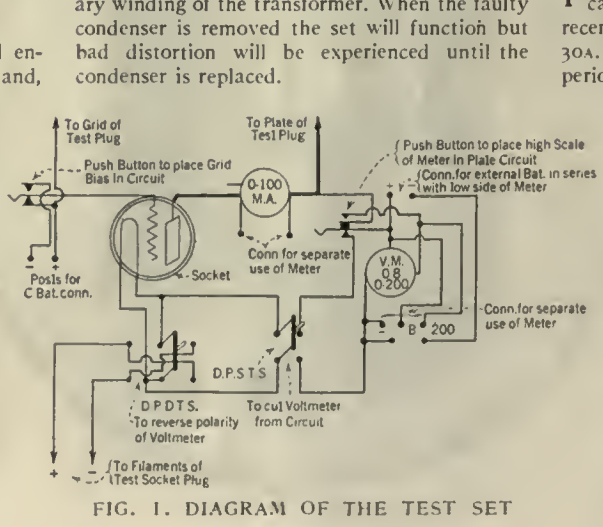


FIG. 1. DIAGRAM OF THE TEST SET

An interesting short circuit of a peculiar nature was discovered recently in a Radiola 18. The receiver provided entirely satisfactory results for several months before the trouble developed, and then the owner reported that the only way it was possible to obtain reception was to remove the first r.f. tube. The service man who was sent on the job went prepared to replace the tube which he considered defective. However, it was found that this was not the cause of the trouble. Upon removing the set from the cabinet after the usual test failed to indicate the fault, it was discovered that when the tube was inserted in the socket, instead of fitting into the contact springs, one of the filament prongs pushed its contact spring against another lead, thus causing a dead short circuit through the first r.f. coil and making the set inoperative. A simple operation with a pair of pliers shifted the spring to its proper position and corrected the difficulty.

One of the simplest receivers ever placed on the market developed one of the most unusual difficulties which has ever come to the attention of the writer. The set referred to was one of the old bread-board-type Atwater Kent receivers, and because of the simplicity of the receiver no complications were expected when the call for a service man was received. The owner stated that the set performed perfectly on the previous evening, but that he was now unable to coax it into operating. When the service man arrived he discovered that the set would play satisfactorily when held in the hand, but as soon as it was placed on the table it was inoperative; this was indeed an unusual condition. After carefully checking the set it was found in perfect condition, and then the surroundings were examined. Finally the trouble was found to be caused by the table cover on which the set had been placed; the cover being made of metallic tinsel, it caused a number of short circuits in the exposed wiring of the receiver. Then a little judicious questioning disclosed that the lady of the house had placed the table cover under the set during the day, and this explained why the set performed on the previous evening.

Table covers having metallic tinsel in their make-up have been the cause of more than one set being inoperative. A few days after the experience described above a service man was asked to repair a Radiola 18 which was found to have a short circuit caused in this way. In this particular case the location of the short circuit was never discovered, but removing the table cover corrected the difficulty.

CARELESSNESS IN SOLDERING

INNUMERABLE short circuits are caused by carelessness in soldering at the factory, and a recent example of this was found in a Radiola 30A. This set had been operating perfectly for a period of three months when it suddenly stopped, and all the usual tests failed to disclose the cause; even the continuity test of the manufacturer did not show anything wrong, still the set remained perfectly silent. Finally, it was discovered after a careful inspection, that a thread of solder, which was so fine that it was barely visible to the eye, was across the antenna and ground connections. This thread of solder probably was caused by the iron being slid from one connection to another when the set was wired and it did not cause a short circuit until the vibrations from the speaker caused it to sag. However, in the proper position, a thin piece of solder is as effective in stopping the operation of a receiver as a piece of No. 14 bus bar.

The Service Man's Corner

THE number of radio service men appears to be increasing with great rapidity. Many service men, both old and new are readers of RADIO BROADCAST and quite naturally look to these pages for information of specific help to them in their daily problems. It is true, in a sense, that every radio article is of some help to those working in the field, but articles prepared with the problems of the service man chiefly in mind are badly needed.

Regular features now found in this magazine are designed to be of general help to those working in this field. In this classification fall the RADIO BROADCAST Laboratory Data Sheets, RADIO BROADCAST's Service Data Sheets on Manufactured Receivers, "Strays" from the Laboratory, "Our Readers Suggest . . .," and to a certain extent, RADIO BROADCAST's Home Study Sheets. And, beginning with the November issue, we started a series of general articles on radio service problems by B. B. Alcorn.

The chief problems encountered in the field by service men are classified in order of their importance by Mr. Alcorn as follows:

1. Dead tubes.
2. Run-down batteries.
3. Open circuits.
4. Defective parts.
5. Defective grounds.
6. Use of various "gadgets."
7. Defective antenna.
8. Misconnections.
9. Short circuits.
10. Lightning arresters.

A few of these problems were discussed in Mr. Alcorn's November article. In later articles, he treats of the others. Do men actually facing the problems of curing sick radio sets in the field agree with this estimate? If not, in what order do they list the troubles? What interesting short-cuts to the work in hand have they evolved? What simple test-sets have they built for their own use? What small and persistently annoying little problems have been solved in practise? Wouldn't a short description of any one of these pet ideas prove helpful to others doing the same sort of work? "The Service Man's Corner" will be a regular feature of RADIO BROADCAST from this issue on, and contributions from service men and professional set builders are welcomed and will be paid for at regular rates.

WHAT ONE SERVICE MAN SAYS

THE data that I feel is most needed by the service man is along the lines of test apparatus that he can construct himself, and so know the whys and wherefores of what is happening when he uses the test sets, I have found a number of service men who can use the more elaborate test sets put out by several concerns. But few of them understand what the different readings show them about the condition of the receiver under test. These really fine pieces of apparatus are not serving their purpose unless they are in the hands of one who really knows how to use them." This service man concludes: "The servicing of radio receivers is a profession that no one need be ashamed of and the radio industry would certainly suffer if all service men were to be removed from the field."



The radio service man will not depart from the field, for he is too valuable a part of the present radio structure. "The Service Man's Corner" in RADIO BROADCAST will, we hope, be of help in making his work easier, by affording a medium where ideas and comment useful to him can be exchanged.

Field Suggestions

WHEN I received a letter from the editor of RADIO BROADCAST, suggesting that suggestions from service men would be appreciated and asking if I had anything to say, I felt much as I would if anybody had hinted that I might improve Bobby Jones' drive. And—in case you don't know—my golf drive looks like a sine wave. I have fooled around with radio receivers for some time, starting just after "ham" radio opened up after the war, so I can safely say I know nothing about radio. (You know, when you first start, you know it all). I've picked up a few kinks, most of which are doubtless ancient history to real service men. But I am glad to write about them in the hope that it will help bring to light some really good information on the subject from others. There seems to be a surprising dearth of information on the subject; I can't find any book that covers it.

WITH this issue, we start a regular page for the practising service man. This department will, we hope, be a forum where service men can discuss their problems, get their pet ideas into print, and see now and then a hint which will be useful in their daily work. Contributions, which preferably should be short, to the point and typewritten, are solicited and will be paid for if used. Address your articles to the editor, "The Service Man's Corner."

—THE EDITOR.

Use of a Set-Analyzer: The service man should have in his kit a good set analyzer, of any good make. Working without one makes the job harder than necessary, and the use of one has a valuable psychological effect on the set owner, which is worth something. This unit should be capable of measurements on both battery- and a.c.-operated sets, and its use should be thoroughly studied.

Another tool almost as useful is a modulated oscillator that will cover the broadcast spectrum, which can be modulated for balancing sets using neutralized circuits. I have one that is small, self-contained, and does the job. Single-control sets are now in wide use, and if the condensers in the set under test do not gang or do not follow very closely, the receiver cannot give its best performance. One of these oscillators will permit the service man to adjust the condensers to a nicety. Unless there is an adjustment provided, you do it by bending condenser plates, of course. The plates will get out of line in shipping, even when every care is taken at the factory. That, we are sorry to say, is not always the case. (A modulated oscillator was described on page 90, June, 1927, RADIO BROADCAST).

A tool I want is a tube checker working off the a.c. light socket to handle any of the usual tubes. They are on the market, but the price is too high for me and I am hoping RADIO BROADCAST will tell us how to build one. [A description of such a tube-checker as constructed in our Laboratory will appear in "The Service Man's Corner" in an early issue.—*Editor.*]

—H. J. GODDARD, Ellendale, N. D.

MISCELLANEOUS SERVICE SUGGESTIONS

MR. GODDARD has noted down some other service suggestions, which follow:

Line-voltage control: The advent of a.c. sets has shown up the floppy condition of the average commercial power line as nothing else could. Many a set is hooked to a line that varies from 105 to 125 volts. The latter condition is especially hard on tubes. Every service man should see to it, if the line voltage is high, that it is reduced to normal before it reaches the set. A 50-ohm resistor that will handle around 40 watts will do the trick. I like them variable particularly if they can be mounted on a bracket in a console, out of sight. They are cheap and will pay for themselves in no time. I'd like to see some reputable company build such a resistor that can be plugged-in between the outlet and the set plug so that a turn of the cap will permit adjustment. There should be a big sale for them. [A number of resistors which can be used for this purpose are now on the market. Although none of them have precisely the features which the writer desires, the adjustable units are satisfactory for the purpose.—*Editor.*]

Excessive plate voltage: Don't forget that a high plate voltage is almost as hard on a tube as high filament voltage. Watch that plate voltage if you want your tubes to last.

Blinking a.c. tubes: Every now and then you find an a.c. tube that is a blinker. These tubes start all right when cold, but when heated, a small break in the heater filament separates and for all practical purposes, the tube goes dead. When it cools a bit the ends come together and the tube starts again. I found a bad case of "fading" due to this very thing. Watching the tubes and noting which filament goes black of course localizes the trouble. [See p. 428 RADIO BROADCAST, April 1928, where this point was discussed at some length.—*Editor.*]

Caution: Ever notice the instructions to keep your hands out of a set when the a.c. is on? Manufacturers do that because they are sore at the mortician.



AS THE BROADCASTER SEES IT

BY CARL DREHER

Information in the Sound-Movie Field

IN ACCORDANCE with our recently announced intention to broaden the scope of this department, while not departing from its original purpose of serving the broadcaster, we are going to print considerable material on sound movies, of the same general type as the articles which have already appeared in "As the Broadcaster Sees It." For those readers who are interested professionally in talking pictures additional references will be of interest. I have prepared these in the form of a haphazard, informal bibliography—haphazard because sound movie articles giving varying degrees of technical information are appearing in great numbers and in widely scattered publications, so that any sort of complete collation is out of the question, and informal because it contains comments and information not usually included in the austere files of bibliographies. The list:

Transactions of the Society of Motion Picture Engineers. Vol. XII, No. 33. The current issue of this publication contains "A System of Motion Pictures with Sound," by H. B. Marvin of the General Electric Company; and "Some Remarks on the Acoustical Properties of Rooms," by J. B. Engl. Marvin's article is a description of the General Electric system as of April, 1928. With modifications and additions from other sources, this has become the R. C. A. Photophone system. The discussion is interesting, in that a good many questions are asked and answered which are likely to occur to almost all students of sound-movie technique. Copies of this issue may be secured from the Secretary of the Society, Mr. L. C. Porter, 5th and Sussex Sts., Harrison, N. J., at $2.50 each. Earlier issues have also contained sound-movie material.

Motion Picture Projection, by James R. Cameron. Cameron Publishing Co., Inc., Manhattan Beach, N. Y. The fourth edition of this handbook contains over 1200 pages, of which 124, starting with page 699, are devoted to sound movies. There are descriptions, mostly of the "hand-out" variety, of Movietone, some of Hoxie's pre-Photophone equipment, Vitaphone, Vocafilm, and Phonofilm. The paper on the last named is ascribed to Dr. De Forest. Following these general outlines there are detailed instructions for the operation of Western Electric sound-picture apparatus. Apparently this stuff is reprinted from the manufacturer's bulletins. It includes general layout wiring diagrams. The whole book is $6.00.

Bell System Technical Journal, Vol. V, No. 2, April, 1926. Published quarterly by the American Telephone and Telegraph Co., 195 Broadway, New York City. $1.50 per year; 50 cents per copy. This issue contains a treatise on "The Alkali Metal Photo-electric Cell," by Dr. Herbert E. Ives. The general characteristics of central cathode and central anode cells are given, together with a consideration of the effect of such factors as gas, polarization and wavelength of the incident light, the nature of the emitting material and the surface coated with it, temperature, etc. A selected bibliography is included. For those who can follow scientific expositions articles of this and the following type are very valuable.

General Electric Review, Vol. 31, No. 7, July, 1928. Published monthly by the General Electric Company at Schenectady, N. Y. $3.00 per year; 30 cents per copy. This issue contains an article by Dr. L. R. Koller on "The Photo-Electric Cell." It is of the same scholarly type as Ives' paper and contains valuable curves. A few references are given as footnotes.

The American Cinematographer, Vol. IX, No. 6, September, 1928. A camera man's magazine published monthly by The American Society of Cinematographers, Inc., at the Guaranty Building, Hollywood, Calif. Yearly subscription is $3.00; single copies, 25 cents. Material on sound pictures is printed quite regularly. The issue cited contains a story by Delmar A. Whitson on his system, and a discussion by the editor on "Who Invented Talkies?" The material is uneven and often not free from mistakes, but should prove informing to readers who do not know much about the field and want to acquire semi-technical knowledge.

The Motion Picture Projectionist, Vol. I, No. 11, September, 1928. This magazine is published monthly by the Craft Publishing Co., 45 West 45 Street, New York City; its readers are mostly motion-picture operators and the material is semi-technical, about on the same level as that in the *Cinematographer.* The September, 1928 issue contains a leading article on "Light Sensitive Cells" by Samuel Wein, a discussion by Friend Lescaboura on "Just What May We Expect of Television?" some Electrical Research Products material, a reprint from the *Electrical Workers' Journal* by Prof. C. M. Jansky, "How a Rotary Brush of Light Paints Pictures from Afar" (picture transmission) and various little items of interest. Like most of the movie-trade journals, it carries a lot of audio picture stuff.

Exhibitors Herald and Moving Picture World. This trade weekly carries a monthly supplement, *Better Theatres,* which contains semi-technical sound-movie articles of varying degrees of reliability. The New York office is at 565 Fifth Avenue. Subscription costs $3.00 a year. The September 1 issue carried a theatre architects' symposium, the conductor of which announced as one of the major conclusions, "Corrective work will be necessary in houses where no acoustical properties now exist," while some of the contributors were responsible for such illuminating statements as, "Will probably require the use of loud speaker equipment" (in answer to the question, "What effect will the synchronized pictures have on the acoustics in building the theatre of the future?)" and, "Yes, where this has not been considered, sounds and tones are more sharp," the question being, "Will it be necessary for present day theatres to reconstruct so as to provide for the proper acoustical properties in the auditoriums?" Although the number of such inane answers was large, the idea of the symposium was good and a few searching comments were elicited. A comical piece in this issue was an illustration of a section of the dome of a theatre, showing treatment with acoustical felt, and captioned, "Acoustics in the Fox Theatre, Detroit." In the September 29 issue F. H. Richardson, who edits the "Better Projection" department of the *Exhibitors Herald and Moving Picture World* had a discursive but fairly informing article on "The Pick-Up," covering methods of getting audio

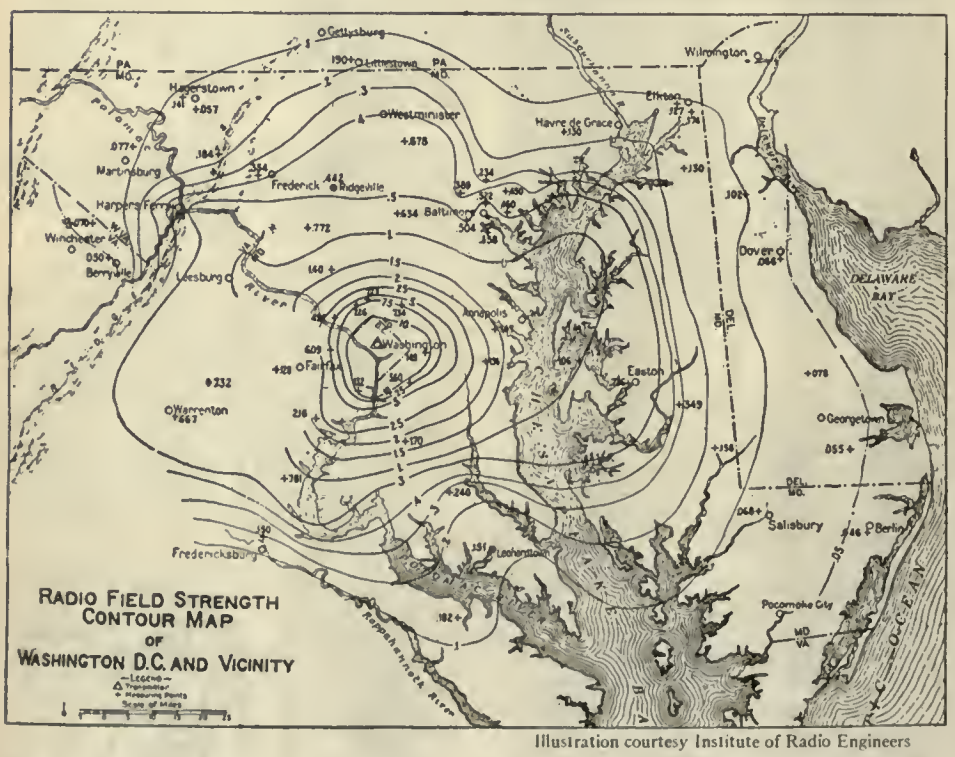


Illustration courtesy Institute of Radio Engineers

MAP OF WASHINGTON, D. C. SHOWING FIELD STRENGTH OF SIGNALS FROM WRC

input to the amplifiers from film and disc sound records. The illustrations were excellent. Richardson talks on paper, so to speak, which is fine in fostering informality but uses up a lot of words when carried too far. The August 25 issue of the same magazine carried a description of the RCA Photophone system, under the title of "How RCA Photophone Times Synchronism." Except for the title and a few mistakes in the text, the article was informing enough.

The combined bibliography and review printed above will give some idea of the variety of publications in which articles on or pertaining to sound pictures are to be found. It includes only those periodicals in which such material appears more or less regularly.

Broadcast Standardization

THE National Electrical Manufacturers' Association (NEMA) has a transmitter Section which deliberates occasionally on the subject of what broadcast transmitters should be like and in what terms it is valid to talk about them. The last meeting, in June, 1928, discussed a number of technical subjects especially pertinent in view of present developments.

The following methods for adherence to assigned frequencies by means of automatic master oscillator control are specified:

a. Quartz crystal
b. Standard clock with harmonic amplifier
c. Tuning fork
d. Magnetic striction bar

In any case it is specified that the master oscillator is to be arranged to be independent of external changes in humidity, temperature, barometric pressure, or loading.

Under the allied subject of frequency monitoring the Section adopted as a standard the use of an oscillating or heterodyne frequency meter whose frequency is held constant by one of the methods above, and so constructed that it can be shipped periodically to a primary standardizing laboratory.

In rating the coverage of a broadcasting station the population contained within the area over which the field strength is 5000 microvolts per meter, or more, is considered basic. Beyond this, under favorable transmission and reception conditions, it is permissible to add the population within a circular area having a radius four times the mean radius of the basic area. In determining the distances corresponding to the 5000 microvolts per meter field strength, measurements are to be made during the daytime on not less than 10 radii spaced at approximately equal angles around the station.

All this is, of course, empirical, but it is certainly effective in bringing down estimates of broadcast coverage from the blue sky to the solid earth. Applying the method to a specific case, we may use the Radio Field Strength Contour Map of Washington D. C., and Vicinity, presented as Fig. 9 in the paper by Bown and Gillett: "Distribution of Radio Waves from Broadcasting Stations over City Districts," (*Proceedings* I. R. E., Vol. 12, No. 4, August, 1924). This map was based on measurements made on the old WCAP 500-watt transmitter, which is no longer in existence. The contour lines in the case of Washington are quite close to circles, the transmitting conditions being favorable for urban conditions (few high buildings, and a general distribution of low buildings and open spaces). The 5 millivolt per meter contour is a circle with a radius of about 14 miles around the transmitter. The population within this circle would have been the basic population served by WCAP. Under favorable conditions WCAP would have been credited with the population within a radius of 56 miles (four times the mean radius of the basic area, in this case fourteen miles). The half-tone on these pages shows the radio field strength contours for WEAF superimposed on an aërial photograph of New York City.



© Fairchild Aerial Camera Corp.

AN OLD MAP SHOWING RADIO FIELD-STRENGTH CONTOURS OF WEAF SUPERIMPOSED ON AN AERIAL PHOTOGRAPH OF NEW YORK CITY

In rating the audio-frequency characteristics of a broadcasting station the NEMA Transmitter Section prescribed the following method: The number of octaves transmitted above 800 cycles (the mean speech frequency) and those transmitted below 800 cycles, with a deviation not to exceed plus or minus 1 TU, measured from the microphone input terminals to the rectified antenna output, shall be counted, and the smaller of these two numbers multiplied by two. The resulting number shall stand as the audio-frequency characteristic rating of the station.

On this basis a transmitter with a frequency characteristic flat within 1 TU between 100 and 7000 cycles would receive a rating of 6, since it transmits 3 octaves both above and below 800 cycles. If it only went up to 4000 cycles its rating would drop to 4, since it would be based on the two octaves above 800. Even if it went down as low as 50 cycles it would receive no extra credit, since the method of rating requires a balance between the ability to transmit high and low notes. About the highest rating within reach is 8, entailing flat transmission up to 12,800 cycles on the high end, and 50 cycles on the low. Apparently no one can get credit for going down below 50 cycles. If loud speakers are improved this point might be criticized, and likewise the 1 TU tolerance is open to question, since it cannot be detected by ear. A 3 TU tolerance might be preferable in practice. The general method, however, seems excellent.

Under "Modulation Capability" the committee specifies a single-frequency sine-wave audio input, to the maximum degree of modulation possible without "noticeable distortion," the analysis being on the basis of rectified radio-frequency output.

For the purpose of supervising modulation the Section specifies the use of a standard volume indicator, on the scale of which the following relative limits are to be allowed:

Constant testing tone	30 divisions
Music peaks	30
Piano peaks	20
Speech	15–20

These values correspond to standard practice in chain broadcasting. The piano is more sensitive to slight overloading and so is given more margin, while speech is kept down to a value where announcements will not break into the music with obtrusive loudness.

Regarding microphone set-ups for broadcasting the committee decided that, in "view of the present relatively undeveloped state of this portion of the art," this subject should be tabled. This was no doubt a prudent move, since as things stand there are as many microphone set-ups for a given aggregation of musicians as there are musicians, announcers, engineers, musical directors, acousticians, program managers, commercial sponsors, studio supervisors, and advertising experts in the room, every man is sure he is right, and nobody can prove anything one way or the other.

Under "Standard Reference ('Zero') Level for Broadcasting Use," the NEMA group laid down the following specification: "It shall be standard for broadcasting use, to regard the term 'reference level' ('Zero level') as referring to a power of 10 milliwatts, corresponding to a current of 4.17 milliamperes flowing through a resistance of 600 ohms, or 2.47 volts across 600 ohms." This definition should put a stop to the endless wrangling about "zero level" which has been going on among the broadcasters.

Transmitter name plates, says the NEMA, should contain the following data: (a) Power rating in kilowatts; (b) Radio-frequency range over which the set will deliver full power; (c) Characteristics of the antenna for which the set is designed. That the power rating is to be in terms of power delivered to the antenna should have been specified, since in many countries power to the plates of the radio-frequency tubes is the basis of rating.

If the Transmitter Section continues its work on this plane it will become one of the most influential agencies in this branch of the industry.

Some Experiments With Band-Pass Filters

By KENDALL CLOUGH

Engineering Department, Silver-Marshall, Inc.

FOR months we have been trying to secure quantitative data on band-pass selectors and filters for use at broadcast frequencies. Not only does Mr. Clough, who is Chief Engineer of Silver Marshall, Inc., give the result of his laboratory work, but he gives some idea of how the home experimenter may play with the circuit for himself. Mr. Clough promises more interesting how-to-do-it material for an early issue.

—THE EDITOR.

A CONSIDERABLE amount of material has appeared in the engineering press on band-pass filters for radio-frequency tuners. Principal among these is the circuit discussed by Dr. Vreeland in the *Proceedings* of the Institute of Radio Engineers, March, 1928. In his paper Dr. Vreeland points out very completely the advantages of the use of a band-type filter in the tuner of the receiver, but for the benefit of those who have not had access to this paper, these advantages are redescribed here.

If we were to connect a stage of radio-frequency amplification, as shown in the circuit of Fig. 1, and run a resonance curve at 1000 kc., we would find that the circuit responded at and about resonance as shown in curve A of Fig. 2. Now in receiving a signal from a transmitter at 1000 kc., we would find that, in the course of modulation, frequencies varying from 995 kc. to 1005 kc., had been combined with the carrier. Obviously, if the reproduction is to be of the best, a band of frequencies must be transmitted from the antenna to the loud speaker with equal amplitudes rather than the single carrier wave only. Just how wide this frequency band should be has been the point of many discussions, some contending that we need to regard only a band 5 or 6 kc. either side of resonance, while others believe that a band 10 kc. wide each side of the carrier is necessary for perfect fidelity of reproduction. The finest audio equipment manufactured to-day is designed on the 5 kc. basis, so it seems superfluous to consider a band of greater width than this. We are not concerned here with the actual band width, however. The fact remains that, whichever stand one wishes to take, the resonance curve A of Fig. 2 does not permit the free passage of a band of frequencies of any

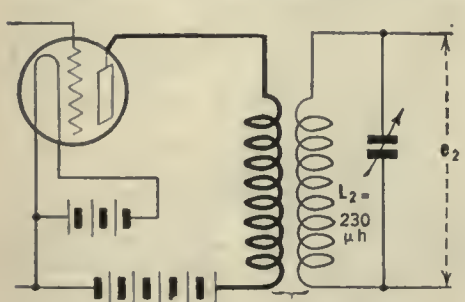
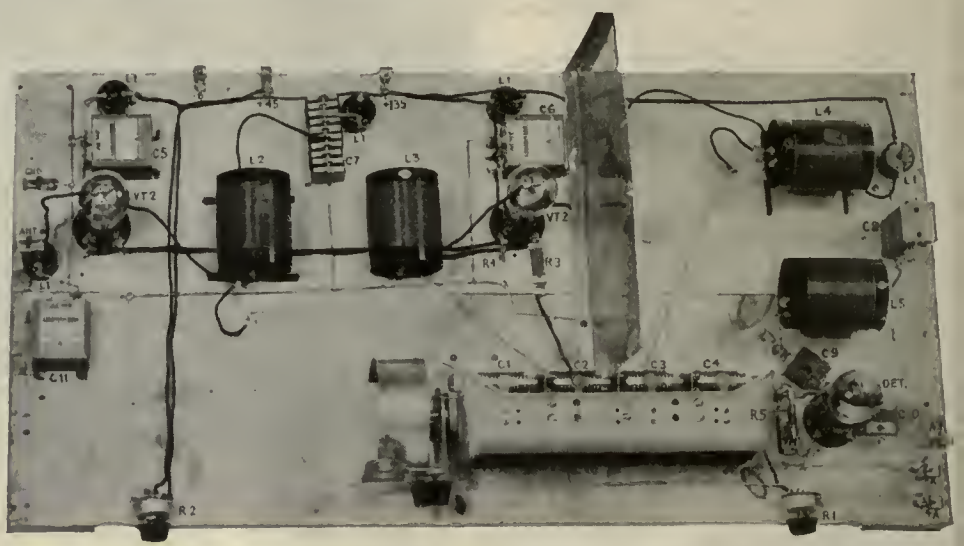


FIG. 1

A transformer with a tuned secondary constitutes the coupling device used between one radio-frequency amplifier tube and another in the vast majority of present-day receivers.



THIS PICTURE SHOWS THE EXPERIMENTAL BREADBOARD RECEIVER WHICH THE WRITER CONSTRUCTED TO TEST THE BAND-PASS PRINCIPLE

appreciable width. It will be seen in the curve that a frequency 5 kc. off resonance is amplified only 83 per cent. as greatly as the carrier, and a frequency 10 kc. off resonance only 62 per cent. as great.

RESULTS WITH THREE STAGES

FROM an interference standpoint the single stage of amplification would be far from adequate for modern conditions, so we have shown the resonance curve B in Fig. 2 which was obtained by cascading three of the circuits. It can be seen that the selectivity to an interfering station is greater, while the 5 kc. amplification is only 60 per cent. of normal and the 10 kc. amplification 25 per cent. of that of the carrier. The operation of this receiver would be equivalent to the use of a tuner with a perfect band pass and an audio amplifier having good amplification of the bass notes and falling to 60 per cent. of the bass amplification at 5000 cycles, and 25 per cent. at 10,000 cycles. It should be remarked that the receiver having the resonance curve B of Fig. 2 would not be considered a particularly selective receiver, so the reader can judge for himself the side-band cutting that is going on in the high-grade selective outfits. The ear is a tolerant device, and never seems to miss that which it has not heard.

Now, it may be demonstrated that the resonance curve shown is a definite geometrical shape. By this we mean that there is no adjustment (such as the resistance of the coil, the primary coupling, or the L/C ratio) which will cause the circuit to admit, say, a 5 kc. band with more facility without admitting an interfering station 10 or 20 kc. off resonance with corresponding facility. Thus, the only circuit of the usual resonant type which would provide perfect fidelity would be a circuit infinitely broad, a mathematical fiction which would be worthless in reality. This indicates that an entire change in the shape of tuner response would be desirable.

The dotted-line rectangular curve of Fig. 2 would be the theoretical ideal shape. This shape is not capable of attainment, but there is a circuit, old in the art, which under proper conditions will produce a response approximating this curve more or less closely.

Dr. Vreeland has discussed a similar circuit (Fig. 3) in detail in the paper mentioned, but it can be shown that this circuit is the analytical equivalent of the circuit with which we are to deal, Fig. 4, and which has been covered theoretically in all standard texts. So thoroughly has it been discussed that there is little we can add to the treatment other than to present curves and observations made in the laboratory. It is hoped that certain readers will find sufficient material and interest in these notes to enable them to go on with the experiments in this interesting field of band-pass filters which is far from a state of perfect practical application.

The theory of this circuit indicates that, when the coils, coil resistances, and condenser capacities are identical in each circuit, both circuits are tuned to the same frequency (due to the identical construction) when operated independently.

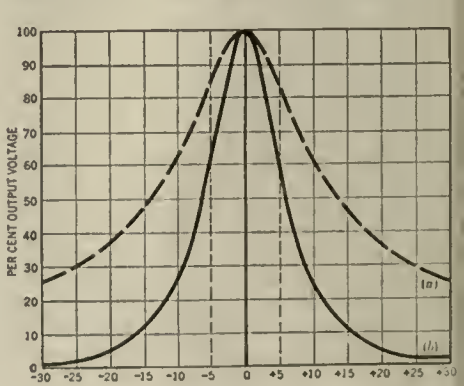


FIG. 2

If the voltage across the condenser in Fig. 1 (e_2) were measured as the frequency of the voltage input to the preceding tube was changed, a curve similar to "a" in this graph would result. If three stages were used, the selectivity would be greater, as shown by the decreased response at points far away from resonance in curve "b."

However, they actually tune to two separate frequencies when operated with coupling between the two circuits as shown. In other words, if the coils and capacities are of the proper size to tune both circuits, L_1, C_1, and L_2 C_2, to a frequency of F_1 kc. independently, the combination will not have any resonant peak at F_1 kc., but will have two resonant peaks at other frequencies. One of these peaks will be F_m kc. above the frequency of resonance, the other will be F_m below the frequency of resonance and this interval of F_m is defined by the equation:

$$\frac{M}{L_1} = \frac{M}{L_2} = 2\frac{f_m}{f_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

This equation says in simple terms that, if the mutual inductance between the coils is A per cent. of the inductance of either coil, there will be a peak of resonance A/2 per cent. either side of the frequency of resonance of the circuits considered independently. Thus, in the circuit of Fig. 4, if we select two coils of 230 microhenries each, tune them independently to 1000 kc., and then couple them with a mutual inductance of 2.3 microhenries, there will not be a resonant peak

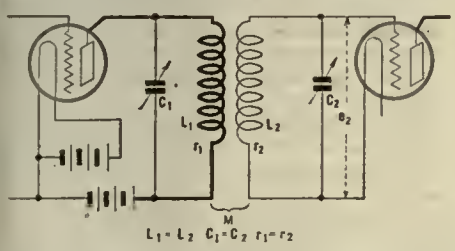


FIG. 4

Mr. Clough chose to study this variation of the Vreeland scheme—he uses the mutual inductance between two coils as the coupling impedance.

at 1000 kc., but there will be two other peaks, one at 995 kc., and the other at 1005 kc. Anticipating that this arrangement would approximate ideal selectivity, the circuit was set up for measurement and curves were run.

ANALYSIS OF CURVES

THE circuit used for these curves is shown in Fig. 5. Two commercial coils of very low-loss construction, the specifications of which are given on the circuit, were chosen for the tuner. Two mechanical placements are given in Fig. 5A which resulted in a measured mutual inductance of 1 per cent. of the coil inductance. In order to compensate the tube and other capacities of the circuit, the tuning of the condensers was accomplished by disconnecting the primary condenser, C_1, and tuning the secondary to resonance with the desired wave, then disconnecting the secondary condenser, C_2, and tuning the primary. It was necessary to use a strong signal from the oscillator while tuning in this manner as the transfer from one coil to the other was very low. After tuning each circuit independently, both condensers were connected and the curve for a particular frequency measured. These curves were taken at 600, 1000, and 1500 kc., and are shown in the full lines of Fig. 6. It will be noted that they check very well with the theory of the circuit, for in the 600 kc. curve Fig. 6A, we have the two resonant humps lying very close to 3 kc. off resonance on either side while in the 1000 kc. curve, Fig. 6B, they are 5 kc. off the normal resonance of the individual circuits. The 1500 kc. curve did not turn out as well, although the separate resonances can still be distinguished. It will be noted that the curve at 1000 kc. compares very favorably with the ideal curve as the amplification varies very little in the 5 kc. pass band either side of the carrier. Attention is called to the variation with frequency in the width of the band passed in the three curves, which was predicted in equation (1) to which we will refer later.

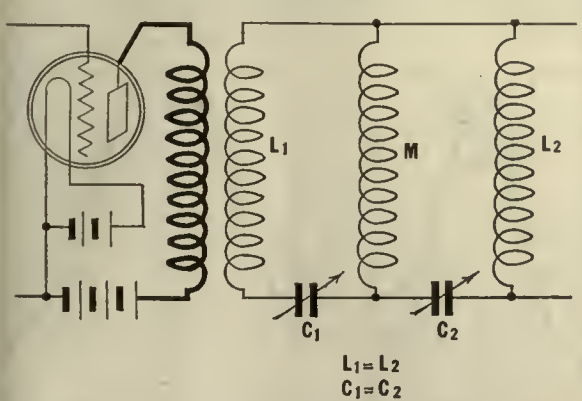
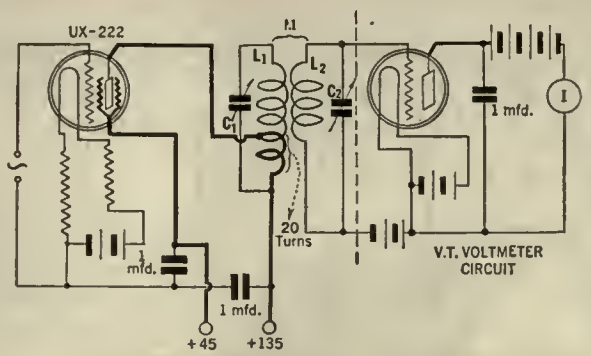
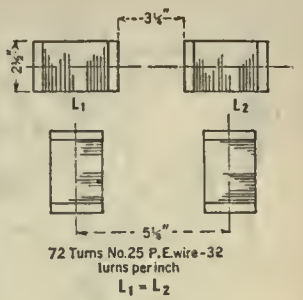


FIG. 3

Dr. Vreeland's circuit started all the discussion regarding band-pass tuning for broadcast-frequency amplifiers. It consists of two identical coils and condensers tuned to the same frequency and coupled together by an inductance.





(DIAGRAM A)

FIG. 5

How the circuit actually was set-up to be measured. A screen-grid tube fed the vacuum-tube voltmeter by means of the band-pass coupling mechanism. Diagram A—Two possible methods of obtaining one per cent. coupling between the two Silver Marshall coils used by Mr. Clough.

The low amplification obtained with the screen-grid tube in the above curves is of no moment for our discussion. It was due to the low value of coupling used between the tube and primary circuit (20 turns at the base of the coil), which was employed in order to prevent the tube circuit from affecting the coil circuit until the curve shapes were assured.

In order to compare the shapes of the band curves of Fig. 6 with the performance that would be obtained when using the same tube, coupling, and coils in Fig. 7, the secondary circuit was removed and the measurement repeated with the single circuit shown in Fig. 7. These curves are plotted in dotted lines in Fig. 6 so they may be compared with the band-pass filter performance. It will be noted that at each measured frequency the selectivity of the band circuit is greater than the ordinary resonant circuit and that the amplification is about on a par, one with the other.

Other curves were checked using the whole primary coil for coupling to the tube. It was found that the curve shapes remained substantially the same as shown in the full lines of Fig. 6, but the amplification went up to an average of 30 per stage.

NEW FILTER UNIT

OTHER studies of this circuit indicate that the coil resistance must be kept very low in order to maintain the desired shape of curve and amplification for the stage. A similar type of band-pass filter having two sections has appeared recently upon the market and the writer had an opportunity of running a curve on the selector feature. The size of the coils was such that a high resistance could be predicted and the resulting curve is shown in Fig. 8. It will be noted that the amplitude varies very badly with the frequency and the band effect, while better than the average tuner, is far from the desired shape.

To check by actual observation the effect of the band passed on the reception, a receiver was made in breadboard style with two of the band circuits and screen-grid tubes. Feeling that some readers may desire to hear this circuit for them-

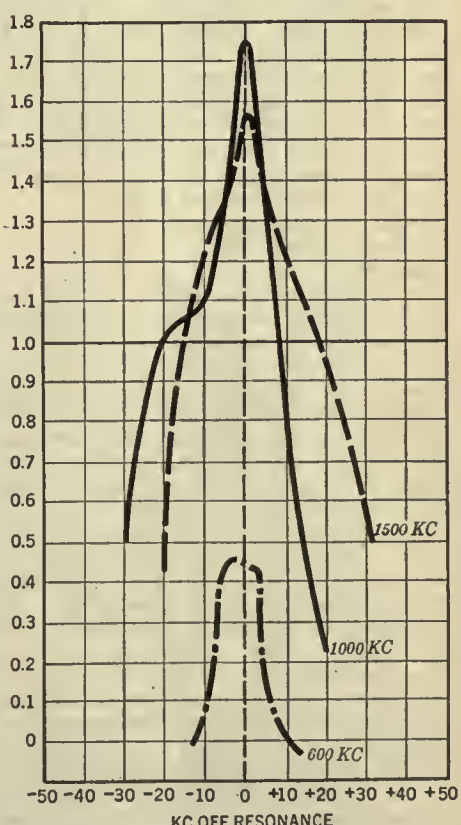


FIG. 8

A commercial receiver uses a system somewhat similar to the one described in this article. The result obtained in measuring the ratio between output and input voltages of such a band-pass selector is shown in this figure.

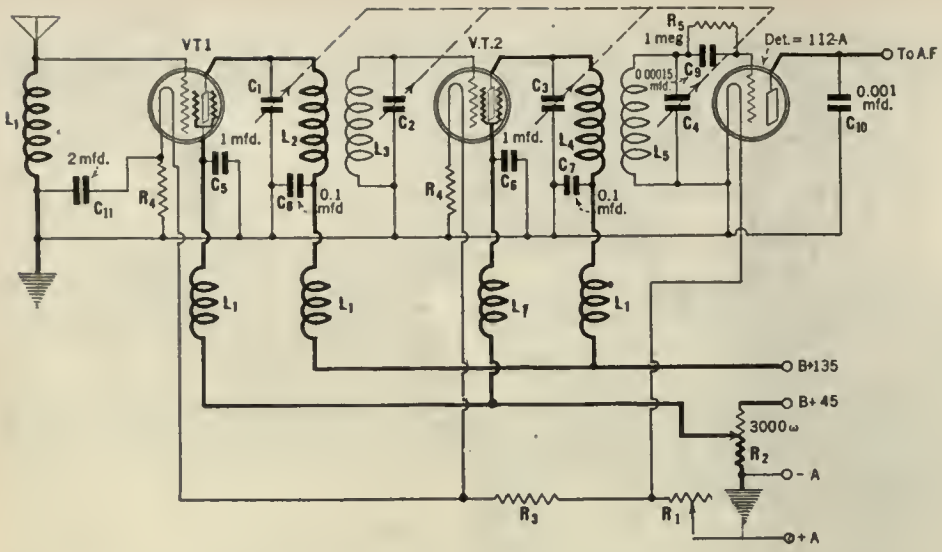


FIG. 9

The complete schematic diagram of the experimental breadboard receiver which is pictured at the head of this article. Note the thorough filtering of all the screen-grid and plate leads, the volume control which varies the screen-grid voltage, and the absence of shielding except the single metal plate.

selves, the complete circuit diagram of this set-up is given in Fig. 9, as well as a photograph from which the physical considerations can be seen. One coil of each of the pairs was mounted in slots so that the coupling could be varied, thus varying the width of the pass band. The distance between coils used in making the curves was marked so that it could be referred to during operation of the receiver.

This receiver was operated for two evenings in conjunction with a Silver-Marshall type 682–250 pack with remarkable results from a quality standpoint. Several unbiased observers stated that it was the finest quality of reception they had ever heard, noting particularly the excellent timbre of the high notes of the piano and organ. It would be even safe to say that some of the curse is removed from soprano solos when the overtones are freely admitted by a band filter.

By placing a milliammeter (0–3) in the plate circuit of the detector, the double hump of the curve could be noted at the lower broadcast frequencies. Selectivity was ample for Chicago conditions, good clear spaces being obtained between the local stations in a location where local field strengths were very great. In these clear spaces on the dial two out-of-town stations could be heard weakly, but the amplification of the system was not sufficient to provide a good signal. The receiver in the form indicated could be called an excellent local receiver of the highest quality. To extend the scope of this model beyond local reception, two possibilities present themselves for the future. The first would be the addition of band-pass filter stages. This does not appear feasible except for those who can bear the expense and the necessary difficulties attendant with the matching of the large number of stages which would be involved. The other possibility is the use of a broad amplifier having no manual adjustments and equally responsive over the whole broadcast band. Many will recall the amplifiers of this type used in the early days of broadcasting when the tuned radio-frequency receiver came to the rescue. Perhaps with more general knowledge of electrical theory better success could be obtained with this type of circuit than in the past. The two tuned circuits above present sufficient selectivity to form very fine receivers with a good "untuned" amplifier of this type.

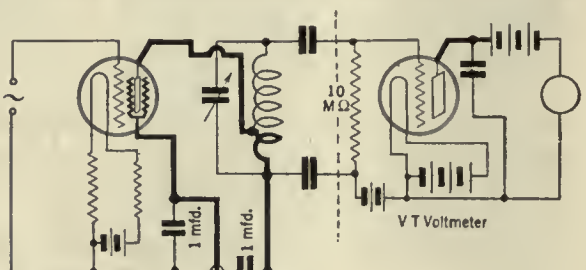


FIG. 7

The dotted curves in Fig. 6 were taken with this circuit, which is an auto-transformer in which part of the coil is used as primary and all of it as secondary.

CONCLUSIONS

WHILE this is not intended to be a "final hearing" on the subject of band-pass amplifiers, it would appear that sufficient material has been presented to arrive at the following conclusions with regard to circuits of the type discussed:

(1) That the coils must be carefully matched and of low-loss construction in order to obtain a good band-pass filter effect. Good coils are usually large physically, so good band-pass filters can be expected to have a considerable amount of bulk in their finished form.

(2) That with good coils, better selectivity per stage can be attained than is to be had with the same coil operating as a conventional radio-frequency transformer. In general, it can be said that this increase will not be great enough to compensate the greater cost of the band-pass tuner stage, which is at least double that of the single circuit.

(3) That the width of the band passed will vary with frequency when attempting to tune the broadcast band by means of fixed coils and variable condensers. This follows from the theory of the device, and was confirmed by the curves which show that with a 1 per cent. coupling the band passed was 10 kc. wide (total) at 1000 kc.; 6 kc. wide at 600 kc. This constant percentage relationship prevents the attainment of the correct band width except over a small range of frequencies without changing the coupling between the coils. A similar situation has been long tolerated in radio-frequency transformers, however, so this is not a serious consideration.

(4) That it is not possible to cascade sufficient of these stages to obtain the degree of amplification that is usual in sensitive radio receivers without prohibitive cost and constructional difficulties.

(5) Far superior tone quality can be obtained by the use of a band-pass device than from the use of simple resonant circuits. It is undoubtedly on this last point that the band-pass filter will find a prominent place in the radio art.

LIST OF PARTS

THE apparatus used by the writer in making this investigation is given below. There is nothing special in any of the parts, and similar apparatus would perform as well. The coils, as mentioned above, must be of low-loss construction.

The list follows:

L_1—1 S-M r.f. choke coil, No. 275;
L_2, L_3, L_4, L_5—4 S-M inductances, No. 140 (minus primary);
C_1, C_2, C_3, C_4—1 Four-gang condenser, 0.00035-mfd.;
C_5, C_6, C_{11}—3 Parvolt condensers, 2-mfd.;
C_7, C_8—2 By-pass condensers, 0.1 mfd.;
C_9—1 Carter condenser, 0.00015-mfd.;
C_{10}—1 Condenser, 0.001-mfd.;
R_1—1 Filament resistor, 10-ohm;
R_2—1 Potentiometer, 3000-ohm;
R_3—1 Filament ballast, 10-ohm;
R_4—2 Filament ballasts, 10-ohm;
R_5—1 Durham grid leak, 1-megohm;
8—Fahnestock clips;
VT_1, VT_2—2 Screen-grid tubes;
Det—1 Detector tube, 312-type.

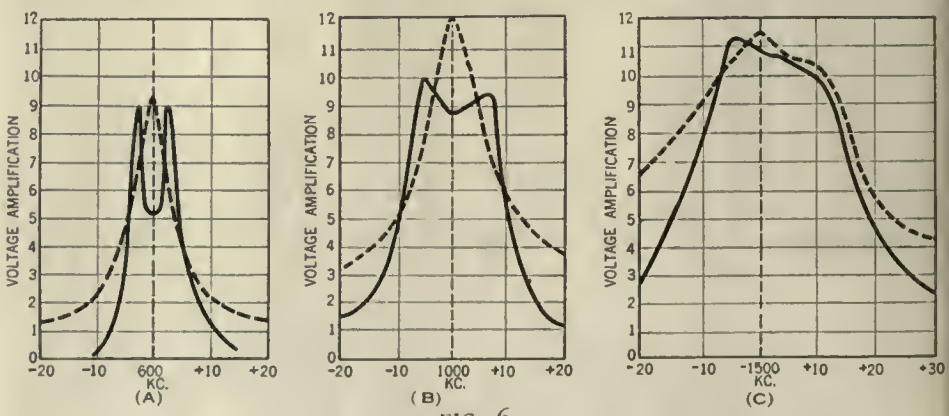


FIG. 6

The result—note that in each case the dotted curve, which represents a conventional transformer with only the secondary tuned, has poorer selectivity than the double-tuned transformer.

No. 11 **Radio Broadcast's Home Study Sheets** December, 1928

Resonance in Radio Circuits

Part I

WHENEVER one tunes his radio receiver or transmitter he performs one of the most interesting and most fundamental experiments in all electrical science; he demonstrates a phenomenon that underlies practically all radio work. This is the phenomenon of resonance which occurs in an a.c. circuit under certain conditions of inductance, capacity, and frequency.

To study, experimentally, this phenomenon of resonance, we will need the following:

LIST OF APPARATUS

1. A simple radio-frequency generator consisting of a vacuum tube connected to a coil and condenser as in Fig. 1. The plate potential of 150-180 volts may be supplied by a standard B-power unit.

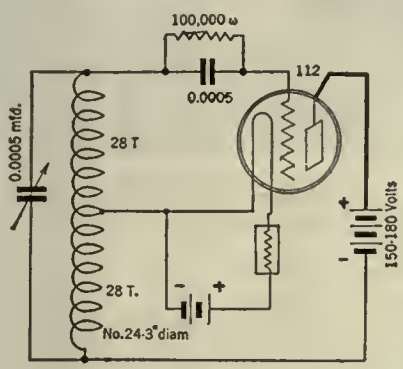


FIG. 1

2. A meter which will read radio-frequency current. The Weston Model 425 thermo-galvanometer is a good example. It will measure 115 milliamperes at radio frequencies, has a resistance of 4.5 ohms, and costs $18.50. This is rather expensive, but, in view of the number of uses to which it can be put, it is found in every well-equipped laboratory. Other meter manufacturers make similar meters.

3. A coil. The one used in taking data for this experiment was part of a Browning-Drake Kit and had the following dimensions: number of turns, 46; length of winding 1–11/16"; diameter, 2–11/16". The wire was about No. 24 and was spaced about the diameter of the wire.

4. A calibrated variable condenser—a good one is a General Radio Type 247-E in which the capacities are engraved on the dial.

PROCEDURE

Start up the generator, and if possible, measure its frequency or wave length. This is not essential, however. Connect the coil, the condenser, and the current meter in series. Couple the coil loosely to the generator inductance, and slowly tune either the generator or the tuning condenser until some current is read on the meter. Tune through "resonance," indicated when the current is a maximum, making sure that the meter does not go off scale. Now use as loose coupling as possible to the generator, and plot the current (or deflections of the meter) against condenser degrees and condenser capacities, as the tuning condenser is varied through resonance with the generator. A specimen "resonance" is shown in Fig. 2. Add a 10- to 30-ohm resistance in series with the circuit and repeat.

Calculate the inductance of the coil from the formula given in Home Study Sheet No 2 (August RADIO BROADCAST) and from the formula connecting wavelength, inductance and capacity,

$$(\text{wavelength})^2 = 3.54 \times L \times C$$

where C is in mmfd.
L is in microhenries
wavelength is in meters.

DISCUSSION

What is happening that the current in such a combination of apparatus, known as a series-resonant circuit, increases at first slowly, then more rapidly, then decreases sharply, and finally falls off to a very low figure?

The answer may be found in Home Study Sheets 7, 8 and 10. In these sheets the effect of a capacity, and an inductance upon the a.c. current in a circuit was discussed. Thus, in an inductive circuit

$$I = \frac{E}{X_L}$$

$$= \frac{E}{6.28 \times L \times f}$$

and in a capacitive circuit,

$$I = \frac{E}{X_C} = E \times 6.28 \times C \times f$$

and when L, C, and R all exist in a series circuit, the current I is

$$I = \frac{E}{Z} = \frac{E}{\sqrt{R^2 + (X_L - X_C)^2}}$$

$$= \frac{E}{\sqrt{R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2}}$$

where Z is called the impedance of the circuit
ω is equal to 6.28 × f
f is the frequency in cycles
X is the reactance of L or C

Now an inspection of this formula for current shows that the capacity reactance is to be subtracted from the inductive reactance to get the total reactance in the circuit which, combined with the resistance, forms the impedance which controls the flow of current. If, therefore, we add sufficient capacity reactance to the circuit, so that it is equal to the inductive reactance, the two, when combined by subtracting their values, add up to zero, and the impedance then is composed of the resistance only. In other words, tuning the condenser changes the capacity reactance, thereby decreasing the total reactance, decreasing the impedance, and increasing the current.

This is exactly what was done in the above experiment. We balanced out the inductive reactance, which is determined by the coil and the frequency, by changing the capacity reactance, which is determined by the condenser and the frequency. When the two reactances are equal in value but of opposite effect, the total impedance offered to the flow of current is very low, consisting of R only at this value of L, C, f, and the current is a maximum.

In a series resonant circuit the current may become very high although the driving voltage, which is across the entire circuit, may be fairly small, and although the individual reactances of the coil and condenser are large.

VOLTAGE IN CIRCUIT

As in all circuits the voltage across any part is the product of the current through it and its impedance. Thus the voltages across a resistance, inductance, or condenser in such a circuit are:

$$E_R = I \times R$$
$$E_L = I \times X_L = IL\omega$$

$$E_C = I \times X_C = \frac{I}{\omega c}$$

and since the current at resonance may become very high—it is governed by the voltage and resistance only—the voltage across the coil and condenser may become very high. For example, if 100 milliamperes flow in a circuit at a resonant frequency of 1000 kc. when the inductance is 200 microhenries, the voltage across the coil is

$$E_L = I \times L\omega = (100 \times 10^{-3}) \times (200 \times 10^{-6}) \times (6.28 \times 1000 \times 10^3)$$

$$= 125.6 \text{ volts}$$

although, if the resistance in the circuit is 10 ohms, the impressed voltage necessary to drive 100 milliamperes through it is only one volt.

A series circuit may be tuned to resonance by varying either the capacity as is usually done—or the inductance, or the frequency. Below the resonant frequency the principle reactance is capacitive. The inductance offers little reactance at low frequencies. At frequencies higher than resonance, the major reactance is the inductance, because the condenser reactance steadily decreases with frequency. At the resonant frequency the two reactances are equal, and hence the voltages across them are equal. This occurs when $X_L = X_C$, or when

$$f = \frac{159200}{\sqrt{L \times c}} \text{ when } L = \mu h,\ C = \text{mmfd.},\ f = \text{kc.}$$

Thus a series-resonant circuit is a kind of voltage multiplier. A small driving voltage across a low-resistance ("Low-loss") circuit will cause a high current flow at resonance and a large voltage to appear across the inductance and coil.

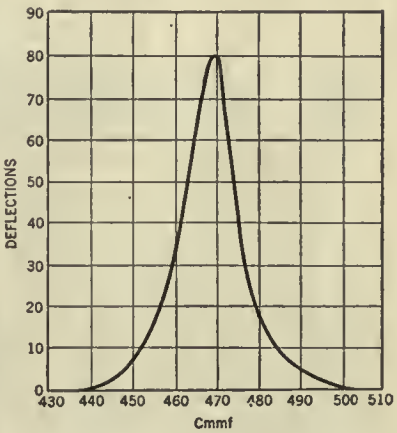


FIG. 2

PROBLEMS

1. Assume L = 200 microhenries, C = 500 mmfd, R = 10 ohms. Calculate the reactances, impedance, current, resistive, and inductive and capacitive voltages in the circuit when E = 10 volts. Plot all these against frequency from 400 to 600 kc. If the experiment outlined under Procedure has been carried out, use the values of L and C obtained there and assume R = 10 ohms. Since the current is known, calculate the voltage across the circuit at resonance.

2. How do the two calculated inductance values check?

3. Does the current lag or lead the voltage below the resonant frequency? At the resonant frequency what happens to the phase angle? What above the resonant frequency?

4. In an amateur transmitter tuned to 40 meters, the antenna current is one ampere. This flows through a series tuning condenser of 100 mmfd. capacity at resonance. What voltage must the condenser stand?

5. In Problem 1, what is the ratio between the current at resonance and at 20 kc. below resonance? What would be this ratio if R were doubled, or halved? Do you see the importance of low-resistance circuits?

No. 12 **Radio Broadcast's Home Study Sheets** December, 1928

Resonance in Radio Circuits

Part II

RESONANCE may occur in a radio circuit in one of two ways. The series resonant circuit was discussed in Home Study Sheet No. 11. Suppose, instead of having the voltage impressed in series with the inductance and capacity, it is impressed across the condenser and inductance connected in parallel, as in Fig. 1. What happens, as the frequency is changed?

DISCUSSION

Unfortunately the experiment to show just what happens to the various currents and voltages in such a circuit is difficult to perform. It is simple, however, to calculate what happens and to plot it. Instead of going into the laboratory for this experiment, then, we shall rely on the slide rule and graph paper to delve into another interesting radio phenomenon known as parallel resonance.

In a series circuit the same current flows through all the units, but the voltages across these units may differ. In a parallel circuit, the same voltage exists across the branches, but the currents through them differ. The total current, I, flowing out of the generator, in Fig. 1, is the sum of the currents flowing in the two branches. Since, however, a capacity reactance is considered as a negative reactance, the current through such a reactance may be considered as having an algebraic sign opposite to that of a current through an inductive branch. The total current, then, is the difference of the currents, i.e.,

$$I = I_L - I_C$$

and from previous Home Study Sheets, the currents in these branches may be calculated if the reactance and the voltage is known.

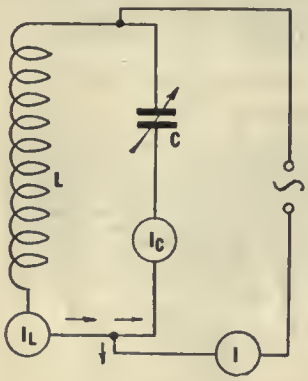


FIG. 1

The formula above, which gives the generator current flowing into the parallel circuit, shows that if the current in the capacity equals the current in the inductance, the difference, or generator current, becomes zero.

IMPEDANCE OF PARALLEL CIRCUIT

The impedance of any device or circuit may be defined as the ratio between the voltage across it and the current through it. Thus, the impedance of a parallel tuned circuit is

$$Z = \frac{E}{I}$$

and if, at resonance, the current, I, is zero, the impedance must be infinitely high, because current would not flow out of the generator no matter how high its voltage.

A series-resonant circuit, looked at from the viewpoint of the generator is a very low-impedance circuit at resonance. The current it draws from the generator is large. On the other hand, at resonance the impedance of a parallel-resonant circuit, looked at from the generator, is very high, and the current fed into it from the generator is very small. Series circuits are used when low impedances are desired; parallel circuits, when high impedance circuits are needed.

If we measure, or calculate, the current flowing in each of the two branches in Fig. 1, and the total or generator current as well, we shall obtain curves similiar to those in the accompanying figures. These are theoretical curves and do not take the resistance of a circuit into account. Resistance usually exists in the inductance of such a circuit, but in well-designed radio circuits it is small compared with the inductive reactance of the coil. If this is true, the impedance into which the generator feeds current at resonance is equal numerically to $\frac{L^2\omega^2}{R}$ where R is the resistance of the coil.

As the frequency of the generator is changed, the current through the inductance decreases and the current through the capacity increases as in Fig. 2. At very low frequencies there is a large difference between the two currents—the inductance current being the larger—and so a large current flows from the generator. At very high frequencies the capacity current is much greater than the inductance current and so a large difference current, i.e., the generator current, flows as in Fig. 3. For this reason, below the resonant frequency the generator views the circuit as inductance shunted by a condenser whose reactance is so high it takes but little current. At frequencies above resonance the inductance has little effect upon the generator current and so the circuit is said to be capacitive. At the frequency which makes the inductive and capacitive reactances equal, the currents are equal, the circuit as a whole is neither capacitive or inductive and, therefore, must be resistive only, so far as the generator is concerned. At this frequency, then, the circuit looks like a resistance to the generator, and the expression above for its impedance is properly called its effective resistance. Thus,

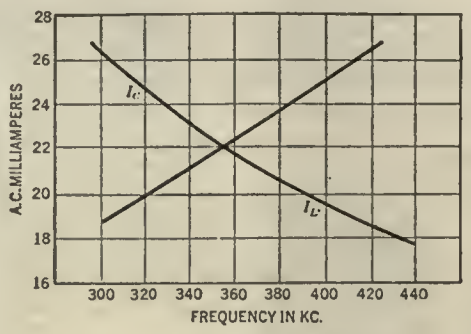


FIG. 2

$$R_{EFF} = \frac{L^2\omega^2}{R} \text{ or } \frac{L}{CR}$$

where L = coil inductance
$\omega = 6.28 \times f$
C = capacity required to resonate the coil
R = series resistance of coil

For example if L = 200 microhenries, R = 10 ohms and f = 1000 kc., R_{EFF} = 160,000 ohms.

PROCEDURE

1. Assume L = 200 microhenries, C = 500 mmfd., E = 10 volts. As the frequency varies from 400 to 600 kc., calculate; a. reactance of inductive and capacitive branches, b. currents in these branches, c. total current flowing from generator, d. impedance presented to generator;

2. Plot all of this data against frequency.

PROBLEMS

1. If the coil in Procedure has 15 ohms resistance at 300 meters, and the grid and filament of a vacuum-tube amplifier is connected across the circuit, what impedance does the tube work out of? Suppose it is in the plate circuit of a power tube which feeds 100 milliamperes into it. What is the power required from the tube if $P = I^2 R_{EFF}$

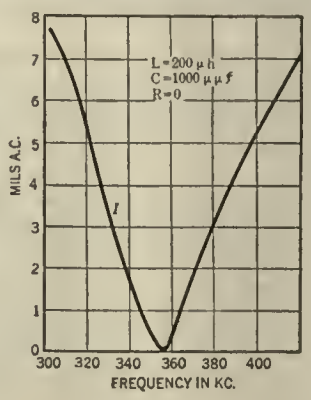


FIG. 3

2. An antenna-ground system has a capacity of 0.00025 mfd. An inductance is to be put in series with it so that the entire circuit will be resonant to 400 meters. Calculate the total circuit inductance. If a distant station impresses across this system causes voltage of 100 microvolts, what voltage is across the inductance at resonance?

3. An interfering station working on 600 meters also sets up across the antenna a voltage of 100 microvolts. If the system is tuned to 400 meters, what voltage at the interfering frequency will appear across the inductance?

4. Suppose in series with the antenna is connected a circuit like that of Fig. 1 and tuned to 600 meters. Assume the resistance of the coil is 10 ohms. Calculate the impedance this circuit would offer to the 400-meter and the 600-meter signals. Then calculate roughly the ratio of wanted to unwanted voltage across the inductance L. The complete antenna system is shown in Fig. 4. In calculating the impedance neglect the effect of L and C.

5. If doubling the inductance of a coil doubles its resistance, too, what effect upon the effective resistance of a shunt tuned circuit has doubling the inductance? Of course, a smaller condenser would be used to reach the resonant condition. How much smaller would the condenser be?

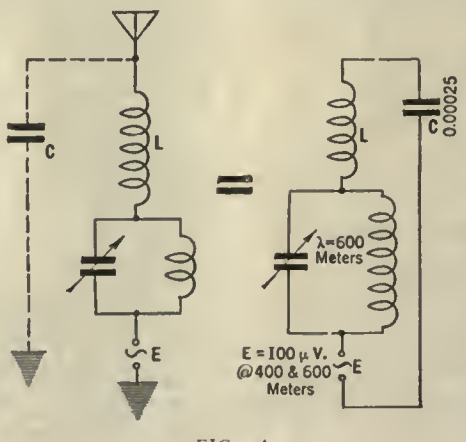


FIG. 4

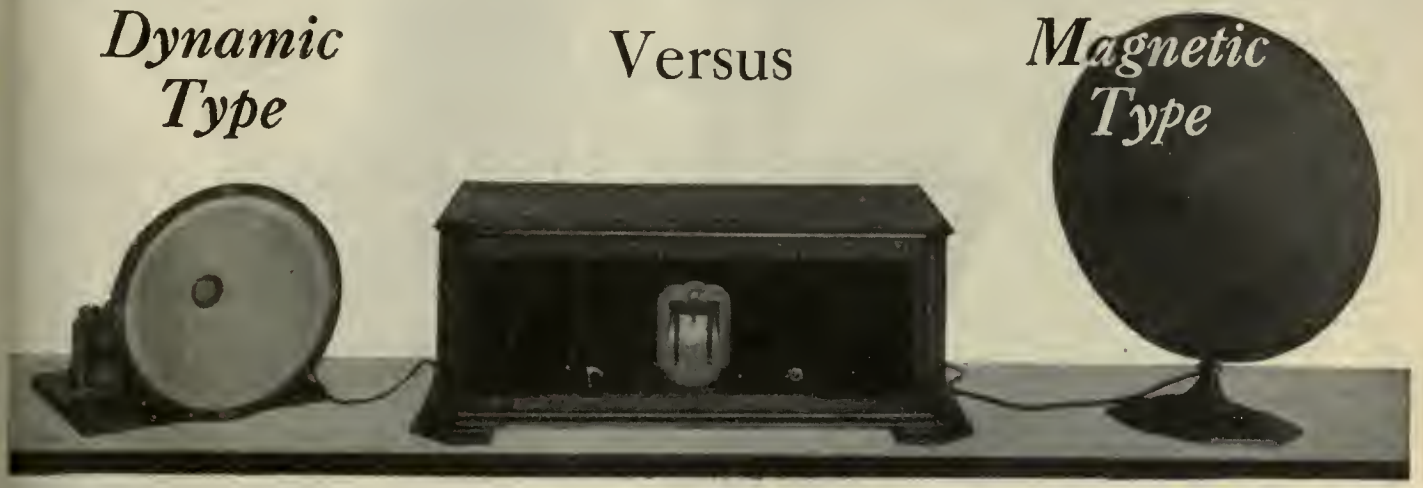
6. A plate-supply device has considerable 120-cycle hum in its output. Suppose a parallel tuned "trap" is placed in the positive lead. A 30-henry inductance is available. Calculate the size of condenser needed. If the inductance has 500 ohms resistance what impedance will the trap offer the 120-cycle current?

7. The maximum voltage gain that may be secured from a screen-grid tube may be calculated from $Gm \times R_{EFF}$, where Gm is the mutual conductance of the tube and R_{EFF} is the impedance of the tuned circuit into which the tube works. Assume that Gm=300 micromhos, L=200 microhenries, wavelength=300 meters and calculate the maximum resistance that can be tolerated in the coil and condenser which tunes it to permit an amplification of 60. If the resistance of the coil is doubled, what happens to the gain of the tube and coil-condenser combination?

Note: Readers may send their answers to these questions to the Editor to be checked.

LOUD SPEAKERS—A DEBATE

Dynamic Type Versus *Magnetic Type*



AT THE end of an average day, the waste-paper baskets in the Editorial Office of RADIO BROADCAST are almost filled with press releases written about every known kind of a radio equipment. It is a rare release which contains information which can be used in this magazine. The truth is, that it is a rare release which has any information of use to anyone. Occasionally, however, the mail clerk brings one which promises a great deal.

The following statements are taken from a release dated August 29th, titled "Little-known Facts About Well-known Cone Speakers," and signed by the Director of Research of a cone-type loud speaker corporation. The replies to these statements were made at our request by an engineer who has no connection with the loud-speaker industry, but who, in our opinion, is equipped with as much unbiased data as any engineer in the country. His interest, as shown in his statements below, is the interest, of engineering truth. We believe this little debate may give our readers more information than a much longer article written in conventional style and form.

RADIO folk feel keenly that, out of the mass of near-accurate statements and downright mis-statements about topics which may at the moment be uppermost, there must be some generally accepted facts to which they may cling. This is usually so, but the search for simple and real truth is not easy. In the comparative merits of different types of loud speakers, the flow of inaccuracies has recently been especially strong. The short discussion here of the comparative merits of the magnetic vs. the moving-coil loud speaker is as technically accurate as we know how to make it, without ascending to the rarefied atmosphere of higher physics. We hope it proves interesting and valuable to our readers.

—THE EDITOR.

The release: "It is freely claimed that the efficiency of the usual rocker-type driving unit for cone speakers is from 4 to 7 per cent., and that its power rating is strictly limited to that for which it is set. The Western Electric unit, for example, is set for 1 watt, the BBL for 2.5. watts, while the Stevens unit will take 3 watts and still maintain an efficiency of 7 per cent., although at 0.5 watt its efficiency is only 2 per cent."

Our engineer replies: "The so-called wattage that can be put into a speaker varies with the frequency. The Western Electric cone handles about 1½ watts at the lower end of its response without striking the pole pieces. Because of its rather greater efficiency than most cones this gives as much sound output as a cone 3 TU less efficient capable of handling 3 watts."

We should like to put in a word here. The average listener need not worry about the power-handling ability of his loud speaker. What difference would it make if his speaker could handle 100 watts of energy without smoking, blasting, or hitting the pole pieces? What he should be interested in is the amount of sound he gets out of the speaker with a given electrical input. We have stated already that, if a speaker could be made 10 TU more efficient than the best of our present devices, we could obtain sufficient volume of sound from it without using expensive power apparatus.

The fact that the efficiency of the unit which the release mentions differs at various power levels indicates, according to the engineer, "considerable lack of linearity in response. When the ratio of input to output is not linear, the harmonics are very bad."

EFFICIENCY OF DYNAMIC UNITS

SPEAKING of moving-coil loud speakers, the release states, "The very best design available develops an electrical efficiency of only 50 per cent., and this figure is attained only by employing a push-pull transformer which has been designed specially and constructed of very expensive material.

"The electrical efficiency of some of the most popular makes of electrodynamic speakers is a scant 30 per cent., when actuated by push-pull amplifiers. When, however, they are actuated by ordinary transformers, and from a single power tube, the efficiency drops to as low as 20 per cent. with some distortion. In some of the cheaper makes, the efficiency is further impaired by mechanical losses due to the cone suspension."

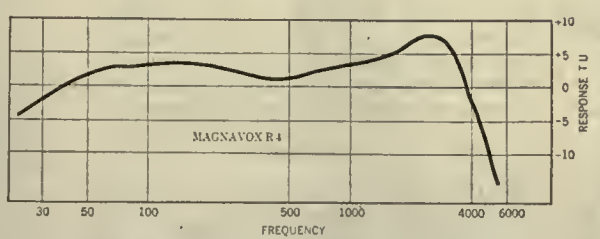


FIG. 1. FREQUENCY RESPONSE CURVE OF A TYPICAL MOVING-COIL SPEAKER

Our engineer says: "The push-pull element has nothing to do with it. Equal efficiencies can be obtained with either single or push-pull amplifiers and transformers. An efficiency of 30 per cent., is probably high for even the best of the dynamic speakers. Any speaker worked from improper conditions will perform unfavorably."

The release: "These figures, let it be understood, are electrical only, and to obtain the overall efficiency, we must subtract the cone losses. It is quite true that in cones of the same size—the 18-inch size, for instance—the efficiency of a cone actuated by a dynamic unit is greater than that of one actuated by an electromagnetic unit. This is due to the greater power available for flexing the material, provided, of course, that the source is capable of furnishing the energy. On the other hand, it is well known that the amplitude of the apex of the cone varies inversely as the square of its diameter, plus a logarithmic constant for air slippage."

POWER VS. EFFICIENCY

THE engineer: "The power available has nothing to do with efficiency; the losses are what reduce it. Dynamic speakers may be made to have less eddy current and hysteresis losses than the rocking-armature units. In the latter type the armature itself is saturated rather heavily. In addition, mechanical masses are supported better and distributed so that impedances, both mechanical and the resultant electrical, are more uniform and permit of better matching in the dynamic type.

"This is true for a constant radiating power at a particular frequency, and provided the whole moves as a unit (piston) without interference between the front and back faces. This latter is not the case for the Western Electric type of cone, and is true for the dynamic only when the baffleboard is sufficiently large (diameter), massive and damped."

The release: "In practice this works out so that if an 18-inch cone requires 0.008-inch amplitude down to 100 cycles,

then a 7-inch cone will require 0.062 inch down to the same frequency. If, however, a dynamic speaker could reach only 100 cycles, it would not be satisfactory; and to reach 48 cycles, a stroke of plus or minus $\frac{1}{4}$ inch or $\frac{1}{2}$ inch is necessary. It is, of course, theoretically possible to make a dynamic unit with this stroke, but at the present time there are only two commercial speakers of this character, and both are sold complete with amplifier and power plant. The very best dynamic unit for 7-inch cones has a possible stroke of plus or minus $\frac{3}{32}$ inch. Others have a possible stroke of $\frac{1}{16}$ inch. One type examined in our laboratory had as little as a $\frac{1}{32}$-inch stroke."

The engineer: "This depends upon how much energy must be radiated. Under any reasonable conditions it will be superior to the Western Electric type of cone in radiation (area x amplitude) at frequencies below 300 cycles because of the baffleboard's effect."

ELECTRICAL TROUBLES

THE release: "Electrical troubles are caused by the following factors: To begin with, dynamic units are not provided with a spring resilience as are the electromagnetic units. Push-pull actuation is therefore more essential. Again, in all cases an output transformer of special design is required, and unless made of special alloy cores, which are quite costly, it can introduce quite as much distortion as a third stage of audio amplification."

The engineer, replying on the spring resilience of the cone-type speaker: "That is the reason dynamic units are so very much superior to balanced-armature speakers from the standpoint of harmonics generated. Since they are always actuated by a.c., theoretically no restoring force should be necessary. The current itself will always return the moving system to the starting position. Push-pull actuation is obtained by the a.c., not by any push-pull feature of the amplifier system. The currents fed to a speaker by a push-pull amplifier can in no possible manner be told from those fed by a single-tube amplifier as long as neither is overloaded and the d.c. component is eliminated by a transformer or blocking condenser."

The release: "Many makes of dynamic speakers now on the market are provided with cheap transformers, so that the distortion caused by combinations of capacities, chokes and resistances—including cut-off filters intended to cover up poor design—tends to cut down the efficiency.

The engineer: "This is equally true of other types."

The release: "The greatest electrical loss, however, occurs in the movable coil itself. The impedance of the movable coil is not matched with the secondary of the output transformer; and even when it is nearly matched, the I^2R loss of the coil is enormous. The reader can obtain a really practical picture of this loss if he stops to consider that in a correctly designed step-down transformer whose ratio is 50 to 1, the secondary wire is No. 18 while the dynamic coil is wound with No. 30 or 32! This means that the dynamic coil is being overloaded from 300 to 400 per cent."

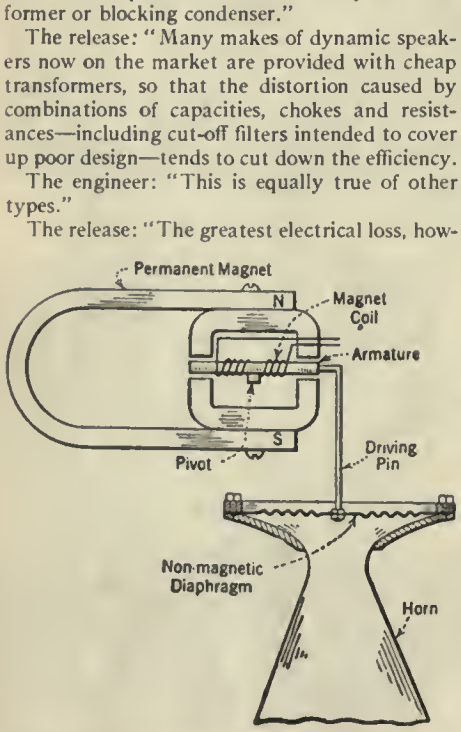


FIG. 2. CONSTRUCTION DETAIL OF A BALANCED-ARMATURE MAGNETIC UNIT

The engineer: "The losses (I^2R) in the coil are fairly large compared to those in certain other parts in the system, and account largely for the 30 to 50 per cent. efficiencies instead of 100 per cent. It is still better than the 3 to 7 per cent. efficiency obtained by other types. The moving coil cannot be considered as "overloaded" unless it is mechanically or electrically likely to be destroyed."

FIELD COIL EFFICIENCY

THE release: "The electrical efficiencies discussed above are those of the signal system only. In addition, we must consider the efficiency of the field, which is from 10 to 25 per cent. When a field for the signal of a 112-type tube was required, this was quite immaterial. To obtain a field for the signal from the 210- or 250-type tubes in push-pull, however, requires enormous power.

"Dynamics of the kind having a signal efficiency of about 20 per cent., with the field rated at 1 ampere at 6 volts were found to take 6 watts at 6 volts, while those having a signal efficiency of 30 per cent., required 16 watts. Those with a signal efficiency of 50 per cent. demanded a 50-watt field. The latter field requirements are far above the usual output of eliminators. Hence the field cannot be used as the eliminator filter choke, but must be fed with a separate rectifier."

The engineer: "Proper design of the magnetic circuit can reduce greatly this loss and apparent inefficiency."

In this connection, we understand the Vitaphone loud speakers in factory production have an average efficiency of 35 per cent., and that the field of these speakers consumes about 10 watts.

The release: "In conclusion, it should be noted that the deep bass notes developed by many dynamics are additive resonance, and if one likes this effect one can readily obtain it by much cheaper and simpler means. The deep resonance is caused by the fact that most dynamic cones are fastened to a metal frame which, in turn, is bolted to a large wooden baffle acting in the capacity of a diaphragm. This serves to accentuate certain low frequencies. To prove this, let the reader actuate a dynamic unit thus mounted, with an organ record of low pitch, and he will hear clearly a bass drum accompaniment. If this effect is desired, the same results can be produced with an impregnated cloth cone (of curved angle) glued to the same kind of baffle and actuated by a high-power electromagnetic unit."

The engineer, "No loud speaker is quite so free from the effects of resonance as the dynamic with a piston-type paper cone or *properly* designed moving system and horn. The reproduction of low notes is *not* due to resonance. The wooden baffle does *not* act as a diaphragm. In fact, the less it moves the more effective it becomes."

OUR DECISION

WE HAVE enjoyed this little argument. The cone designer is correct in stating that good cone-type speakers can deliver excellent quality; the engineer, whose feeling in favor of "dynamic" speakers is so evident, is correct

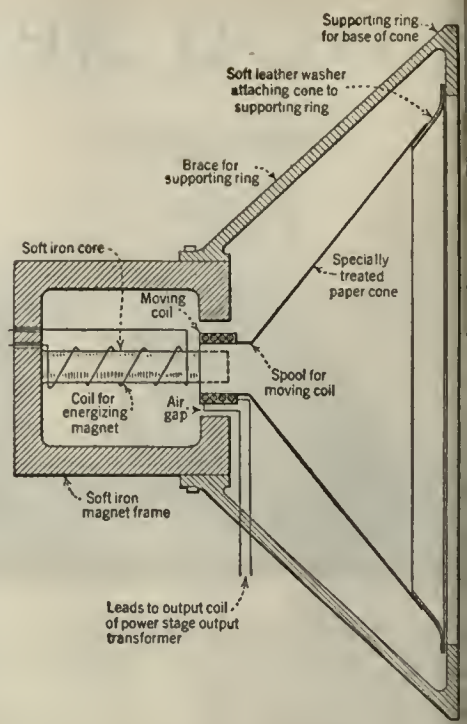


FIG. 3. CONSTRUCTION DETAIL OF A MOVING-COIL SPEAKER UNIT

too—for the best possible reproduction, a good moving-coil speaker is superior to a speaker of the Western Electric type.

There is only one more statement we hope everyone will understand—all speakers are dynamic speakers in that some of their parts move. All dynamic speakers, however, are not "moving-coil loud speakers" which are the type the engineer favors, and what nearly everyone thinks of when the word dynamic is mentioned. Up to the present time there is no type of speaker generally available which is the equal of the better grades of moving-coil loud speakers

More Data on Loud Speakers

THE above argument will be followed by additional data on dynamic speakers, as the Editors have made arrangements with Joseph Morgan, of the International Resistance Company, for the preparation of another of his articles on loud Speakers—the first appeared in August RADIO BROADCAST and was called "All About Loud Speakers." The second of Mr. Morgan's articles will be "All About Dynamic Loud Speakers," and he has been instructed to take every type of dynamic speaker now easily obtainable and put them through their paces in his laboratory. His article will contain curves showing how the various speakers respond to the necessary audio frequencies, what field currents they require, how much audio power is necessary, what their advantages and disadvantages are, and where the magnetic type of speaker stands in the path of progress toward better and better radio reception.

The advantage the second of Mr. Morgan's articles will have over other dynamic-speaker descriptions is that his remarks will be based upon laboratory measurements and actual tests, not upon matters of opinion. Together with the present article made up of the remarks of two engineers, it ought to equip any serious radio thinker with sufficient data to decide for himself and advise his friends on the question, "Is it worth while to invest in a dynamic speaker?"

—THE EDITOR.



A TYPICAL WELL-ARRANGED AMATEUR STATION

Removing Nonsense from Short-Wave Transmission

By ROBERT S. KRUSE

THE transmitter described in the last two installments of this series will supply its owner with a considerable amount of pleasure, whether he be experimenter, scientist, engineer, tinker, or friendly "rag-chewer." It is not intended especially for the highly specialized message-handler, but is quite adapted to the uses of that group as well.

Just how it may be made to serve these various purposes may be told best after we have pushed aside certain very widespread hoaxes. That it is really necessary to do this can be made plain by recalling that grotesque hearing at Washington wherein a large group of gentlemen demanded all the short waves—and more—from the Federal Radio Commission. Not only did these representatives have in mind purposes that ranged from worthy to silly, but a goodly proportion of them were filled with the most amazing illusions as to the possibilities of short waves. Surely Mr. Average Citizen is at least as badly off. In order to give him a fair start one must surely equip him with something approaching the truth.

The fault lies with the evergreen enthusiasm of the reporter and the fish stories told him by the station owner. Between them they produce an illustrated story about some amateur station which is claimed to "talk to every country in the world and be in touch with Australia every night." (The quotation is genuine.) Probably neither one recognized this as a plain ordinary lie—yet a lie it is. No amateur (or professional) station can "talk to every country in the world" for the good reason that not all countries have stations which can reply. Again, one is perfectly safe in saying that no amateur station in this country has ever maintained daily contact with Australia (or any other foreign country with the exception of Canada or Mexico) for even one year. Any attempt to claim that a shorter demonstration is a proof can be set down as an admission that the speaker is not familiar with the seasonal and climatic vagaries of short waves. There are many cases on record to show that quite good international amateur contacts may exist for several months, only to disappear completely with no assurance of recurrence twelve months later.

International amateur contacts are a post-graduate activity in any case. The beginner may make an occasional contact of this sort but as a rule the signals are weak, the interference is strong and the contact at best is fleeting, even with good operating skill. Where a contact is recurrent it is almost invariably due to a schedule, careful hunting and breathless listening—plus some "filling-in" by the receiving operator. Working in that manner certain operators, such as Clifford Himoe, who just returned from the McMillan Greenland Expedition, and Fergus McKeever of Lawrence, Kansas, have accumulated extraordinary strings of "calls-exchanged" and not a few international contacts have persisted for weeks or months. These feats have the same relation to the results obtained by an ordinary operator that Will Rogers' rope spinning has to my attempts—or yours.

BRASS-pounders, message-handlers, rag-chewers—these are terms dear to the heart of all amateurs. In this article Mr. Kruse puts such divisions of the amateur lists into their proper places, and points out that the true experimenter is a combination of all three—and has lots more fun. In the bargain, Mr. Kruse gives some directions about operating the master-oscillator code-and-phone transmitter already described by him in RADIO BROADCAST.

—THE EDITOR.

THE LOW-POWER MYTH

AT ONE time there existed a state of near-anarchy in amateur radio, occasioned by the installation of high-power broadly tuned transmitters by those amateurs who could afford them. The rest of the congregation was allowed to sit and listen. This was combatted by legislation and by a campaign for low-power records. The expected result of such a campaign followed in the form of a low-power cult which was surrounded by as much exaggeration as the international contacts. We read of this or that station which operates a receiving tube (replaced how often?) at 350 volts and is in "constant" (all newspaper radio contacts are constant) communication with amateurs all over the country (even where there are none). Because superb operators like Mason and Waskey maintained Wilkin's lane of communication with sets of the one-mouse-power class we are asked to believe that the range of a battery-driven set using a receiving tube is 500 or 1000 miles. But, nothing is said of the frequent failures, of the painstaking repeat-repeat-repeat, of the nerve-straining listening, and of the weary hours spent in searching for a lost whisper.

If, indeed, these tiny transmitters were capable of reliable work over distances, then we must suspect the Western Electric Co. of being very badly informed; a 500-mile transmitter manufactured by this company occupies most of a standard boxcar when it is shipped.

It all boils down to this, the range of a short-wave transmitter varies with time, weather, operator's skill, location, interference, and adjustment. The total variation that results is certainly at least as large as 10,000 to 1, and it is quite possible for the same small set to communicate with its antipode with fair signal and

on another occasion to fail entirely to "get out of town." There is also another factor which multiplies the above by another 10 or so. This is the fact that "you can always hear a signal on schedule" if it is even partly readable, through that same signal may have been begging vainly for attention for months past.

THE FRIENDLY "RAG-CHEWER"

SEVERAL years ago when engaged in the process of exploring the wave band of 15 to 100 meters a group of experimenters became very much disgusted with the existing fad for extreme curtness toward any radio activity other than the handling of messages. After listening to a large number of the messages, and handling many of them ourselves, we became convinced that they were mainly of no consequence and could be replaced with profit by tests and friendly conversations. F. C. Beekley, *QST*'s Advertising Manager, and L. W. Hatry, well-known to readers of this magazine, conceived a purely paper organization to be called the "Rag Chewer's Club." In order to become a member of this organization one had to furnish written proof of a 30-minute non-message-handling radio conversation with another amateur station, whereupon there was sent out a membership certificate made up as a burlesque of the I.A.R.U. and A.R.R.L. certificates. It was hoped that, if amateurs could once be induced to assume a human friendliness toward their radio contacts, they would never again lapse to the same machine-made routine. That hope was fulfilled to such a degree that the mailing of the "certificates" became almost a full-time job for one person. Even now, after a number of years, the idea is still alive and one may derive considerable pleasure from a friendly conversation with other transmitting amateurs in various parts of the United States.

—AND THE CALL CARD

SEVERAL years ago Don Hoffman of Akron, Ohio contributed to this picture the idea of sending a postal card as friendly acknowledgement of a radio conversation. His postal card had the radio call, 8UX, printed across its face in large letters, and other information was pen-written across it.

Within a year the call-card was a fad and every conversation wound up with "Pse send card," or simply "QSLL". Shortly after this the owners of active stations discovered that the cost of the cards, and the time to write them, would shortly compel abandonment of radio activity—and as a result they sent fewer of them. Then ensued a violent argument which has raged these three years with no conclusion arrived at. The amateur across the Atlantic especially is not at all pleased with the remarkable lack of consideration shown by his American neighbor who fails to reply to all of the apalling flood of cards and letters from European listening posts which have no transmitters. Meanwhile the varieties of cards grows, but no more colors are available, the limit having been reached in Lawrence Mott's famous Catalina Island series, terminating with an eagle-trimmed card in five colors and gold. Beyond that even the Southern California imagination has not gone.

THE EXPERIMENTER

I PROPOSE to give a considerable space to the experimenter because he is in the most interesting of radio fields, also because he is least organized and least catered to. Let us begin by explaining the seeming contradiction in the preceding sentence.

The experimenter, whether he uses a microphone or key, must say something with it, and unless he uses an outright automatically sent test signal there is no easy way to avoid "rag-chewing" or "message-handling." This causes him to be included in one class or the other although he has no primary interest in message totals or call cards, does not gain any satisfaction from the activites of either of the groups, and intends to stop sending as soon as he has worked out the problem that happens to be under way—which is likely to be anything under the sun from an antenna test to an investigation of the electron distribution in the upper atmosphere during an eclipse of the moon. In addition to this the experimenter works best in small groups which break up and re-form about various problems, making it very hard to keep track of their performances or to give them any of that entirely proper publicity which will call in new aid.

By tradition organization has centered about message-handling, and personnel or cash has never been placed in back of an attempt to create a coherent experimenter class or a clearing house for information. This has been done for other activities which, in some cases, have received support extending as far as the employment of laboratorians to solve problems by proxy!

All of these things contributed to an unhappy state wherein the experimenter was an outsider, compelled to seek out his own co-workers, handle all his own correspondence without aid and then, if he had energy left to do any effective work, to take his reward in personal satisfaction. The experimenter is usually neither a publicity seeker nor a shirker, but even he resents such an unfair situation. Several years ago, in an attempt to even matters up, I formed the "Experimenter's Section, A.R.R.L." This organization was as loosely put together as the "Rag Chewer's Club" and the motives were not entirely different. The "Section" proposed to issue at intervals lists which would tell all members what work was being done, and by whom, thus facilitating inter-member contacts. To this were to be added occasional outline-suggestions and the results, which were to be circulated in mimeograph form or made into magazine reports when of sufficient interest. Although this work never received more than one fourth of one man's time it really made surprising headway. From it developed the Official Wavelength Station scheme of Don Wallace, the Standard-Frequency transmissions of 1XM and 9XL-WCCO under Lansingh and McCartney, some really worthwhile information on transmission r.f. chokes, a variety of circuit improvements, the fine General Electric and amateur "April tests." much article-material and a considerable contribution toward a changed attitude of the amateur as to experimental work.

IS IT WORTH WHILE?

ONE may question with perfect justice the value of amateur experimental work, since the professionally equipped laboratory seems so much better able to cope with questions than the amateur.

This may be answered either by logic or from the record. First of all, the logic may be taken from (I think) Josh Billings who said, "It's better not to know so much than to know so much that 'aint so." That is the handicap of the trained man seeking new trails—he is too sure of many facts that are not facts, too certain that a whole variety of things cannot be done, too inclined to reason out his course. Furthermore, he cannot escape this tendency, for he is always under the eye of his associates who feel likewise, and usually under the surveillance of an impatient production department which does not want everything tried and but *one* thing finished.

The amateur is not so; he is not required to be logical, or to know any theory from which the result can be predicted. Therefore, he blathers around cheerfully with just the faintest contact with established knowledge, and often he falls over the most amazing and fundamental discoveries. Later the engineer and the physicist and the mathematician will refine and make useful these discoveries. However, it is a fact that a good share of the fundamental things in radio have been discovered with the poorest of equipment and in the face of contrary opinion.

This is, of course, not a suggestion that all established information is wrong. It is, however,

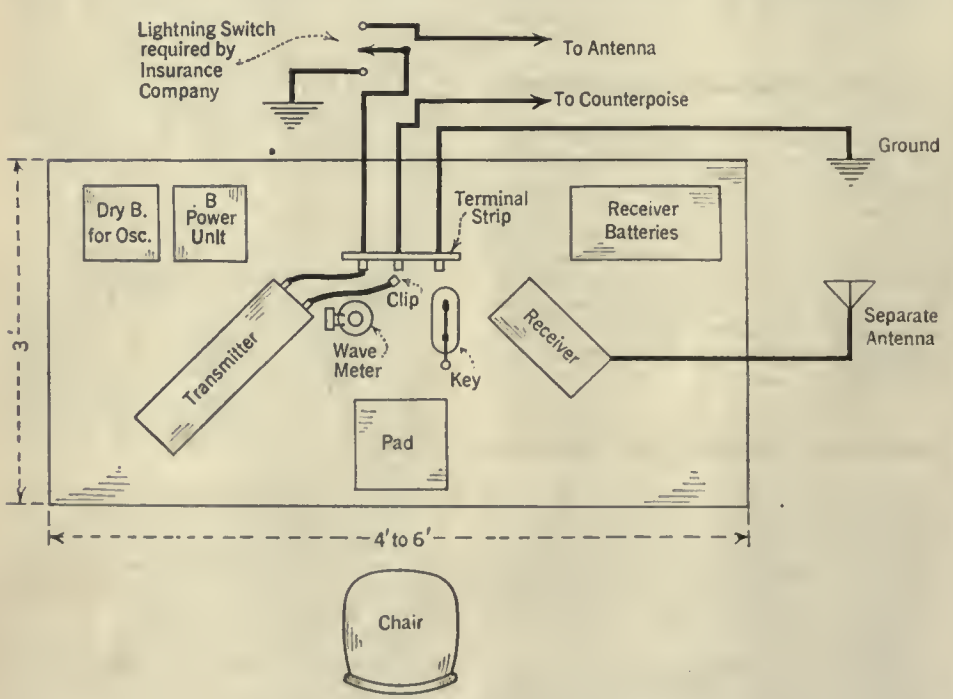


FIG. 1. ARRANGEMENT OF APPARATUS

The table should be about 29 to 30 inches high. If much operating is done the leg room should be entirely free of shelves, batteries or other obstructions. The location of the key is optional, but the transmitter switch should be convenient to the left hand.

an earnest suggestion that the experimenter always be inquisitive and ever ready to try those things that seem to be vague or incorrect. Whatever the conclusions may be which these tinkerings and testings give forth, they should be aired. Progress comes from comparison and from the matching of results.

It seems that sooner or later there must exist an agency which may act as a clearing house for the needs and questions of the experimenter in a manner somewhat as adequate as the provision now made for other activities. This will be a rather difficult matter to frame, for it will be required to deal with all manner of interests from the most serious and important to the case of the misguided boy who is trying earnestly and persistently to determine whether Hartley or Armstrong invented the "best sending circuit."

THE INNER URGE

THAT this agency does not exist now will not matter greatly to a real experimenter; when the genuine radio experimenter is interested in a problem time, cash, and correspondence deter him no more than a violent golf fiend is deterred by a pneumonia fog. Similarly I also suspect that such stubborn persistence does produce the best work. At any rate the genuine radio experimenter need not read this discussion, nor will I convert anyone who is not already an experimenter of some sort. The thing is organic, like red hair, and if artificially produced is equally temporary.

THE MESSAGE-HANDLER

AS HAS been suggested above, the handling of amateur radiograms seems to carry less opportunity for developing something worthwhile than do other uses of amateur radio. In the main it serves only to develop operating skill which can then be diverted to worthy ends. The messages handled meanwhile are mostly worthless in the same manner that a copybook is worthless after one has learned to write.

The applications of that operating skill have been advertised so widely that it seems almost useless to mention them. Radio contact with exploring expeditions, occasional emergency work when wires are down, application to military situations, have all been mentioned many times. There exists an Army-Amateur scheme of coöperation as well as a Navy-Amateur scheme, the activity of each differing materially in various territories. The object of these systems is that in case of war there will exist a partly trained reserve.

Recent hearings before the Federal Radio Commission suggest that if no better agreement, can be made between the various interests who "must" have radio for emergency contact we may well consider the possibility of a public-property or corporation-operated radio emergency net whose operators may keep in practice by talking to amateurs. A preliminary tryout of such an idea was instigated some years ago by G. L. Bidwell of Washington and operated by A. L. Budlong for the Pennsylvania railroad. It gave a very good account of itself and I (who began as a skeptic) feel that, with somewhat stronger support, it would have expanded easily into the scaffolding on which a permanent system such as suggested could be erected. Certainly the tryout would have been made easily with amateur stations—and can to-day. It would be a most unhappy matter if instead we were to have a horde of privately owned stations working for their separate owners, having no contact in normal times and hampered by financial affiliations so as to be unable to work in the free-handed manner that a good emergency net must base upon.

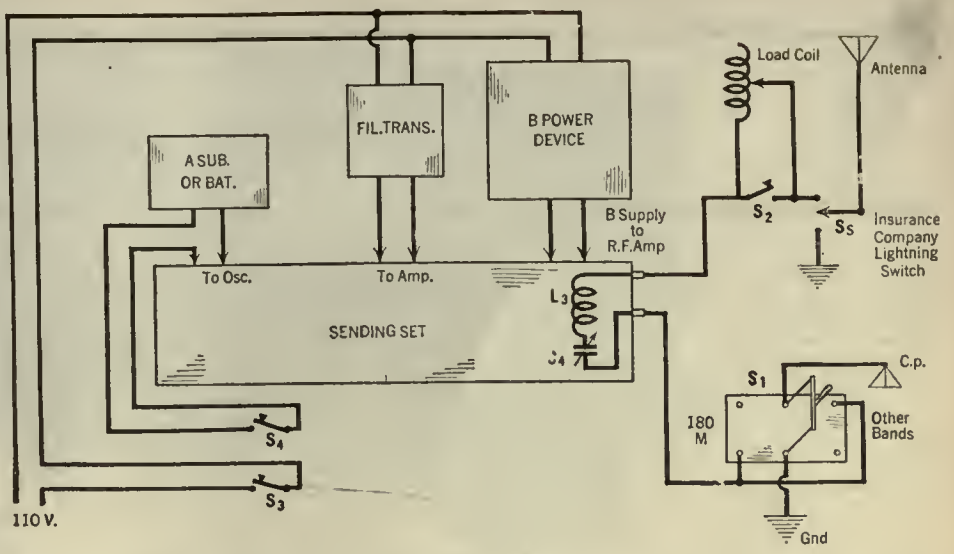


FIG. 2. SWITCHING ARRANGEMENT

Switch 1 changes the antenna so that various bands may be employed. Switch 2 shorts or opens the antenna loading coil used to operate on the 180-meter band. Switch 3 turns on and off the a.c. power input to the transmitter. Switch 4 turns on and off the A battery—if used. It must be kept away from Switch 3, and if a.c. is used in place of the A battery switch 4 is not necessary. Switch 5 is the lightning switch required by the fire insurance company.

The suggestion just made, is that certain but ill-defined military value seems to be the main reason for the message-handling game. Expeditions will not continue indefinitely to depend on amateur stations, though they will continue to use amateur operators because they are able to work under limitations of apparatus. International message handling is involved just now in a great bog of diverse opinion from which it may not emerge for a long time, if indeed it emerges.

TEST TRANSMISSIONS

I CANNOT resist a paragraph regarding test transmission. These sendings are typified by the "test number one, test number two, test number three" of the man making circuit adjustments or by the dreary machine-sent "Test 1XAM" or "Test 10A" that has gone out so many times during these years of short-wave exploration. Such transmissions are meaningless to those who have not been informed in advance, except when supplemented by hand-sent or spoken information, but this does not in any way mean that they are out of the way or to be condemned. On the contrary, they deserve a hundred times as much respect as the senseless calling of station after station for the purpose of hastily asking for a card and then jumping to the next station. Such foolery teaches nothing, does not provide satisfaction to the stations so curtly dismissed, and may well step aside for even a machine-sent "test test test" which at least represents an attempt to learn.

CONCERNING THE STATION

EVERY man is free to choose which of the foregoing activities he cares to indulge in, but he will find that certain conventions relating to operating and station arrangement apply in each case. One must comply obviously with the legal provisions as to manners of calling and signing to some degree. A certain use of abbreviations is also most helpful and in any case is forced upon one if key operation is employed. These abbreviations fall into two classes, the absolutely arbitrary ones, which are matter of international agreement, and those which are merely butchered words such as "Xtal" and "Xmitter" for "crystal" and "transmitter" or "Wx" for "weather." Picking these up is not as painful as it sounds. Another class of abbreviations occasionally met is that sort made by phonetic spelling or by dropping vowels, as "sine" for "sign" and "tmrrw" or "Tmw" for "to-morrow." These too dawn on one soon enough.

Station arrangements are suggested in the illustrations herewith and usually a wide departure from these is not advisable. It is really surprising how much more one can accomplish when things are arranged conveniently. Especially one should avoid placing apparatus in cabinets or against walls in such a manner that alteration or inspection requires disconnecting wires. The transmitter as here shown is without a case and this is my preference since a dust-cover made of khaki cloth serves all the useful purposes of a cabinet. If a case is desired it should be made so that it may be removed without disturbing wires. Mere opening of the lid does not suffice.

Other than these generalities it seems destructive to give advice. Such matters as the exact antenna arrangement, the construction of the loading coil, etc. can be decided best by the owner, and useful experience is gained at the same time. If the antenna must be made shorter than was described, perhaps the counterpoise may be made longer, or a different combination altogether worked out to cover the various wavebands. If a loading coil is necessary no exact dimensions need be followed. One may start with the first thing handy—a Dutch Cleanser box for example—and wind it with ordinary annunciator wire. A little loop should be brought out and twisted together every 5 turns until perhaps 40 have been wound. As soon as the loops are skinned one can connect to the lower end of the coil, clip the antenna to one of the loops and, by trying various wavelengths and noting the condenser setting, one can arrive quickly at the correct number to load to the desired 20-meter wavelength. This is quite as effective and much more educational than a set of ready-made directions which might not fit the antenna. At the writer's station the process was timed and it required 20 minutes.

"Our Readers Suggest—"

OUR Readers Suggest—" is a clearing house for short radio articles. There are many interesting ideas germane to the science of radio transmission and reception that can be made clear in a concise exposition, and it is to these abbreviated notes that this department is dedicated. While some of these contributions are from the pens of professional writers and engineers, we particularly solicit short manuscripts from the average reader describing the various "kinks," radio short cuts, and economies that he necessarily runs across from time to time. A glance over this "Our Readers Suggest" will indicate the material that is acceptable.

Photographs are especially desirable and will be paid for. Material accepted will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas.

—THE EDITOR.

An A. C. Screen-Grid Booster

IN THE August RADIO BROADCAST there appeared the description of "An Extra R.F. Stage For Any Receiver," employing a d.c. screen-grid tube. I was very much interested in this arrangement, but as I desired to use it in conjunction with an a.c. receiver, I thought it logical to redesign the circuit for the Arcturus a.c. screen-grid tube. The altered diagram is shown in Fig. 1. The following is a list of the parts used in the construction:

2—Frost UX-type sockets;
1—broadcast-range plug-in coil;
1—Variable condenser, 0.00035-mfd.;
1—Frost fixed condenser, 0.00025-mfd.;
2—Silver-Marshall r.f. choke coils;
3—Tobe by-pass condensers, 1-mfd.;
7—Eby binding posts;
1—National dial;
1—Front panel, 7" x 9";
Baseboard or sub-panel;
Corwico Braidite for wiring;
Miscellaneous hardware;
1—Power Clarostat;
1—Step-down transformer, 15-volt;
1—Frost strip resistor, 500-ohm;
1—Arcturus screen-grid tube, 22-A.C.-type.

The unit is wired to antenna, ground and receiver as indicated. The output post is led to the antenna post on the receiver. An Arcturus 22-type tube is plugged into the socket. The ground is connected both to the receiver and to the booster.

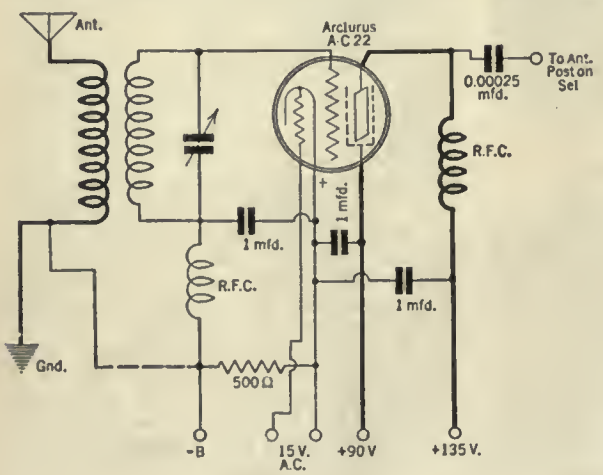


FIG. 1

The dial on the booster functions as an additional tuning control.

The power Clarostat is placed in series with the primary of the step-down transformer and is employed to regulate the output to fifteen volts for the Arcturus tube. The voltage is best determined by means of an a.c. voltmeter, however, if this instrument is not conveniently available, the voltage may be adjusted by noting the time lag between the turning on of the current and the heating of the tube to its normal operating temperature. When the voltage is correctly adjusted, the lag will be approximately 30 seconds.

PETER L. JONES, Boston, Mass.

Work Bench Clamp

THE presence of wires indiscriminately strewn about the test bench is hardly conducive to efficient work, to say nothing about the possibility of short circuits, wrong connections and general lack of order. I have found it decidedly worth while to equip my test bench with several simple clamps designed to hold the various wires to the table.



FIG. 3

A simple clamp for this purpose is shown in the picture, Fig. 3. It was assembled from odds and ends out of the junk box.

A small strip of thick wood provides the base. Near one end a recess is filed out for the cable. The latter is held in position by a narrow strip of ebonite which acts as the upper jaw.

Slightly off the center, a countersunk hole is drilled in the wood block for a $\frac{5}{16}$-inch screw, and the ebonite strip is forced down by a small wing nut. Although a spring washer is used between nut and ebonite strip, the latter will have a tendency to turn when the nut is tightened. To prevent this, the other end of the ebonite strip has been slotted; in this slot lies a stop—a nail driven into the wood block and snipped off about $\frac{1}{8}$" above the surface of the latter.

C. A. OLDROYD, Lancs, England.

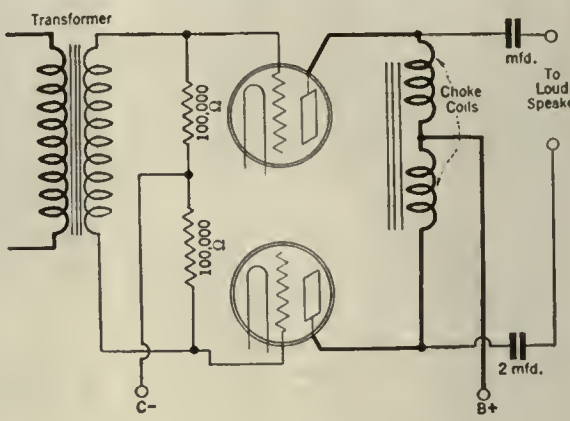


FIG. 2

Push-Pull with Standard Transformers

FOR clear and undistorted output, with abundant volume a well-made push-pull amplifier is the standard of comparison.

The transformers specially made for such circuits have a center-tapped secondary winding in the first stage, and a center-tapped primary winding in the output stage. Yet a *standard* audio transformer may be used with excellent results if an external center-tap is provided, as indicated in Fig. 2.

Two 100,000-ohm resistors are connected in series across the secondary. The grid bias is applied at the central junction of the two resistors. The value of the resistors is not critical, and slightly higher or lower values may be used if the experimenter happens to have them at hand.

The only other special part needed for a push-pull amplifier is the output transformer or a center-tapped output choke through which the B current reaches the plates of the power tubes.

A commercial choke may be used in this position, but the same results can be secured by using two standard chokes connected in series.

The inner turns of the two chokes are joined by a connecting lead, to which the B-plus lead is wired. Two fixed condensers are connected as shown in Fig. 2 to keep the loud-speaker windings at a low potential.

C. A. OLDROYD, Lancs, England.

Home-made Soldering Lug

RUNNING out of soldering lugs in the midst of a radio construction job, I twisted the loose ends of the stranded hook-up wire together and bent them in the form of a hook. To reinforce the stiffness of the lug it was tinned thoroughly. While the solder was still soft, the hook was flattened with pliers, thus providing a better contact surface.

This lug is no harder to make than it is to solder the wire to a conventional lug—and it costs nothing.

EDWARD PIRANIAN, Philadelphia, Pa.



FRONT VIEW OF RECEIVER

The New A. C. Screen-Grid Browning Drake Receiver

By GLENN H. BROWNING

Browning Drake Corporation

THE Browning-Drake Kit-Set has enjoyed a continued popularity since its introduction a number of years ago, doubtless due to the efficiency of the radio-frequency transformers, combined with the simplicity of the circuit in which they were used. During this time some slight improvements have been made.

With the introduction of the screen-grid tube, the problem of designing a one-stage tuned radio-frequency amplifier was attacked again from an analytical standpoint and an extremely efficient transformer was developed for this type of circuit. The problem of obtaining selectivity and gain in a radio-frequency amplifier employing a screen-grid tube differs considerably from that encountered when using a 199- or 201A-type tube. This is due to the inherent electrical characteristics of the tubes themselves. For instance, the 201A-type tube has a plate impedance of approximately 12,000 ohms, and an amplification factor of 8, while the screen-grid tube has approximately 400,000 ohms of impedance with an amplification factor of from 150 to 300. With the 201A-type maximum gain could be obtained easily by the proper number of turns on the primary, together with a normal coefficient of coupling which was about 0.5. This, together with a low-resistance secondary, resulted in a gain of about 12 to 15 per stage. However, when using this tube careful neutralization, even in a single-stage amplifier, was necessary to obtain the best results. The primary purpose in the design of the screen-grid tube was probably to make the capacity between plate and grid so small that neutralization was usually unnecessary. In interposing the screen-grid between control grid and plate, high amplification in the tube itself resulted as well.

PROBLEMS OF DESIGN

THERE are two ways of obtaining radio-frequency amplification under the new condition imposed by the screen-grid tube, i e., by an auto-transformer (tuned impedance), or by the usual tuned radio-frequency transformer, consisting of a primary and secondary winding. These have been discussed at some length in a previous article in this magazine and will not be dwelt on here. It is sufficient to say that tuned impedance has the advantage of slightly more amplification per stage while the transformer gives greater selectivity. The design of such a transformer, however, is not a simple matter by any means. With the increase of plate resistance that the screen-grid tube has over the 201A type, the turns on the primary of the radio-frequency transformer should be increased a great deal for maximum gain, or the coefficient of coupling must be increased, or both. Unfortunately, there is a very definite limit to the number of turns which may be used on the primary of the transformer. This limit is determined by the distributed capacity and inductance of the winding itself, coupled with the capacity placed across it due to the plate to ground capacity of the tube used as the radio-frequency amplifier.

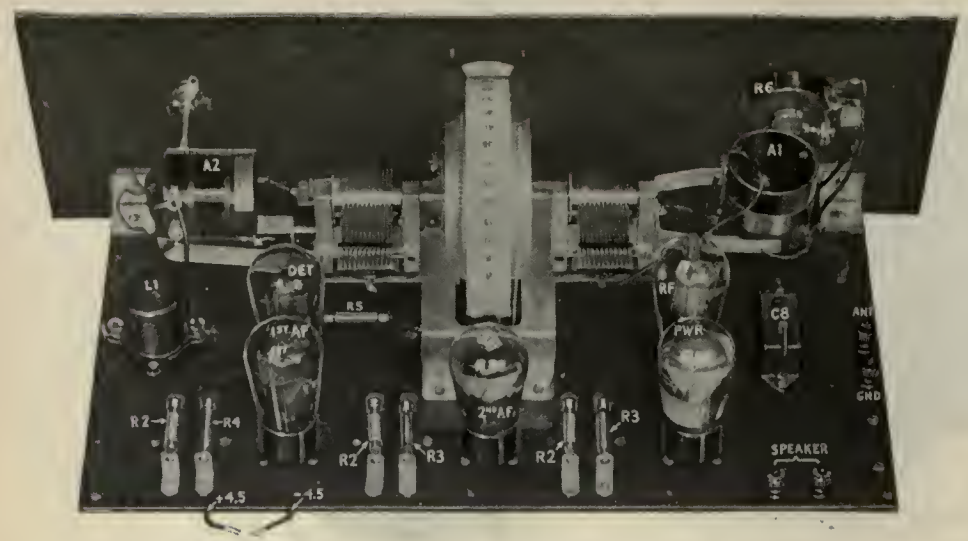
These two capacities tune the primary to a definite wavelength, and if this wavelength is 200 meters or above, the transformer as a whole will tend to pass a signal coming in on this wave no matter where the secondary is tuned. In designing a transformer for the screen-grid, the high plate resistance means that primary turns should be increased, but the plate to ground capacity is increased over the 201A type of tube by a factor of three or four times, due to the proximity of the screen grid to the plate. Therefore, it is essential to increase the coefficient of coupling as much as possible.

Some months ago the writer started to determine just how this coefficient of coupling could be increased from its normal value of about 0.5 to as great a value as possible (the maximum theoretical value is 1). The result was that, with a short winding length for the secondary and a slot wound primary placed in about $\frac{1}{4}''$ from the low-potential end of the secondary, the coefficient of coupling increased to 0.91. Thus, with this coefficient of coupling and placing as many turns on the primary of the radio-frequency transformer as possible, consistent with keeping its natural period below 200 meters, a transformer for the screen-grid tube was developed, which has an extremely good gain. However, it might be stated that as far as the writer has been able to determine, it is impossible to get the maximum theoretical gain at broadcast wavelengths from the screen-grid tube because of the limitations imposed on the number of turns on the primary winding of the radio-frequency transformer.

THE SELECTIVITY

THE selectivity of the transformer under discussion, as well as the amplification, is considerably better than in the case of using the 201A-type tube as a radio-frequency amplifier. There are two reasons for the increase in selectivity. First, other factors being equal, the selectivity is better in a radio-frequency transformer when the gain is below maximum. Second, for a given amount of gain the higher the coefficient of coupling the greater the selectivity, provided the resistance of the secondary winding of the transformer is approximately the same in both cases. This later statement will probably not be evident but can be proved mathematically or can be shown readily in laboratory measurements.

The 1929 Browning-Drake Assembly employs one stage of tuned radio-frequency amplification with either a.c. or d.c. screen-grid tubes with the transformer described. Tickler feed-back is used in the detector as previously. No neutralization or shielding is necessary for efficient operation. The antenna system has been changed to use an untuned primary. This is because the coefficient of coupling between primary and secondary has been increased to 0.91 so that a primary is as effective as direct coupling and aids somewhat in making the kit absolutely single control. The 0.0001-mfd. condenser (C_1) is con-



VIEW OF RECEIVER SHOWING ARRANGEMENT OF APPARATUS

nected in series with the primary in the antenna circuit so that the primary is never tuned by the capacity of any antenna length within the 200–550 meter band.

Three stages of resistance-coupled audio amplification are recommended, although other types may be used if desired.

It is unnecessary here to give constructional details for the kit-set as these may be obtained directly from the Browning-Drake Corporation, who manufacture the 1929 Browning-Drake A.C. Shield Grid Kit.

The Kit-Set has been carefully designed by mathematical and laboratory methods, and the writer feels that it is the best Browning-Drake ever presented to the public. Not only does it outperform all previous models from the standpoints of selectivity and sensitivity, but its tone quality is as nearly perfect as can be obtained at the present stage of the radio art. Coupled with this is the feature of simplicity of operation, due to its being absolutely single control.

LIST OF PARTS

A COMPLETE list of the apparatus employed in the construction of the A.C. Screen-Grid Browning-Drake Receiver follows:

A_1, A_2 One Browning-Drake 1929 kit (a.c. screen-grid type);
L_1, L_2 Two radio-frequency transformers;
R_1 Three Browning-Drake center-tapped resistors;
R_2 Three Aerovox or Durham resistors, 0.05-megohm;
R_3 Two Aerovox or Durham resistors, 0.1-megohm;
R_4 One Aerovox or Durham resistor, 0.5-megohm;
R_5 One Aerovox or Durham resistor, 8-megohm;
R_6 One Frost volume control and 110-volt switch;
R_7 One Yaxley resistor, 1000-ohm, type 71,000;
R_8 One Aerovox resistor, 2000-ohm, type 992;
C_1 One Aerovox or Sangamo moulded fixed condenser, 0.0001-mfd.;
C_2, C_3, C_4 Three Aerovox or Sangamo moulded fixed condensers, 0.001-mfd.;
C_5 One Aerovox or Sangamo moulded fixed condenser, 0.00007-mfd.;
C_6 One Aerovox or Parvolt by-pass condenser, 1-mfd.;
C_7 Three Browning-Drake special amplifier coupling condensers, 0.1-mfd.;
C_8 One Aerovox moulded condenser, 0.5-mfd.;
Two Eby vacuum-tube sockets, UY-type;
Four Eby binding posts (Ant., Gnd., Speaker and Speaker);
One Browning-Drake Foundation Unit consisting of drilled front and base panels with amplifier sockets and resistor mounts, twisted a.c. filament wire, connecting cable and all hardware.

The total cost of the parts in the above list is $59.45.

The additional apparatus required for placing the receiver in operation follows:

One screen-grid tube, a.c.-type;
One detector tube, UY227-type;
Two amplifier tubes, UX226-type;
One power tube, 171A-type;
Filament transformer, B-power unit, aerial, ground, loud speaker, etc.

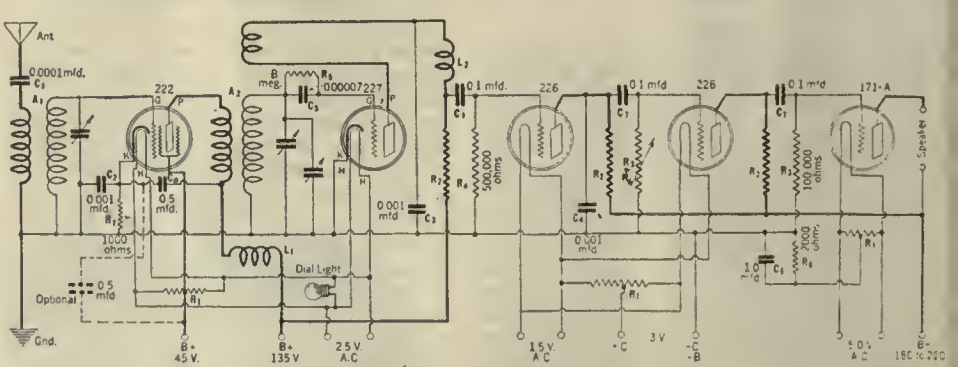


FIG. 1. COMPLETE SCHEMATIC DIAGRAM

Book Reviews

"A TREATISE ON 25 TESTING UNITS FOR SERVICE MEN." Published by Radio Treatise Company, New York City, 26 pages. Price—$1.00.

THE title of this book defines clearly and definitely its scope and purpose. In the description of the various testing units the author has also given considerable general data on how to test receivers. The service man, endeavoring to service a radio receiver by simply following instructions, has before him a task comparable to that which Diogenes had. To successfully service a set one needs, besides the mechanical tools of the trade, a clear understanding of how receivers and set-testing devices work. The educated service man will not hesitate to try this strange food—for an understanding of why the wheels go round is strange to many service men.

The testing devices described in this book are many and include the following:

Tube Reactivator and Filament-Emission Tester.

Vacuum-Tube Bridge, by which one can measure the amplification constant and plate impedance of a tube.

Tube Tester, for measuring the electrical characteristics of all types of a.c. and d.c. tubes.

Voltage Tester, for measuring the A, B, and C potentials in any modern receiver.

Oscillators, both audio- and radio-frequency, to be used as local sources of signals in servicing sets or in making laboratory tests.

Laboratory Oscillators, producing frequencies throughout the audio range and up to about 300 kilocycles. This is useful in measuring audio-frequency apparatus intermediate-frequency transformers, etc.

Indicating Devices, which include descriptions of several vacuum-tube voltmeters.

On page 17 is described a vacuum-tube voltmeter of the design generally known as the "slide-back" type, in which the unknown voltage is balanced against the C-battery voltage. It is not generally the case, however, that the unknown voltage is equal to the change in grid voltage, although the author states that such is the case. When very large voltages are being measured the slide-back method can be used with quite a small error, but with small voltages, such as one frequently must deal with in amplifiers, the slide-back method, in the reviewer's opinion, is quite inaccurate. However, the service man generally is interested in *qualitative* rather than *quantitative* values and in such cases this type of vacuum-tube voltmeter probably can be utilized satisfactorily.

As we indicated previously, the appeal of this book is confined generally to the dealer or service man, although many set builders should find the constructional data on laboratory instruments very helpful.

—H. E. R.

An A. C. Band-Pass Screen-Grid Receiver—

The Master "Hi-Q 29"

By WILLIAM E. BARTON

Hammarlund-Roberts, Inc.

FOR as many moons as the oldest radio editor can remember, writers and engineers have deplored the fact that one cannot have both selectivity and fidelity—and yet nothing much has been done about it. On the one hand, we have receivers which may get all the audio notes in proper proportion, but which, so far as selectivity is concerned, are as broad as the proverbial barn door. On the other hand, we have receivers which, to use an advertising phrase, are as sharp as a knife blade, but which—and advertising writers say nothing about this fact—get few notes above 3000 cycles. And there you are. You may pick and choose, but you can't have your loaf and eat it.

A radio receiver first of all must select the program you want to listen to, and then must amplify the audio tones to the level desired, whether it be for head-phone reception or full loud-speaker volume, usually the latter. But if, in the process of selecting, half of the audio tones you want to hear are lost, no amount of audio amplification will bring them back again in their proper proportion. There will be plenty of "lows" to be sure, lots of the bass drum—unharmonious instrument—but few of the human-like notes of the violin.

And so in a congested district where broadcasting stations are placed far enough apart not to bother each other, but close enough together to prevent any "getting out," people built receivers which were not very selective, and so the quality was good. Fans outside the large cities, however, had a different problem. Surrounded by stations, all over 100 miles away, the receiver had to have selectivity enough to cut out a geographically near-by station which might be poor in quality in order to receive a good station only 10 kc. away from the nearer station. No wonder side bands were clipped. No wonder few notes above 3000 cycles were received.

Up until about a year ago such a dilemma as this existed in every constructor's mind—should he build a selective receiver, one that would get out, or should he be satisfied with local broadcasting and build a broadly tuned receiver? In most cases a compromise was difficult to effect. Then, at a meeting of the Institute of Radio Engineers, Dr. F. K. Vreeland gave his paper of band-pass tuning which promised not only more selectivity but greater fidelity of response as well. This started many engineers thinking and remembering their text books and wondering why they hadn't thought of Dr. Vreeland's scheme themselves. For the truth must be told, Dr. Vreeland called to mind the old system of tuning two circuits to the same frequency and then coupling them closely enough together that the response curve no longer looked like a steep mountain, but like twin peaks side by side. It no longer had gently sloping sides down at the interference-frequency region, but a sharp cut-off.

And what good is such a curve, you may ask? Why have a broad top and steep sides. The answer is the reply to the prayers of engineers and those who want more selectivity and more fidelity of response. At the top of the curve—where the audio tones are—a broad flat plateau exists, at the sides of the curve—where interfering stations are—there is a steep precipitous drop in response.



THE HI-Q IN A COMBINATION PHONOGRAPH-RADIO CABINET

THE theoretical background of the 1929 model of the Hi-Q receiver, as outlined in October RADIO BROADCAST, *is amplified in this article from the Hi-Q organization. In the Laboratory, as tested under average conditions, the receiver seemed to have considerable r.f. amplification, the selectivity was good, and the fidelity of response was excellent. The completeness with which the r.f. circuits are filtered probably has much to do with the stability, and simplicity of operation. There are no trick adjustments.*

There is one interesting point which is not mentioned in this article, and about which we hope to present data soon. This is the fact that the shape of the response curve depends upon the frequency—that is, the curve will be one thing at 500 kc, something else at 1500 kc. —when the circuits are coupled by inductance, capacity, or mutual inductance. Just what this effect is, in the present receiver, was not apparent in the Laboratory. At the top and bottom of the broadcast-frequency spectrum good response was obtained. Perhaps the receiver had been adjusted somewhere in the middle of the band so that at the two ends it still had a band-pass circuit characteristic. —THE EDITOR.

BAND-PASS FILTER CURVES

LET us look at Fig. 1 which represents engineering data on the Hammarlund Roberts "Hi-Q 29," a receiver making use of the time-honored method of obtaining the flat-topped response curve described above. In the case of the single coil and condenser tuned to 1000 kilocycles, the top of the curve is peaked markedly, and if, as is usual, a little regeneration creeps into the amplifier, this peak becomes even more marked. The dotted line represents the response or resonance curve of a circuit with a resistance of about 5 ohms at 1000 kc. a low-loss circuit. At 2000 cycles the curve is beginning to droop and at 5000 cycles the response has been reduced to only 60 per cent. of the response at, say, 100 cycles. Now look at the full-line curve which represents the band-pass tuning arrangement. This is laboratory data on a single r.f. stage of the "Hi-Q 29" receiver. At 2000 cycles the curve has not even begun to drop, and at 5000 cycles the loss is only 10 per cent.

At the bottom of the curves in Fig. 1 other interesting things may be noted. The dotted curve shows a response at 20 kc. off resonance of 20 per cent. In the case of the Hi-Q stage, however, the loss is 90 per cent. which, in a two-stage affair, where the loss is squared, gives a response of 1 per cent. instead of 4 per cent. for the simpler circuit.

So far so good, but how is it possible for a receiver to be selective and still have good fidelity of response? Fig. 2 is the diagram of a single transformer-coupled stage of r.f. amplification which has the proper electrical characteristics to give a curve like that of Fig. 1 (dotted-line curve). The less the resistance in this circuit, the greater the amplification, and the greater the loss to the high audio tones. Now let us contrast this circuit with the more complicated one in Fig. 3, which is the arrangement used in the Master "Hi-Q 29" receiver. Here, again, we have a transformer-coupled stage of r.f. amplification, but both the primary and secondary windings are tuned—and they are tuned to the same frequency. In fact the primary and secondary coils

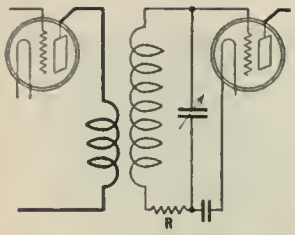


FIG. 2

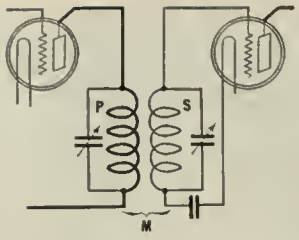


FIG. 3

and condensers are identical. The lower the resistance of the coils, the greater the amplification, but the side-band clipping depends upon the coupling between the coils which can be adjusted mechanically.

Theory states, and if you care to look it up you will find it in Pierce's *Electrical Oscillations and Electrical Waves*, pages 73 to 85, or Morecroft's *Principles of Radio Communication*, pages 119 to 136, that when two such circuits are tuned to the same frequency, and coupled electrically to a sufficient degree, the circuit no longer responds to the frequency to which the individual circuits were tuned but to two new frequencies which are displaced from the single-circuit frequency a certain amount, depending upon the coupling. In Fig. 4 may be seen two extremes of coupling. In one case (A) the coupling is very loose, so that a single sharp peak shows up, and with this adjustment little energy is transfered from primary to secondary. In the other case (B) the coupling is too close. Two peaks arise with a sharp dip between. Somewhere between these two degrees of coupling is found the type of curve we want, broad at the top and steep at the sides.

COUPLING ADJUSTMENT

THE coupling, then, is the important thing, and fortunately it can be controlled and adjusted until the desired type of response curve results.

So much for the theory of the Master "Hi-Q 29" receiver, It employs a band-pass filter type of r.f. amplifier using screen-grid tubes (a.c. or d.c.) which selects and amplifies but which clips side bands far less than the conventional low-loss coil transformer of the type used in nearly all present receivers. The detector of the receiver is conventional—a grid leak and condenser type. The audio amplifier is composed of two stages coupled with high-grade audio transformers. The last tube is a 171 type, and, as may be seen in the picture, sufficient room is allowed on the chassis for mounting an output device, or if desired a push-pull amplifier.

This chassis is made of steel, plated with cadmium which prevents rust, and has almost the same dimensions as last year's model. The individual stage coils and condenser are housed in aluminum boxes. The tubes themselves are between the shields and shielded leads make the connections from the control grid to the apparatus within the boxes The volume control governs the voltage on the screen grids. The antenna stage is tuned separately from the other circuits,

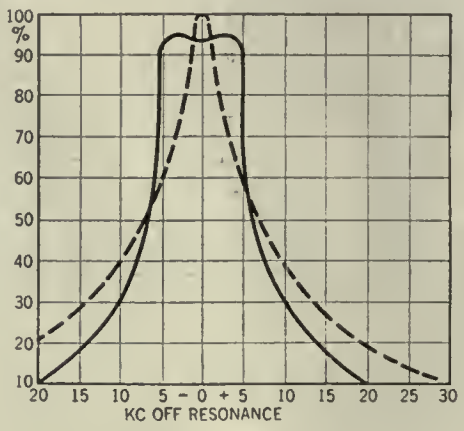


FIG. 1

and an additional tapped arrangement on the coil permits some range of selectivity control in the antenna stage. Careful shielding is necessary in this circuit where the primary windings of the radio-frequency transformers are tuned. Any feed-back coupling would introduce serious difficulties. For this reason the stage shields used are tight fitting, and the wires which connect coils to the tubes are enclosed in screening which is supplied as part of the Hi-Q kit.

So much for the electrical and mechanical properties of the new receiver. Complete data on how to build, adjust, and operate the set are obtainable from Radio Broadcast or from the Hammarlund-Roberts organization. The list of parts on the next page is the list specified by the manufacturer. The coils and mountings are special, and difficulty would be had in attempting their construction. Their essential dimensions are given in the complete circuit diagram, however, so that if the constructor desires he may try his hand at it.

What does the receiver do on the air? Just as an automobile manufacturer sends his product out over the road to see how long it will run without falling apart, how fast it can go, or other tests which the user probably never will desire to make himself, so must the radio set manufacturer make his receiver go through a "road test." The following is a report of such a test made for the Hi-Q organization.

In a small town on Long Island, about 8 miles from WEAF, 30 miles from WJZ and 10 miles from WABC we set up the model using Arcturus a.c. screen-grid tubes in the r.f. circuits, Arcturus type 46 and 48-tubes in the detector and first a.f. circuits, and a Cunningham type 371A tube in the power a.f. stage. The antenna was used ordinarily for a 40-meter amateur transmitting station and was about 60-feet long with the lead brought in from the middle. The two ends were about 45 feet above ground, and the set was operated in a second-story room. The set was not grounded—this was accidental, not intentional—and the selectivity and sensitivity might have been improved if proper grounding had been looked after. The night was October 13, the beginning of the winter season of heterodyne notes and ether jamming.

The stations whose calls were identified definitely came in with a more than ample volume for a large Peerless dynamic speaker in a three-foot baffleboard. WLS and WOO in Chicago were very strong. WIP in Philadelphia was very loud—ordinarily he is difficult to hear on Long Island—and the old stand-by's, KOKA and WGY were roaring in. WHAM at Rochester was easy to get, so were WBZ, WTAM, and one station between WEAF and WJZ was separated easily from these

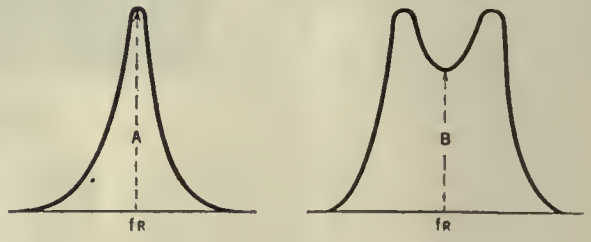


FIG. 4

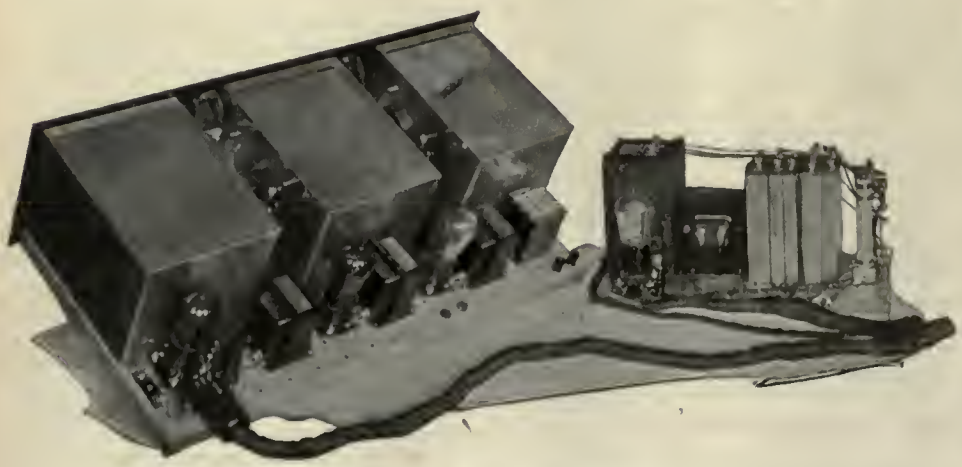
two near-by stations. It was probably WRC in Washington. All in all, the writer had an enjoyable evening and predicts much fun for the owner of such a receiver.

OTHER MODELS

THERE are two models of the Master Hi-Q receiver. One is designed for d.c. tubes, and the circuit diagram for it was published in October Radio Broadcast, page 343. The other is for a.c. tubes and the diagram is published herewith. This receiver uses Arcturus screen-grid tubes which require a 1.5-volt filament supply. The Thordarson power-supply equipment illustrated in Fig. 5 supplies this voltage as well as the other filament plate and grid voltages for the operation of the entire receiver.

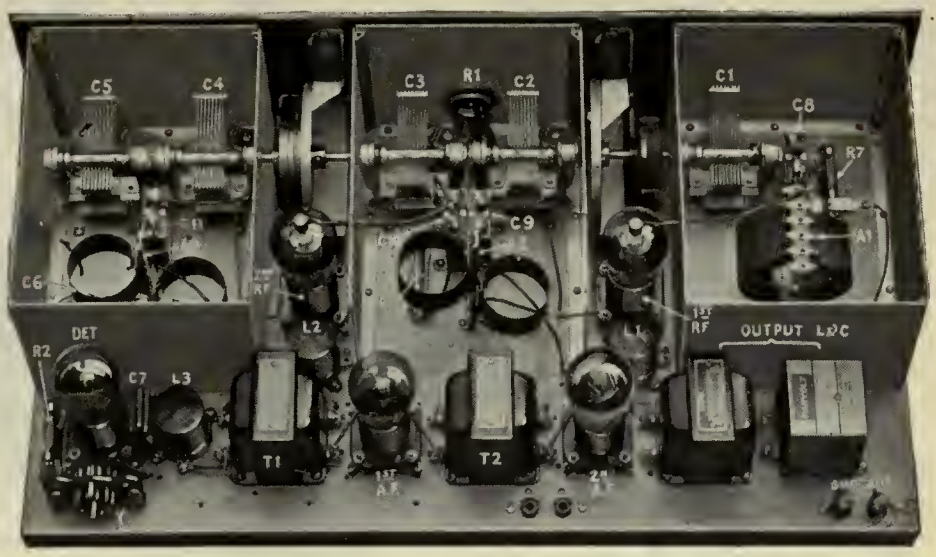
The foundation unit supplied by the Hi-Q organization includes the resistors R_6, R_7, and R_8 which are the center-tapped 50-ohm units for the first tube. And small fixed resistors used to filter the screen-grid circuits.

The picture of the receiver which appears on the next page shows several interesting features of its mechanical construction. One of the sides of the middle shield has been removed to show how



REAR VIEW OF HI-Q AND POWER UNIT

the two coils of the transformers are located, one above the other and on opposite sides of the insulating strip on which they are mounted. The position of the coils is fixed in the factory so that the desired coupling is attained. The double-condenser system, one condenser for each coil, is easily discernible, as well as the fact that all of the condensers, except the antenna tuning capacity, are controlled by a single dial. The antenna stage is, of course, in a separate shielded compartment, and consists of a high-gain, low-loss coil with taps on it so that antennas of various lengths can be accommodated. In operation the proper antenna tap should be found by trial and then the top of the compartment screwed down tightly, thereby reducing unwanted coupling to near-by fields to a minimum, and effectively sharpening the tuning of this stage when operated in the vicinity of several local stations.



VIEW OF HI-Q WITH SHIELD COVERS REMOVED

The list of apparatus employed for the construction of the Master Hi-Q a.c. receiver follows:

A_1, A_2, A_3 One Hammarlund Hi-Q 29 coil set;
C_1 to C_5 Five Hammarlund midline condensers, 0.00035-mfd., type ML-17;
C_6 One Sangamo fixed mica condenser, 0.00025-mfd.;
C_7 One Sangamo fixed mica condenser, 0.001-mfd.;
C_8 to C_{13} Six Parvolt by-pass condensers, 0.5-mfd., series 200;
C_{14} One Parvolt by-pass condenser, 4-mfd., series 200;
L_1, L_2, L_3 Three Hammarlund r.f. choke coils, type RFC-85;
L_4 One Thordarson choke coil, type 196;
R_1 One Carter "Hi-Pot" Potentiometer, 100,000-ohm, Type 11;
R_2 One Durham metallized grid resistor, 1.5-megohm;
R_3, R_4 Two Durham metallized resistors, 0.25-megohm;
T_1, T_2 Two Thordarson a.f. transformers, type R-300;
Y One Yaxley cable and connector plug, 12-wire;
Two Hammarlund knob-controlled drum dials, type SDW (Walnut);
Five Benjamin Cle-Ra-Tone sockets, type 9040;
Two Eby binding posts, engraved;
One Hi-Q Foundation Unit containing one drilled and engraved Westinghouse Micarta panel, three complete aluminum shields, one drilled steel chassis, shafts, one binding-post strip, Fahnestock clips, fixed resistor units R_6, R_7 and R_8, resistor mounts, brackets, clips, wire, screws, nuts, washers, and all special hardware required to complete the receiver.

The total cost of the parts required for the construction of the receiver is $109.45.

The following is a list of the parts used in the construction of a power unit for the Master Hi-Q a.c. receiver:

C_{15} One Parvolt by-pass condenser block, 3-mfd.;
C_{16} One Parvolt filter condenser, 1-mfd., series 200;
C_{17} One Parvolt filter condenser, 2-mfd., series 200;
C_{18} One Parvolt filter condenser, 4-mfd., series 200;
C_{19} One Parvolt filter condenser, 2-mfd., series 400;
P One Thordarson power compact, type R-171;
R_5 One Electrad "Truvolt" resistor, Hi-Q-type;
T_3 One Thordarson filament transformer, 15-volt, type T-2610;
S. S. One Pair of Yaxley insulated phone-tip jacks, type 422.

The total cost of the apparatus employed in the construction of the power unit for the Hi-Q is $41.60.

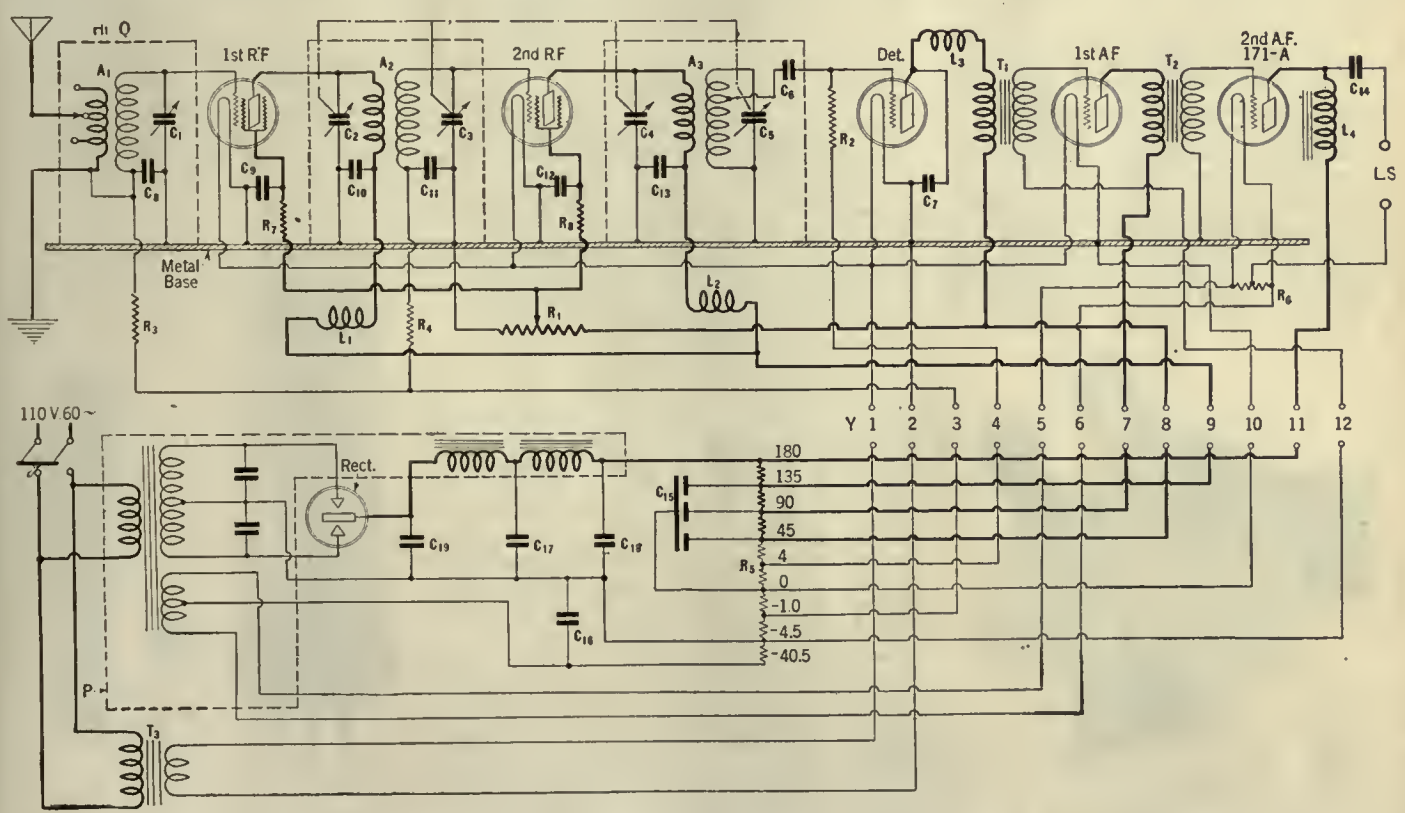


FIG. 5. THE COMPLETE SCHEMATIC DIAGRAM OF THE MASTER HI-Q RECEIVER TOGETHER WITH THE CIRCUIT OF A SPECIAL POWER UNIT DESIGNED FOR THE RECEIVER

New High-Voltage Metallic Rectifiers for B-Power Units

By J. GEORGE UZMANN

THE rectifier described in this article is a new device designed for use in Majestic, Thordarson R-171, or other similar types of B socket-power devices. This new unit was made possible only after many months' research and experiment with metallic (electronic) rectifier systems by Harry Shoemaker, Chief Engineer of Elkon, Inc., New York City. While the underlying principles of contact rectification (into which class falls this rectifier) perhaps are not new, still the pitfalls were many, particularly when dealing with potentials in the order of 350 volts many problems arise that must be solved.

Any means of high-voltage rectification must be comparable in performance to that produced by modern high-vacuum filament-type rectifiers. This new rectifier, known as the new Elkon type EBH, is the first of a series of high-voltage rectifiers. The pictures show the new Elkon EBH rectifier in assembled and partially complete forms; it is $5\frac{1}{8}$ inches in height, has a diameter of $1\frac{3}{4}$ inches and weighs approximately 16 ounces. The use of a standard tube base permits its use in the same way as any other ordinary type of rectifier—gaseous or thermionic. Since the unit is nearly all metal and contains no glass envelope or supporting structure it is obvious that little or no damage can come to it. The outer aluminum casing serves essentially as a heat radiator.

The actual rectifier consists of a large number of couples made up of cupric sulphids in contact with an aluminum-magnesium combination. These coupling elements have all the appearances of a large number of washers, and are $\frac{9}{16}$-inch in diameter. In proper combination they are assembled into four stacks, and then by means of clamping collars are forced together hydraulically to a predetermined pressure. The four main sub-assemblies are then inter-connected so as to fit electrically the circuit for which the rectifier is intended; thus the base-plug permits supplying the high voltage raw a. c. to the coupling units, and finally taking off the full-wave rectified d.c. output component.



FIG. 2

How the rectifier compares in size with a screen-grid tube

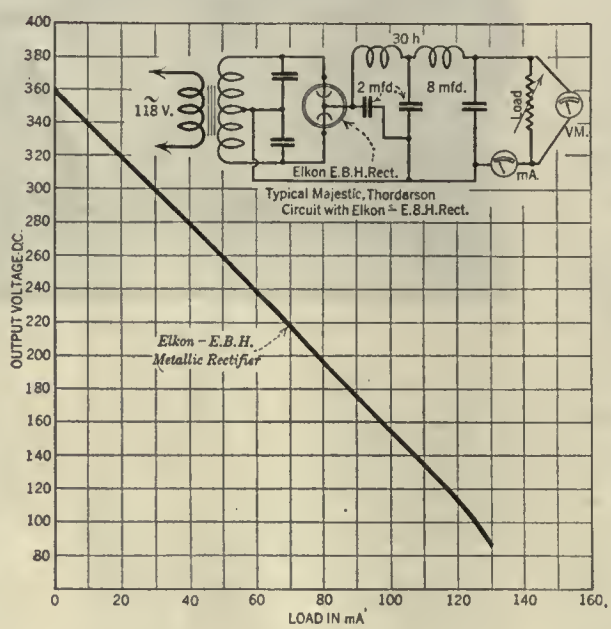


FIG. 1

THE article on this page presents the description of a new high-voltage metallic rectifier which may exert a great influence on the design of power-supply devices of the future. The data were prepared by J. George Uzmann at the request of Elkon, Inc. —THE EDITOR.

The process of manufacture, treatment and aging, around which the device evolves, makes a story in itself, but space does not permit a lengthy description. In the complete assembly 240 pair of "couples" are employed, and, since the maximum impressed voltage per anode is 350 r. m. s. (700-volt total), it is evident that the couples are designed for a potential pressure of approximately 3 volts r. m. s. per pair of couples. The operation of the EBH rectifier is based upon the physical fact that when relatively high electropositive and electronegative bodies are brought into proper contact, and current passed so that an electrochemical reaction takes place at their junction, an asymmetrically conducting film is formed at the junction which permits the passage of current in one direction only. These films can be formed and continuously maintained when proper electrical and physical conditions prevail at the junction.

The load characteristic of a typical B-power unit using the Elkon EBH rectifier is given in Fig. 1. It should be noted that the slope is very uniform from no load to maximum load, with but a slight curvature at the extreme ends. For gas tube rectifiers the curve would show the output voltage rising abruptly within the no load area. The output voltage of an EBH rectifier is about 20 volts lower, over the useful ranges, than that of a gaseous rectifier.

An important feature of these new metallic rectifiers, according to the manufacturer, is that they have a life of approximately 5000 hours as compared to 1000 for other types of rectifiers.

The Elkon EBH rectifier may be used in constructing new power units or may be used as a replacement rectifier in existing power units using a gaseous rectifier. In using it as a replacement rectifier no circuit changes are required; simply remove the present gaseous rectifier and place the EBH rectifier in the socket. The EBH rectifier *cannot* be used to replace rectifiers of the filament type without making changes in the wiring of the power unit.

The electrical characteristics of the Elkon EBH rectifier follow:

Use: In full-wave rectifier circuits of B-power units.

Base: Standard UX Base. The anodes are connected to the two filament prongs and the cathode to the plate prong.

Maximum permissible a.c. plate voltage per anode: 350 volts r. m. s.

Maximum d.c. output current: 125 milliamperes.

Maximum overall height: $5\frac{1}{8}$ inches.

Maximum overall diameter: $1\frac{3}{4}$ inches.

General: This rectifier is designed for use in the construction of B-power units to supply sets requiring plate voltages not in excess of about 180 volts. The prongs on the tube's base are so wired that this rectifier may be used as a replacement rectifier in all types of B-power units originally designed to use a gaseous-type rectifier. The Elkon Rectifier type E80 has similar characteristics to the type EBH except that the base is arranged to replace 280-type filament rectifiers in power units.

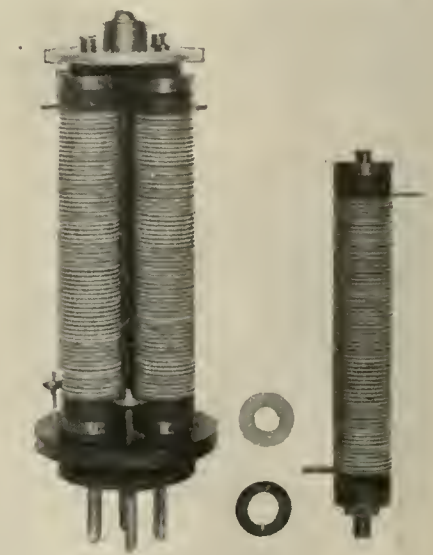


FIG. 3

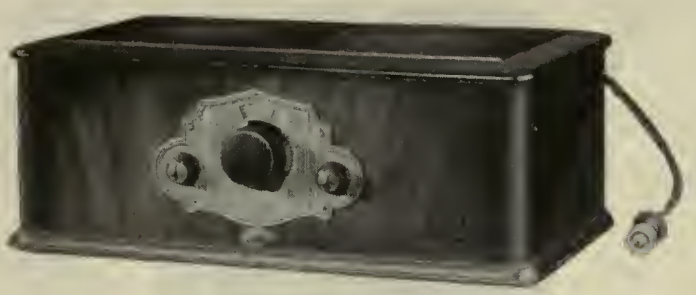
Picture shows mechanical construction of the new metallic rectifier

No. 13. December, 1928.

Radio Broadcast's Service Data Sheets

The A. C.-66 Dayton Receiver

THIS data sheet is devoted to a discussion of a receiver that utilizes the screen-grid tube as an r. f. amplifier. There are three r. f. stages in the set, the a. c. screen-grid tube being used in the first stage and 226-type tubes in the second and third r. f. stages. The detector circuit uses a 227-type tube, the first audio stage uses a 226-type tube and the power stage employs a 250-type tube. This receiver can be considered unique in that it is one of exceedingly few manufactured receivers that utilizes the screen-grid tube in the r. f. circuit and a 250-type tube in the output circuit.



MODEL A.C.-66

TECHNICAL DISCUSSION

1. Tuning System

The four tuning condensers are ganged to a single control. Across the first tuning condenscr is placed a midget variable condenser so that this circuit may be tuned to exact resonance. An antenna of ordinary length is connected directly to antenna terminal No. 1; a long antenna is connected to terminal No. 2 so that the signals are compelled to pass through a small fixed condenser, C_1, which has a capacity of 0.00025 mfd. No neutralizing or stabilizing devices are necessary in conjunction with the 222-type tube. To suppress oscillations in the 226 circuits 900-ohm fixed resistors are connected in series with the grid of these two tubes.

2. Detector and Audio System

In the grid circuit of the detector is placed a 2-megohm grid leak and a 0.00025-mfd. grid condenser. The detector is a 227-type tube and the output of the detector is bypassed to ground with a 0.001-mfd. fixed condenser, C_2. The audio amplifier contains two transformer-coupled stages. A 0.0025-mfd. fixed condenser is connected across the secondary of the first audio transformer to improve the high-frequency response. The 250-type output tube feeds into a choke-condenser combination located in the power unit.

3. Volume Control

The volume control in this receiver consists of a 100,000-ohm resistor, R_1, connected across the secondary of the first tuned circuit. By adjusting this control it is possible to regulate the amount of energy fed into the r. f. amplifier. In this way the possibility of overloading in any of the tube circuits is prevented.

4. Filament Circuits

Filament current for the various tubes in the receiver is obtained from several windings on the power-supply transformer located in the power unit. The 222-type a. c. screen-grid tube obtains its current from a 2.5-volt winding, and 2.5 volts for the detector tube filament is obtained from a winding on a separate filament transformer. The r. f. tubes and the first audio tubes are supplied from a 1.5-volt winding and the 250-type power tube from a 7.5-volt winding. The 1.5-volt winding, is shunted in the receiver by a 20-ohm potentiometer, R_2, with two 0.5-mfd. by-pass condensers connected across it, their center point being connected to the 125-volt lead from the power-supply unit. A 65-ohm center-tapped resistor, R_7, is connected across the filament circuit of the 250-type power tube. The 20-ohm potentiometer is adjusted at the factory to the point of minimum hum in the loud speaker.

. Plate Circuits

The screen grid of the 222-type tube and the plate circuit of the detector tube are supplied with 125 volts through a 35,000-ohm fixed resistor, R_3, which serves to reduce the potential to approximately 45 volts. The plate circuit of the first audio tube is supplied with 125 volts through a 10,000-ohm fixed resistor, R_4, which serves to reduce the potential to about 100 volts at the plate of the tube. The plates of the 226-type r. f. tubes and the plate of the screen-grid tube are all supplied with 125 volts. The 250-type tube is supplied with 350 volts from the power unit.

6. Grid Circuit

The grid bias on the grid of the screen-grid tube is 1.4 volts, obtained by connecting a 900-ohm resistor, R_5, in series with the plate circuit of this tube and then utilizing the drop in voltage across it for grid bias. The 900-ohm resistor, R_6, supplies 9 volts of grid bias to the 226-type r. f. tubes and the first audio tube. There is no bias on the detector tube. A 1500-ohm C-bias resistor in the power unit supplies 63 volts to the grid of the 250-type power tube.

7. The Power Supply

The power supply, not shown in the circuit diagram below, is placed in the cabinet with the radio receiver. The power unit is of conventional design, supplying all the d. c. and a. c. voltages required for the operation of the set. A 281-type tube is used as the rectifier.

The following data was supplied by Mr. R. S. Copp, Chief Engineer of the A-C Dayton Company:

"The a. c. screen-grid tube is rather new to the public and has only been available to manufacturers a comparatively short time, and, therefore, there is not a great deal of data available as yet. Our Engineering Department has been giving quite a bit of time in the laboratory on this new tube and we have found out a few things which might be of interest to the readers of RADIO BROADCAST.

"The a. c. screen-grid tube receiver, known as Model AC-66, uses one of these tubes in the first radio-frequency circuit only. It is placed in the first r. f. circuit in order to gain sensitivity, especially on inefficient antennas. This tube is then followed by two tuned stages of radio-frequency amplification, using the 226-type a. c. tube. The 227-type tube is used as detector, the 226-type tube as first audio and then for the last stage, we are using the new 250-type super-power amplifier in order to give the best of tone quality with the increased volume obtained.

"We are using r. f. transformer coupling on the screen-grid tube with a ratio of one to three. This system is employed in preference to impedance coupling in order to obtain a good degree of selectivity, and yet not destroy the sensitivity which this tube has.

"Inasmuch as this new tube is for a. c. operation we obtain our C bias through a 900-ohm resistor in the plate-supply lead which is in series with the cathode and ground. This gives approximately 1.4-volt bias on the grid of the tube, with 125 volts of plate potential with 45 volts applied to the screen-grid element.

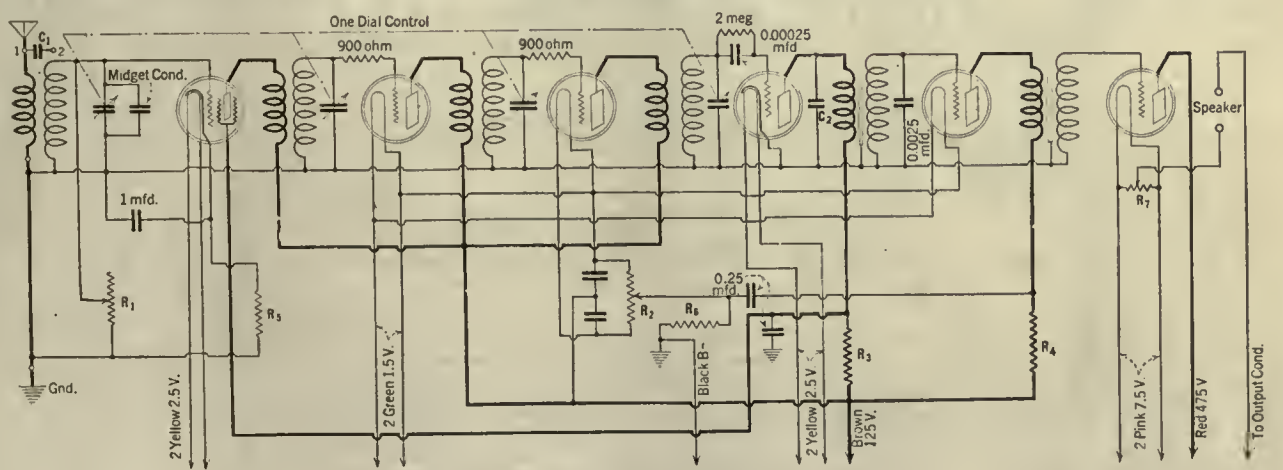
"The heater element of the a. c. screen-grid tube is the same as the one used in the 227-type tube, and the same methods are used as in the 227 heater circuit. The center tap of the heater circuit is grounded and is not connected to cathode as shown in some circuits. By grounding center-tap connection of heater winding the heater becomes 1.4 volts negative with regard to cathode which is necessary in order to obtain maximum efficiency.

"Our experiments on screen-grid tubes have shown us that this tube is very efficient. In fact, so much so in some cases as to prohibit the use of more than one of the tubes in a tuned r. f. set, without decreasing selectivity to an undesirable degree. Then again if several of these tubes are used and coupled properly to obtain the highest order of amplification, the sensitivity becomes so great as to increase background noises which in the end does not give satisfactory results, unless the volume is reduced and then the efficiency is back again to that of one tube, in the first r. f., followed by regular tubes as r. f. amplifiers.

"The shielding of a screen-grid amplifier is very important, otherwise, inter-coupling of circuits will develop and cause uncontrollable oscillation. Where only one screen-grid tube is used, it is not necessary to employ extreme shielding, as is the case where two or more are used in a receiver.

"With our form of construction and circuit design, we find a gain of approximately twenty in the first stage as compared to approximately eight in the second and third stages of the r. f. circuit, therefore, our gain up to the detector tube is in the order of about 1300, whereas the gain on a straight 226-type set-up of three stages is about 500. This we believe is a sufficient increase over a 226-type set-up, presenting a compromise of amplification and selectivity.

"If three stages of screen-grid amplification were used, a gain of twenty per stage could be maintained; the result would be 8000. However, this gain is entirely theoretical and would be decreased by several thousand in actual practice. Granting that we could count on a gain of 6000, what would our chances be in using it all? Atmospheric static and electrical disturbances in the average community are such to-day that this enormous amplification would cause a noise level in the volume of a roar and in order to reduce this roar, the volume control would have to be retarded greatly, so we would be only bringing up something we could not use and there is no object in this."



THE RECEIVER CIRCUIT

No. 14. December, 1928.

Radio Broadcast's Service Data Sheets

The Fada 50, 70, 71, 72 A. C. Electric Radio Receivers

THE Fada receivers, models 50, 70, 71 and 72, all use the same chassis so that in operation and in technical characteristics they are similar. The model 50 is a table model, the 70 is housed in a low-boy console, the 71 in a high-boy console, and the 72 is contained in a console which also contains a phonograph turntable and pick-up unit. The receivers are of the single-control type, the station finder being calibrated in wavelengths and also in degrees. The sets may be operated on either a loop or antenna. The models 70, 71, and 72 are equipped with a new Fada model-14 dynamic speaker.



MODEL 72

TECHNICAL DISCUSSION

1. Tuning System

The tuning system used in these receivers comprises four r.f. transformers and tuning condensers and include of L_1C_1, L_2C_2, L_3C_3 and L_4C_4. The four tuning condensers are ganged to one control and are operated by a single drum dial. Between the first and second r.f. tubes is placed a special untuned radio-frequency transformer designed with a gain-frequency characteristic essentially opposite to that of an ordinary tuned radio-frequency transformer; the result of using such a transformer is that the gain-frequency characteristic of the entire receiver is made much more uniform than it would otherwise be. All of the stages are neutralized by the Hazeltine method. The neutralizing condensers are C_5, C_6, C_7 and C_8. Each radio-frequency transformer is enclosed in a shield in order to prevent interstage coupling. The tuning condensers, C_2, C_3 and C_4, are shunted by small midget condensers which are adjusted at the factory to bring each stage into exact resonance.

2. Detector and Audio System

A grid-leak-condenser-type detector is used, C_9 being the grid condenser and R_1 the grid leak. The output of the detector is bypassed to ground by the fixed condenser C_{10}, and, in order to keep the radio-frequency currents out of the audio system, the r.f. choke coil, L_6, is placed in the detector plate lead. The audio amplifier is a two-stage transformer-coupled affair with a phonograph jack placed across the primary terminals of the first audio transformer. An interesting point about the audio amplifier is that the d.c. plate current of the first audio tube is kept out of the primary of the input push-pull transformer, T_2, by means of the fixed condenser C_9 and the audio-frequency choke coil, L_6. The removal of the direct current from the transformer winding eliminates the possibility of saturation in the core which would lower the inductance and cause a loss in amplification at low frequencies.

3. Volume Control

The volume control, R_2, is a variable high resistor connected across the secondary of the untuned radio-frequency transformer. In this position it serves to control the amount of energy fed into the remainder of the r.f. amplifier and detector system.

4. Filament Circuits

Since 227-type tubes are used in all the sockets of this receiver with the exception of the power stage only two filament windings are necessary on the power transformer. One of these windings supplies approximately 2.5 volts to the heaters of all the 227-type tubes and the other winding supplies current to the power tubes in the push-pull amplifier. To prevent the r.f. currents in the amplifier circuits from circulating around the various circuits, choke coils, L_7, L_8, L_9, L_{10}, are placed in the cathode leads to each of the four r.f. tubes.

5. Plate Circuits

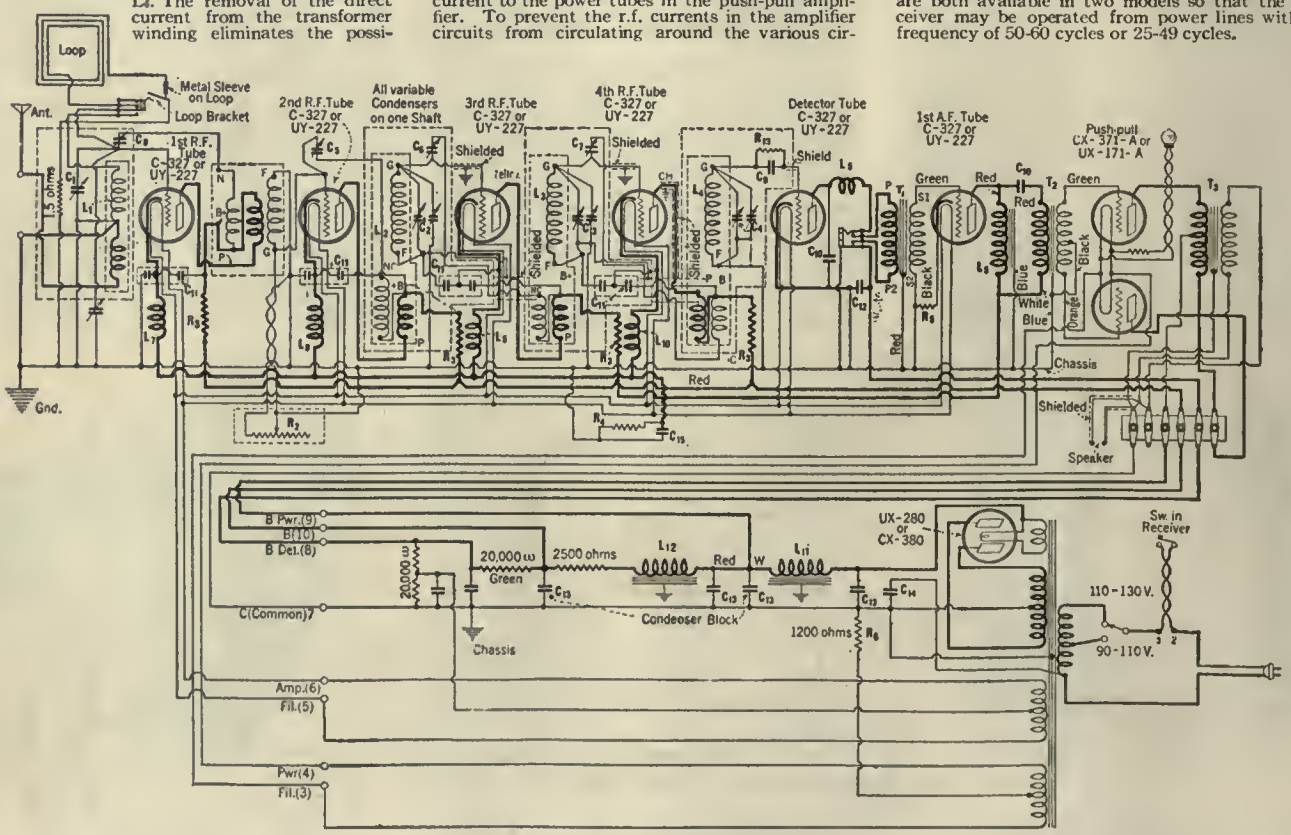
Filters are used in the plate circuits of all the r.f. tubes so that the r.f. currents are compelled to return directly to the cathodes of the 227-type tubes. If the filter systems were not used these currents would pass into the power system where common coupling would result. The filter systems in the r.f. plate circuits consist in each case of R_3, and C_{11}. The filter system in the plate circuit of the detector tube consists simply of C_{12}.

6. Grid Circuits

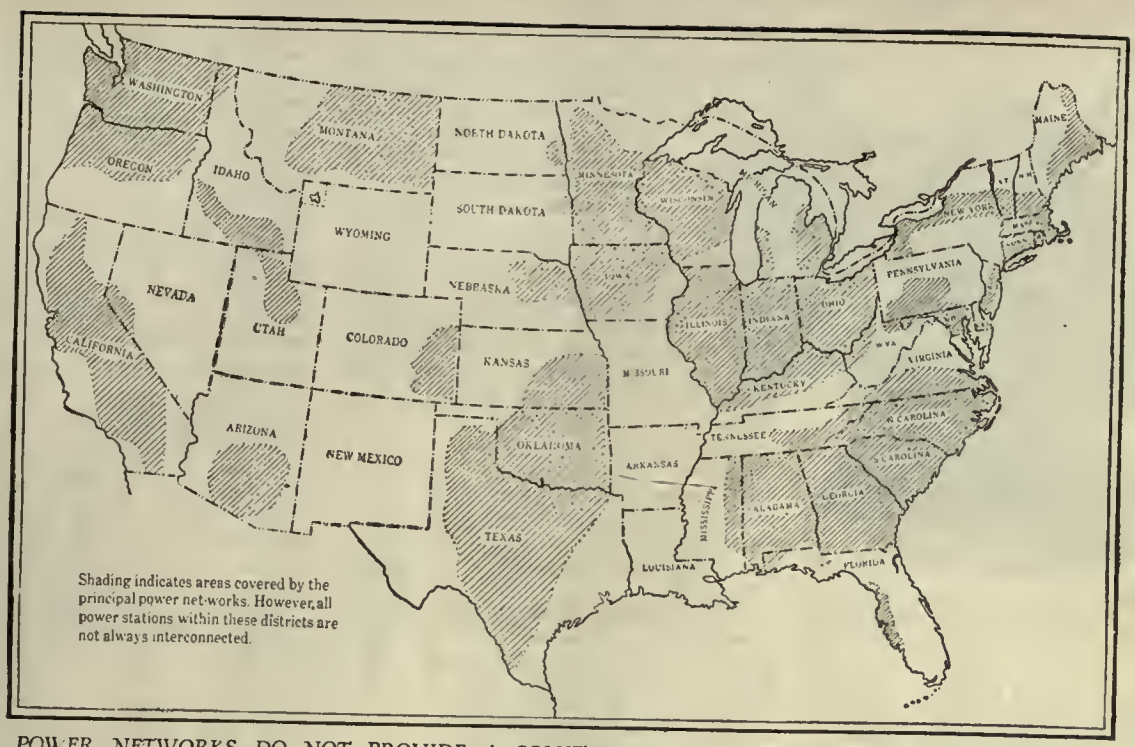
C bias for the various grid circuits is obtained by connecting fixed resistors in series with the cathode leads in the case of the 227-type tubes and in series with the center-tap connection of the filament-transformer winding in the case of the power tube. For bias on all the r.f. tubes a common resistor, R_4, is used. It is bypassed by C_{15}. Bias for the first audio tube is obtained from R_5 and bias for the power tubes is obtained from the resistor, R_6, located in the power-supply device.

7. The Power Supply

Two power-supply units are available for use with this series of receivers. The type E-420 is for use with 210-type power tubes and the type E-180 is for use with 171A-type power tubes. The latter power unit is illustrated in the circuit below. This power unit consists essentially of the power transformer, T_1, which supplies plate and filament voltages for operation of a 280-type full-wave rectifier tube and filament voltages for the receiver. The output of the full-wave rectifier leads into the filter system, consisting of the two filter choke coils, L_{11} and L_{12}, and the filter condensers C_{13}. The condenser, C_{14}, connects from side of the 110-volt line to the ground circuit and this condenser serves to bypass to ground any line noises which might otherwise be audible in the output of the receiver. Plate voltage for the power tube is obtained at the junction between the two filter choke coils, and plate voltages for all the other tubes in the receiver are obtained by connecting suitable resistors across the output of the filter system. The primary of the power transformer is arranged with two taps, one for use with line potentials of 110 to 130 volts and the other for use on line potentials of 90 to 110 volts. Power to the entire receiver is controlled by the switch, SW. The power units E-420 and E-180 are both available in two models so that the receiver may be operated from power lines with a frequency of 50-60 cycles or 25-49 cycles.



THE RECEIVER AND POWER CIRCUITS



POWER NETWORKS DO NOT PROVIDE A SOLUTION TO THE PROBLEM OF SYNCHRONIZING TELEVISION RECEIVERS

The rapidity of development makes it practically impossible to obtain an accurate up-to-date map showing the power networks in the United States. Nevertheless, the shaded districts in the above illustration give some idea of what has been accomplished in this field. In addition many of the networks shown above may be connected if necessary

Problems in Synchronizing Television Receiving Discs

By BOYD PHELPS

THE development of a system for keeping the scanning disc of a television receiver in *exact synchronism* with that of the transmitting disc is one of the biggest problems in radio at the present time. The simplest method would be to have the disc at the transmitter on the same shaft with the similar disc at the receiver. For a review of the principles of television, this simplified arrangement will be considered.

In diagram A of Fig. 1 the subject, A, at the left is being viewed by the electrical eye, C, through the holes in the rotating scanning disc, E. The varying electrical impulses in C, produced by different intensities of light reflected from light and dark parts of the face of A, are amplified by a common vacuum-tube amplifier and cause the brilliancy of the flat plate in the neon tube, D, to vary in step. An observer, B, looks through spirally arranged holes in disc F at this plate and, although he actually sees it through only one hole at a time, the rapid rotation of the disc gives him the impression that image, A, is on the flat plate in D. What B sees is shown in diagram B of Fig. 1, the dotted line representing the margins of the scene. Each hole in the disc passes across the scene and traces the light-intensity variations on the plate below the path of the previous hole until the last hole in the spiral comes around when the process is repeated.

It will be evident what a mess would be made of the picture if the receiving disc should slip around on the shaft only half a picture width, or if it was half a turn out of phase with the transmitter disc. But such a difficulty would be tame as compared to cutting the shaft between the two discs and running the discs with separate motors *at different speeds!* A rain or black and white dots or streaks with no trace of a picture would be the result. With these remarks as an introduction the necessity for precision in the maintenance of exact speed of the receiving disc in television may be more apparent.

SYNCHRONIZATION is one of the major problems in the accomplishment of television. Although in experimental television, manual control may be used satisfactorily, it is absolutely essential, if any sort of practical television is to be achieved finally, that some method of synchronization be evolved that will hold the received image exactly stationary on the screen of the television receiver. At one time or another many of us probably have thought over the possibilities of synchronizing the television receiver with the transmitter by the use of synchronous motors operated from the power lines of the local power company. A discussion of this method of synchronization is the subject of this article.

The author, Mr. Phelps, after many heated arguments with radio enthusiasts who felt that this method would work satisfactorily, decided that the only way to settle the argument was actually to get the "dope" and the ingenious method which he used to secure the data certainly makes interesting reading.

—THE EDITOR.

SYNCHRONOUS MOTORS

FOR distance transmission where a shaft connecting transmitter and receiver is impractical, the first method of synchronizing that seems obvious is to use synchronous motors operating on the same alternating-current supply. This works fairly well under some conditions, but we shall speak more of this later. An ordinary 1760 r. p. m. squirrel-cage induction motor will run synchronous at 1800 r.p.m. on 60 cycles if four slots are cut in the rotor, and similarly, motors can be made to run 3600, 1200, 900, etc. Fifteen complete pictures per second means 900 r. p. m. of the scanning disc and is about the minimum speed permissible without flicker. This speed is used at present by C. F. Jenkins at his station 3XK in Washington, D. C., on 46.72 meters (see Table 11). Twenty pictures per second means 1200 r. p. m. of the scanning disc and is the speed used for receiving the WGY pictures on 380 meters from Schenectady, N. Y.

A frequency higher than 60 gives a more accurate lining up of the edges of the picture, so in the Bell Telephone demonstra-



A variable-speed motor with a highly developed speed control is used in this televisor

tions a 2000-cycle current was generated by the motor turning the transmitter disc. This current was carried by a pair of wires, or a separate radio-wave channel, to the receiver where it was amplified and fed into a 2000-cycle synchronous motor. This motor was aided in driving the receiving disc by a larger motor adjusted quite closely to the right speed. Rumors have it that the Baird system scrambles a synchronizing signal in with the picture frequencies and thus needs only a single pair of wires or wave band for the whole television operation. If so, and it is simple, it is a great step in the right direction.

Then we have many semi-successful speed regulators for variable-speed motors. Some are highly developed mechanical governors similar to the one shown in the picture. It is an interesting diversion to put a slip of paper under the edge of a phonograph record on the turntable and try adjusting the speed to, say, 75 revolutions per minute. After several minutes of timing and readjustment notice if the slip of paper crosses the starting position at the end of every minute. Electrical equivalents often include a resistor that may be short circuited periodically with a button or key manipulated by the operator who must pay close attention to the direction the picture is slipping, bring it back quickly, and not overdo it. The exact speed adjustment may be found finally with any of these devices, but at that moment the disc may be part of a turn around from where it should be, so exact synchronism in every respect is not easy. It is quite a ways from throwing a switch and sitting in the big arm chair for an evening's entertainment as we now do with audible programs (or until some advertising program gets so nauseating we tune in another station)

So far it might appear that a synchronous motor connected to the home-lighting current is the final answer, as 60 cycles is the standard frequency supplied about 98 per cent., of the homes in this country having public electric service. Indeed, many believe this is the only satisfactory answer, and in most any radio store one can get into heated argument on either side of the question. The only tangible evidence seems to be that a brand of clock, known as a "Telechron," which has a miniature synchronous motor geared down to the hands, seem reasonably accurate when operated on a 60-cycle circuit. The arguments then proceed along lines of how much deviation from 60.0000 cycles is permissible for television, and if the clocks gain or loose a few seconds per day how many times in so many minutes will the pictures be null and void or worse. Also, if the error accumulating during the 24 hours of the day is corrected in the space of an hour by a worse error in the opposite direction what will be the effect? The writer, being of an experimental turn of mind, and thoroughly fed up on such arguments which get nowhere, decided to find out for himself how the various so-called 60-cycle currents in different parts of the country compare, which data forms the "meat" of this article. If anyone else knew the answer, based on measurements instead of hearsay or guess, he has certainly kept it a close secret.

A few oscillographs costing a few thousand dollars connected to a few leased long-distance telephone lines and an army of engineers putting local lighting current on the end of these lines suggested itself as the first solution. It never got further than a suggestion, however, as every radio amateur has a reputation to uphold, namely, being able to get any result desired from the stuff in his boxes of junk. (That wasn't the only reason, but it may get by.)

Now it so happens that when a neon bulb (costing 55c) held in the hand is moved parallel with an antenna lead of an amateur transmitter it lights bright and dim in spots if a poor filter is used in the transmitter plate-supply system. If no filter is used at all there are spaces between the bright spots that are dark, especially if a single oscillator tube is used in a transmitter operating on one half of the a.c. cycle. This lamp acts the same way if connected through a transformer to the output of several stages of audio-frequency amplification after an ordinary short-wave tuner has been adjusted to similar signals from other amateur stations. Now it was only necessary to compare these flashes produced by the distant station with those caused by the local lighting current to measure their difference in frequency. Here at last was found one desirable feature of the class of transmitter which is most cursed by broadcast listeners in its immediate vicinity!

The first measurements were made by passing enough of the local house current through the neon lamp to light it to about half brilliancy or about the same intensity as the signal which was passed through the same lamp. When the incoming signal was in step with the local power the lamp became bright, and when it slipped behind a half cycle, or gained a half cycle, so it was 180 degrees out of phase the lamp went out or became dim. This would have been entirely satisfactory except for four things: It was hard to time or count the pulsations when the station was keying; it was slow and discouraging trying to call and instruct the right amateur stations to hold their keys down for a few minutes; there was no way of knowing which frequency was the faster, and atmospheric fading, quite rapid at this time of the year, made the results very confusing.

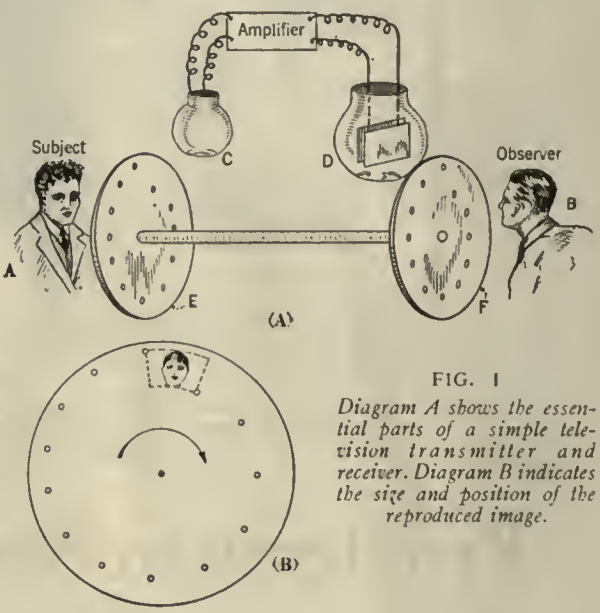


FIG. 1

Diagram A shows the essential parts of a simple television transmitter and receiver. Diagram B indicates the size and position of the reproduced image.

Experimental research at this point gave way to plain "monkeying." Engineers seldom use this undignified expression but their "cut and try" is much the same. An old quarter horse power induction motor with a white cardboard disc on the shaft and a black diameter line inked across the disc was illuminated with the neon lamp connected on the local lighting current. With this arrangement it was noticed that the motor ran so near synchronous (1800 r. p. m.) that the black line looked like a four-spoke wheel slowly turning backward (like old time movies of buggy carriages). A hack saw and cold chisel on the rotor soon made a synchronous motor and the "spokes" thereafter stood still. But when the neon lamp was lighted by the amplified signals of distant "raw-a.c." amateur stations the spokes revolved, sometimes fast, sometimes slow, sometimes backward, and sometimes forward, and therein hangs this tale.

Table I. Comparisons of Lighting Frequencies

*Time	Call	Location	Sec. per Rev.	Direction	Frequency
8:21	3BR	Toronto, Ont.	2.2	Same	59.546
8:22	3ALS	Richmond, Va.	5.2	Same	59.615
8:27	3ALS	Richmond, Va.	17.0	Same	59.882
8:37		Tampa, Fla.	.75	Against	62.666
8:39	3AJD	Catonsville, Md.	1.0	Same	58.000
8:42	9BEU	St. John's Sta., Mo.	3	Same	59.333
8:45	8DVM	Not Listed	?	**	60.000
8:49	WIZ	New Brunswick, N. J.	24.7	Same	59.927
9:00	WIZ	New Brunswick, N. J.	23.7	Against	60.084
9:02	2BGZ	Jamaica, L. I., N. Y.	?	**	60.000
9:04	3APQ	Quakertown, Pa.	5	Against	60.400
9:06	2BKH	Bloomfield, N. J.	30	Same	59.933
9.09	4AAR	Elkin, N. C.	5.3	Against	60.378
9:11	2WI	Westfield, N. J.	?	**	60.000
9:13	CQ	(Unknown)	5.7	Against	60.351
9:14	nu	(Unknown)	6.5	Against	60.308
9:15	3AVL	Not listed	7.3	Against	60.274
9:16	3AVL	Not listed	5	Against	60.400
9:17	3AVL	Not listed	6.2	Against	60.323
9:19	2WI	Westfield, N. J.	?	**	60.000
9:22	4AHO	Not listed	240.	Against	60.008
9:25	WYE	Mt. Clemens, Mich.	120.	Same ***	59.984
9:30	9EWQ	Richmond, Ind.	7	Against ***	60.286
9:32	3CGF	Phoebus, Va.	17.2	Same	59.884
9:35	8DBG	East Liberty, Pa.	?	**	60.000
9:40	2BLX	White Plains, N. Y.	?	**	60.000
9:43	1CTP	West Haven, Conn.	20	Against	60.100
9:46	8BFR	Jeanette, Pa.	20.4	Against	60.098
9:50	3APQ	Quakertown, Pa.	10	Against	60.200
9:53	1CRS	Not listed	28	Same	59.929
9:57	4AB	Raleigh, N. C.	5.8	Against	60.385
9:59	8DNJ	Bay City, Mich.	?	**	60.000
10:00	9ERH	Chicago, Ill.	21	Against	60.096
10:05	9EJO	Geneva, Ill.	30	Same	59.933
9 A.M.	WGT	San Juan, Porto Rico	1	Against	62.000

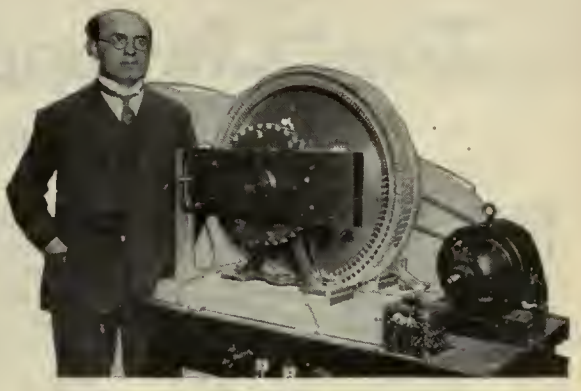
*Time P. M. (Eastern Daylight Saving) unless indicated otherwise.
**Exact synchronism or very close to this.
***Peculiar modulation producing additional "spokes."

Table II. New U. S. Television Licenses

Call	*Locatian*	*Power in watts*	*Wave Band* in meters*
4XA	White Haven, Tenn.	5,000	125–120
2XBV	New York City	5,000	66.67–65.22
6XC	Los Angeles, Calif.	15,000	
2XBS	New York City	5,000	65.22–63.83
8XI	East Pittsburgh, Pa.	20,000	63.83–62.5
1XAY	Lexington, Mass.	500	62.5–61.22
2XBU	Beacon, N. Y.	100	
3XK	Washington, D. C.	5,000	61.22–60.00
8XI	East Pittsburgh, Pa.	20,000	19.86–19.73
2XBW	Bound Brook, N. J.	5,000	

* Each band 100 KC. wide

The motor disc and neon lamp were put in a darkened box. A double-pole double-throw switch changed the lamp from amplifier to local a.c. to check motor synchronism, but it was always found in step. A stop watch timed the number of seconds taken by the image of a spoked wheel to make one complete revolution. There being four poles to the 1800 r.p. m. motor this meant a gain or loss of two cycles per revolution of the wheel image. If the "wheel" moved in a direction opposite to that of the disc the received frequency was leading the local frequency. While it is not certain the local frequency was exactly 60.0000 cycles during this test it generally is found to be very close to this, and synchronous clocks in the vicinity (Jamaica, Queens County, N. Y.) keep very good time. This is more or less confirmed by the fact that about as many of the frequencies measured were found higher as were lower. The observations listed in Table I were taken July 24, 1928, the time being Eastern Daylight-Saving time. The hours during which the tests were made represent possibly extreme power load fluctuations between sunset and evening darkness when lights were being switched on, but also this is the time when most people would be using their television receivers. Due to the quite uniform motion of the "wheel" it could be followed on code stations and none of the amateurs listed know that they participated in this test, it being unnecessary to get in communication with them on the local transmitter. Where the seconds required for a revolution of the "spoked wheel" are a few it means it was revolving fast and indicated a great deviation from the local standard frequency. A great number of seconds for one turn in either direction indicates close to but not quite synchronism. The stations with calls beginning with the numeral "2" that are shown probably were operated from the same power network. Three distant stations had to be listed as being in exact synchronism because for the duration of the measurement, usually two minutes, no variation in their frequency could be noted. Such are probably rare coincidences and if measured for a quarter hour would probably show slow creeping of frequency. Two others came quite near this standard. Due to peculiarities of transmitter circuits, or filters producing frequencies that were multiples of 60 cycles, additional "spokes" were present for some stations, oftentimes eight, occasionally twelve or sixteen, but it was not very hard to time one revolution if the modulation was strong.



NEW TELEVISION PROJECTOR

This apppratus was exhibited at the German Radio Exposition in Berlin by Prof. Karolus of Leipzig

The method of collecting the data as explained above is so similar to what would happen in attempting television by synchronous motors on these power supplies that the answer can be read directly from the notes or data. A synchronous television motor running 900 r.p.m. would, however, take twice as long to get out of step as the figures under the column headed "Sec. per Rev." A better statement of the case would be to say that (except for local stations) there would be no picture practically all of the time, but that every so many seconds the picture would appear correct for a moment. This puts a different angle on the problem and a vote taken amongst television friends seems to indicate that if non-synchronism must be tolerated they would prefer having the picture come flitting in right every second or so rather than spreading out with long periods between correct pictures. In other words, almost exact synchronism would be more of a nuisance than a moderate variation, which is an unlooked for conclusion!



APPARATUS USED BY MR. PHELPS IN CHECKING POWER-LINE FREQUENCIES

The data, even allowing a ten per cent. error in some of the readings, forces us to admit that synchronous motor operation from lines out of our own network is far from satisfactory and thus one more hope for simple synchronizing is shot to pieces. We now understand the hesitancy of the big radio companies in not placing complete televisors on the market immediately after the first public demonstrations. Television to-day is in about the same stage as the old chain-drive, stem-wind horseless carriages of not so long ago, but how many goggled drivers of those days now regret their early escapades when a driver *had* to be a mechanic? By the time this article is published television probably will have made several notable advances. A more interesting and fruitful field for individual experiment is difficult to find.

Book Review

"A LABORATORY TREATISE ON B BATTERY ELIMINATOR DESIGN AND CONSTRUCTION." Published by Radio Treatise Company, New York City, 87 pages. Price—$1.00.

THE text of this book is intended to set forth the essential principles of the design and operation of B-power units.

The book is divided into several major sections as follows: Power Transformers, Rectifiers, Condensers, Filter Chokes, Calculation of Resistances, C-Bias Voltages and Resistances, and General Considerations. The last page of the book contains an index. In the various chapters the functioning of the component parts of a B-power unit is considered.

Probably the major problem one confronts in the building of a B-power unit is the choice of the apparatus; that is, deciding what rating it should have and what capacity. The author discusses these subjects quite fully, and indicates the sort of power transformers which should be used with different B units, the value of the chokes, filter condensers and resistors.

The dictionary being the only book in which one probably can't find an error, the typographical errors (of which there are quite a few) in this book may be excused. Technically the book seems to be sound, although some serious errors are to be found. For instance, on page 57 the author states that, in connection with a.c. voltages, "the average voltage is that value indicated on our a.c. voltmeter." Actually an a.c. voltmeter reads effective values. Average voltages are also confused with effective values in the statement that, "the peak voltage is equal to 1.4 times the average value."

The chapter on filter condensers, page 60, states that if two condensers with similar ratings are connected in series, the total voltage across them may safely be twice the rated voltage. A diagram is given showing two condensers so connected. This is one instance where we cannot recommend that the author's suggestion be put into practice. When two condensers are connected in series across a source of d.c. potential, the division of voltage between the two condensers depends not at all on their respective capacity—it depends entirely on their resistance.

However, in spite of these points about which we differ with the author, we want to assure the reader that the book contains a potpourri of exceedingly helpful data. Its low cost puts it within the reach of all of us and it is certainly a worth-while addition to a library of elementary radio texts.

—H. E. R.

The "Chronophase" for A. C. Tubes

By BERT E. SMITH

Aero Products, Inc.

IN RECENT issues of RADIO BROADCAST, data have been published outlining the development of the new "Chronophase" system of radio-frequency amplification, and describing the construction of a screen-grid receiver using this circuit.

Some kit builders are not particularly anxious to use screen-grid tubes, because of their tendency to amplify microphonic noises and also due to the fact that their filaments are so delicate. Others feel that the storage battery is an unnecessary evil and are anxious to construct a receiver which can be plugged directly into an electric-light socket. For these fans another model of this receiver has been designed which makes use of alternating-current tubes throughout. In this article the a. c. model of the "Chronophase" receiver is described.

The construction of the a.c. model of the "Chronophase" receiver is in many details similar to that of the screen-grid model which was described in last month's issue. The assembly of the set is simple, and complete instructions are supplied with the kit of parts.

The circuit diagram, given in Fig. 1, shows that the leads to the last stage of audio amplification are independent of other parts of the set. Therefore, if the proper power supply is available, a 210- or 250-type tube may be used in this stage, simply by applying 7½ volts to the red and black terminals of the Yaxley cable connector and four- to five-hundred volts to the brown lead. In the event that a 250-type tube is used, a resistor capable of dissipating at least forty watts should be connected between the green lead of the cable connector plate and the B-minus wire. A resistor of 2000 ohms is approximately correct for all types of tubes.

No output device has been incorporated in this receiver since many of the loud-speakers, particularly of the dynamic type which are now very popular, are provided with transformers for coupling the output of a power tube to the actuating windings of the speaker. Several methods of coupling the speaker to the final tube are given in Fig. 2.

Many owners of radio sets have phonographs of a more or less obsolete type. In this connection it is interesting to note that a first-class audio-frequency amplifier, such as is used in "Chronophase," will, with a good loud-speaker, amplify phonograph music equally as well as the finest and most expensive up-to-date phonographs. Therefore, many users may gain a great deal of pleasure by purchasing a phonograph pick-up unit and attaching it to the audio amplifier of their A.C. "Chronophase" receiver.

The audio-frequency amplifier used in the "Chronophase" is ideally suited for use with phonograph pick-up units, particularly in the a.c. models where a 210- or 250-type tube may be used in the last stage. The Aero transformers are designed so that they have a very flat amplification characteristic up to above seven-thousand cycles and above that point almost no amplification whatever is obtained, thus reducing the "needle-scratch".

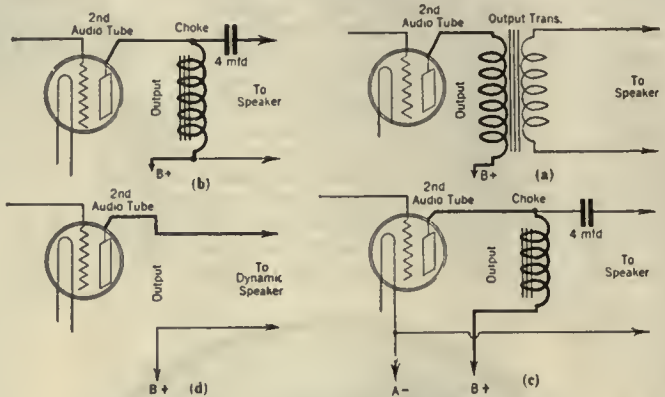


FIG. 2. OUTPUT CIRCUITS

The changes required in the receiver for the reproduction of phonograph music are exceedingly simple. A regular phone jack may be inserted in the set or tip jacks may be used. If tip jacks are used, attach one tip jack to transformer post labeled P and the other to transformer post labeled B as shown at the point marked X in Fig. 1. If this last method is used, the detector tube must be removed from the socket when the phonograph pick-up unit is used.

The following are the parts included in the "Chronophase" A. C. Five Receiver kit:

C_1, C_2, C_3 One Aero triple-gang condenser, .00035-mfd., type AE-2155;
C_4 One Aero Midget condenser;
C_5, C_6, C_7 Three Aerovox moulded mica condensers, .001-mfd.;
C_8 One Aerovox moulded mica condenser, .00025-mfd.;
L_1, L_2, L_3 1 Aero coil kit, type U-203;
L_4, L_5 Two Aero r.f. choke coils, type C-60;
R_1 One Special Centralab resistor, AE-250;
R_2 One grid leak, 3-meg;
R_3 One Yaxley resistor, 2000-ohm;
R_4 One Yaxley resistor, 600-ohm;
T_1, T_2 Two Aero audio transformers, type AE-770;
Y One Yaxley cable connector and plug, type 669;
One Aero A. C. "Chronophase" foundation unit, including No. 400 cabinet, escutcheon plate, base unit with sockets mounted, wire, solder, and all other parts necessary for mounting and completing set, such as machine screws, bushings, etc.
One National dial, type "E";
Three Kurz-Kasch special knobs;
Three Eby "Junior" binding posts;
One pair Yaxley tip-jacks, type 422.
Total cost of kit as supplied by Aero Products Company, $74.50.

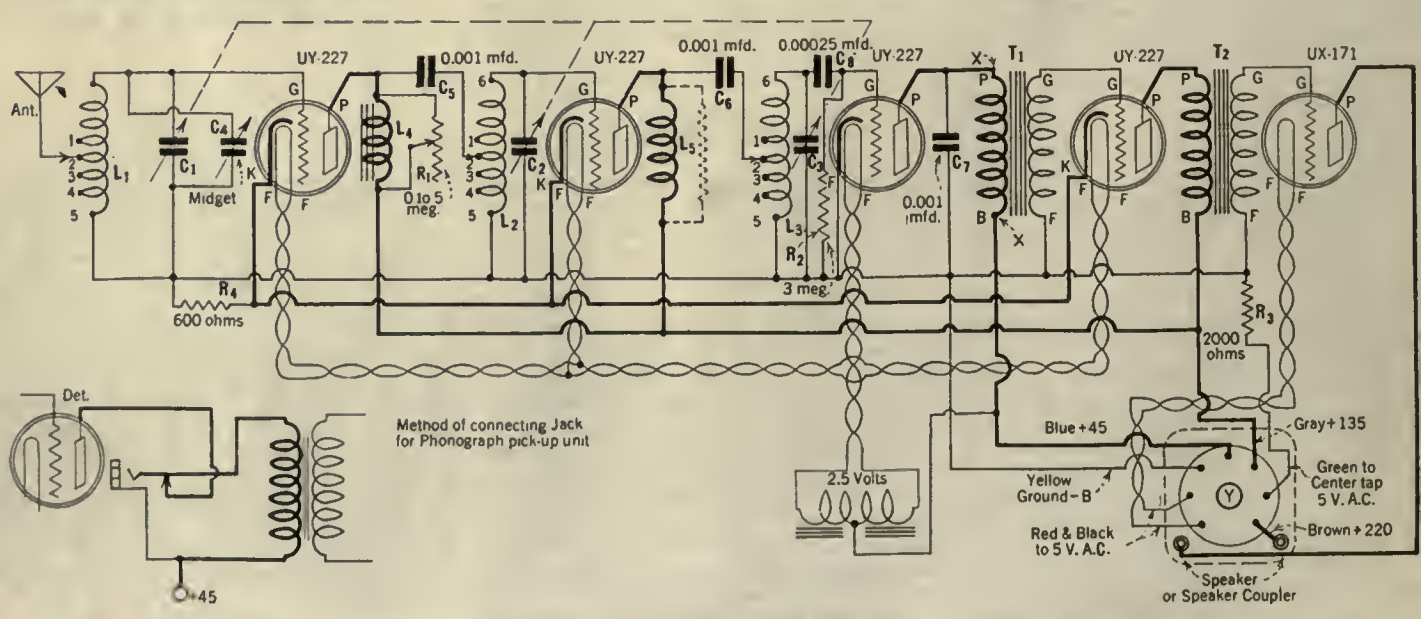


FIG. 1. SCHEMATIC DIAGRAM

New Apparatus and Their Applications

How to Build a B-Power Unit with Recently Announced Parts

ARE you operating your receiver in the most economical manner possible? If a power tube, such as the 171A, is used in the last stage it is advisable to use a socket-power unit to supply the plate power. A B-power unit designed to supply the various plate voltages required for the operation of any standard receiver may be constructed easily. The apparatus required are: a power transformer designed to supply plate and filament voltages for the operation of the rectifier tube and filament voltage for the operation of the power tube if this latter is to be operated from alternating current, filter choke coils and filter condensers to change the pulsating current from the rectifier to a steady d.c. required by the plate circuits of the various tubes, and a bank of resistances and by-pass condensers which will enable you to obtain the intermediate values of voltages required for the operation of the amplifier and detector tubes in the receiver. The illustration on this page shows how such a unit may be constructed easily and inexpensively from a group of standard parts which recently have been placed on the market.

This power unit supplies 180 volts for the plate of a 171A-type tube and also delivers the negative 40-volt C-bias potential which this tube requires. Intermediate potentials of 135, 90, 67 and 45 volts are also available. These latter voltages are variable to some extent—the voltage from the 135-volt tap may be adjusted to any desired value from about 120 volts to 180 volts, the 90-volt tap is adjustable from 80 to 120, the 67-volt tap may be varied from 60 to 80 volts and the 45-volt tap is adjustable from 0 to 60. The voltage from the various taps is adjusted by rotating the arms on the Frost 2000-ohm potentiometers; this arrangement making it possible to use this power unit with any receiver, for it is possible to adjust easily the different output potentials to give most efficient operation of the radio receiver.

The power transformer at the left is a Dongan type 5509 containing three secondary windings —two 5-volts windings and one high-voltage winding, supplying 300 volts either side of the center-tap connection. The Dongan choke coil, type 7542, contains two filter chokes in a single case. The filter condensers are three 2-mfd. 400-volt Frost type 1305. Each of the Frost potentiometers connected across the output have a value of 2000 ohms. The long resistance located at the lower left-hand corner has a value of 2000 ohms and it supplies the 40-volt C bias required for the 171A-type power tube.

To assemble this power unit the apparatus should first be mounted on the baseboard as shown in the picture. The leads from the power transformer should then be connected to the rectifier tube socket. As indicated in the picture, the two red leads from the high-voltage winding on the transformer are connected to the grid and plate terminals of the socket; the two filament posts of the socket are connected to the two black leads from one of the filament windings of the transformer.

The colors of these and the other wires leading from the power transformer and the filter choke coils are indicated in the picture and if it is followed carefully no difficulty should be experienced in constructing the unit. The parts required for the construction of this unit are listed below:

T—One Dongan power transformer, type 5509;

Important Announcement

THIS month an important change is made in the method of treating new apparatus in these pages. All of the various pieces of apparatus available for description were suited for use in B power-supply devices. Therefore, in order to provide a concrete example of an application for each of these units, it was decided to incorporate them in a B-power unit. Not only does this unit illustrate a use for the various pieces of apparatus under discussion, but it also provides an ideal design for the set-builder to follow. The power unit is of up-to-the-minute design, it will provide B potentials to any standard receiver and A, B and C potentials to a 171A-type power tube, it is easy to build, and the cost of the parts is $38.40. In future issues, if the occasion presents itself, this method of presentation will be applied to other types of apparatus.

—THE EDITOR

L_1—One Dongan filter choke coil, type 7542;
C_1, C_2, C_3—Three Frost 1-mfd. 200-volt by-pass condensers, Type 1104;
R_1, R_2, R_3, R_4—Four Frost 2000-ohm potentiometers;
R_5—One Frost 2000-ohm fixed resistor;
1 Frost Socket.

The various Frost resistors used in this unit are part of the "Universal Resistance Kit" which this company manufactures.

New Power Transformers and Filter Choke Coil

X77

Device: Power Transformers and Filter Chokes. Various types, are available to meet the requirements of all different types of power units.

Manufacturer: Dongan Electric Manufacturing Company.

Application: The B-power unit described on this page illustrates a typical application of these filter chokes and transformers in the construction of a power unit. Complete circuit diagram and constructional information on various types of power units may be obtained by writing the manufacturer.

New Power Unit Parts

X78

Device: FILTER CONDENSERS and UNIVERSAL RESISTANCE KIT, TYPE No. 300. These parts are for use in construction of power units.

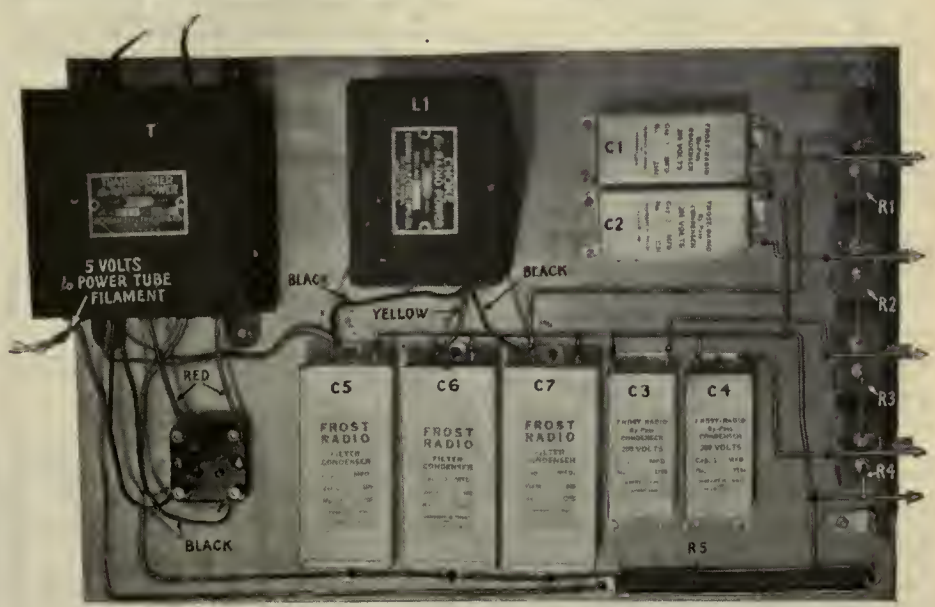
DATA ON UNIVERSAL RESISTANCE KIT

This kit consists of three 2000-ohm fixed resistors each of the A series, wound on flexible bakelite strips, one inch wide and five and one-half inches long; four 2000-ohm heavy-duty wire-wound potentiometers, and one 1500-ohm A series fixed resistor. This kit may be used in all present types of power amplifiers, including those using 210- or 250-type tubes in a push-pull circuit The total heat dissipation of the kit is 72 watts. Price: $9.00.

DATA ON FILTER AND BY-PASS CONDENSERS

Individual condensers in capacities ranging from 0.1 mfd. to 2 mfd. are available. These are designed to work on potentials up to 2000 volts d.c. A block condenser is also made containing four sections, the first section being a 1000-volt 2-mfd. condenser, the second section a 600-volt 2-mfd. condenser, the third section a 400-volt 4-mfd. condenser, and the fourth section a 400-volt 1-mfd. condenser. Prices: Block condenser No. 690: $18.00. Prices of individual condensers vary with size and voltage rating.

Manufacturer: Herbert H. Frost, Inc.



PICTURE DIAGRAM OF POWER SUPPLY

This picture shows the exact arrangement of apparatus and wiring in the B power-supply unit. The wires terminating in arrows on the right connect with the wiring harness of the receiver. The approximate potentials available at the various points follow: wire from R_1, 135 volts; wire from R_2, 90 volts; wire from R_3, 67 volts; wire from R_4, 45 volts, and the lower wire is the B minus connection

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on this page. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. 1928 revised booklet, with circuit diagrams of popular kits. RADIALL COMPANY.

5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.

17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

32. METERS FOR RADIO—A catalogue of meters used in radio, with diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

37. WHY RADIO IS BETTER WITH BATTERY POWER—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.

46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.

47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.

48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.

53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.

56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.

57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.

58. HOW TO SELECT A RECEIVER—A common-sense booklet describing what a radio set is, and what you should expect from it, in language that anyone can understand. DAY-FAN ELECTRIC COMPANY.

67. WEATHER FOR RADIO—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. TAYLOR INSTRUMENT COMPANIES.

69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit; list of American and Canadian broadcast stations. RADIO CORPORATION OF AMERICA.

72. PLATE SUPPLY SYSTEMS. Technical information on audio and power systems. Bulletins dealing with two-stage transformer amplifier systems, two-stage push-pull, three-stage push-pull, parallel push-pull, and other audio amplifier, plate, and filament supply systems. AMERICAN TRANSFORMER COMPANY.

73. RADIO SIMPLIFIED—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. CROSLEY RADIO CORPORATION.

76. RADIO INSTRUMENTS—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. JEWELL ELECTRICAL INSTRUMENT COMPANY.

78. ELECTRICAL TROUBLES—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. BURTON ROGERS COMPANY.

81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

89. SHORT-WAVE TRANSMITTING EQUIPMENT. Data and wiring diagrams on construction of all popular short-wave transmitters, operating instructions, keying, antennas; information and wiring diagrams on receiving apparatus; data on variety of apparatus used in high-frequency work. RADIO ENGINEERING LABORATORIES.

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98. COPPER SHIELDING—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. THE COPPER AND BRASS RESEARCH ASSOCIATION.

99. RADIO CONVENIENCE OUTLETS—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set, also antenna, ground and battery connections. YAXLEY MANUFACTURING COMPANY.

101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. SAMSON ELECTRIC COMPANY.

102. RADIO POWER BULLETINS—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. RAYTHEON MANUFACTURING COMPANY.

104. OSCILLATION CONTROL WITH THE "PHASATROL"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. ELECTRAD, INCORPORATED.

105. RECEIVING AND TRANSMITTING CIRCUITS. Construction booklet with data on 25 receivers and transmitters together with discussion of low losses in receiver tuning circuits. AERO PRODUCTS COMPANY.

108. VACUUM TUBES—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. ARCTURUS RADIO COMPANY.

112. HEAVY-DUTY RESISTORS—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. WARD LEONARD ELECTRIC COMPANY.

113. CONE LOUD SPEAKERS—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. THE MAGNAVOX COMPANY.

114. TUBE ADAPTERS—Concise information concerning simplified methods of including various power tubes in existing receivers. ALDEN MANUFACTURING COMPANY.

115. WHAT SET SHALL I BUILD?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. HERBERT H. FROST, INCORPORATED.

118. RADIO INSTRUMENTS. CIRCULAR "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. WESTON ELECTRICAL INSTRUMENT CORPORATION.

120. THE RESEARCH WORKER—A monthly bulletin of interest to the engineer and home builder. Each issue contains special articles on radio design and construction with special emphasis on resistors and condensers. AEROVOX WIRELESS CORPORATION.

121. FILTER CONDENSERS—Some practical points on the manufacture and use of filter condensers. The difference between inductive and non-inductive condensers. POLYMET MFG. CORP.

123. B SUPPLY DEVICES—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. ELECTRAD, INC.

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126. MICROMETRIC RESISTANCE—How to use resistances for: Sensitivity control; oscillation control; volume control; regeneration control; tone control; detector plate voltage control; resistance and impedance coupling; loud speaker control, etc. CLAROSTAT MFG. CO.

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132. THE NATIONAL SCREEN-GRID SHORT-WAVE RECEIVER—Constructional and operating data, with diagrams and photographs. JAMES MILLEN.

133. THE NATIONAL SHIELD-GRID FIVE—A circuit diagram with constructional and operating notes on this receiver. JAMES MILLEN.

134. REMLER SERVICE BULLETINS—A regular service for the professional set builder, giving constructional data, and hints on marketing. GRAY & DANIELSON MFG. CO.

135. THE RADIOBUILDER—A periodic bulletin giving advance information, constructional and operating data on S-M products. SILVER-MARSHALL, INC.

136. SILVER MARSHALL DATA SHEETS—These data sheets cover all problems of construction and operation on Silver-Marshall products. SILVER-MARSHALL, INC.

139. POWER UNIT DESIGN—Periodical data sheets on power unit problems, design, and construction. RAYTHEON MFG. CO.

140. POWER UNIT PROBLEMS—Resistance problems in power units, with informative tables and circuit diagrams. ELECTRAD, INC.

141. AUDIO AND POWER UNITS—Illustrated descriptions of power amplifiers and power supplies, with circuit diagrams. THORDARSON ELECTRIC MFG. CO.

142. USE OF VOLUME AND VOLTAGE CONTROLS. A complete booklet with data on useful apparatus and circuits for application in receiving, power, amateur transmitter, and phonograph pick-up circuits. CENTRAL RADIO LABORATORIES.

143. RADIO THEORY. Simplified explanation of radio phenomena with especial reference to the vacuum tube, with data on various tubes. DE FOREST RADIO COMPANY.

144. A.C. DETECTOR TUBE. Data on characteristics and operation of 2.5-volt a.c. detector tubes. ARCTURUS RADIO COMPANY.

145. AUDIO UNITS. Circuits and data on transformers and impedances for use in audio-amplifier circuits, plate and output impedances and special apparatus for use with dynamic speakers. SANGAMO ELECTRIC COMPANY.

146. RECEIVER CIRCUIT DATA. Circuits for using resistances in receivers, and in power units with descriptions of other apparatus. H. H. FROST, INC.

147. SUPER-HETERODYNE CONSTRUCTION. Construction and operation of a nine-tube screen-grid super-heterodyne. SET BUILDERS' SUPPLY COMPANY.

148. SHORT-WAVE RECEIVER. Constructional and operation data on a four-tube short-wave receiver. KARAS ELECTRIC COMPANY.

149. FIVE-TUBE SCREEN-GRID RECEIVER. Blueprint with full constructional details for building a broadcast receiver using two screen-grid tubes. KARAS ELECTRIC COMPANY.

150. FIVE-TUBE A.C. RECEIVER. Blueprint for constructing a five-tube a.c. receiver employing the "equamatic system." KARAS ELECTRIC COMPANY.

151. THE SECRET OF THE SUPER. Constructional and operation data on the Lincoln 8-80 One-Spot Super. LINCOLN RADIO CORPORATION.

152. POWER SUPPLY ESSENTIALS. Circuits and data on power-supply devices, and descriptions of power apparatus. POLYME MANUFACTURING COMPANY.

153. WHAT THE EVEREADY FIDELITY CURVE MEANS TO RADIO RECEPTION. An analysis of the frequency range of musical instruments and the human voice which shows how these tones are reproduced by a receiver with an audio range of 60 to 5000 cycles. NATIONAL CARBON COMPANY.

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A Thordarson Power Amplifier (Home Constructed) Will Transform Your Radio Into a Real Musical Instrument

WITH the insistent demand for quality reproduction, power amplification has become a vital radio necessity. Today, it is hard to find a radio set manufacturer who does not employ one or more power tubes in the output stage of his receiver.

There is no need, however, for you to discard your present radio instrument in spite of the fact that it is outclassed by newer models with power amplification. You can build a Thordarson Power Amplifier which, attached to your receiver, will provide a fullness and richness of reproduction that will equal or surpass the finest offerings of the present season.

Thordarson Power Amplifiers are exceedingly easy to assemble, even for the man with no previous radio experience. Only the simplest tools are used. Specific instructions with clear-cut photographs, layouts and diagrams insure success in home construction.

Whether your present receiver is factory made or custom built one of these amplifiers may be attached with equal ease. In fact, most Thordarson Amplifiers require absolutely no changes in the wiring of the receiver itself, attachment being made by means of a special plug which fits the last audio socket of the receiver.

Thordarson Power Amplifiers for the home constructor and professional set builder range from the simple plate supply unit up to the heavy-duty three stage units employing the 250 type power tube in push-pull arrangement. These power amplifiers cover the requirements for every purpose and every pocket-book. They may be used with any type of horn, cone or dynamic speaker.

With a background of over thirty-three years manufacturing quality transformers, it is only natural that so many manufacturers of receiving sets of undisputed superiority have turned to Thordarson as the logical source of their audio and power supply transformers. The discriminating home constructor will do well to follow the lead of these manufacturers when buying his power amplifier.

Write to the factory today, enclosing 25c for the new "Power Amplifier Manual"—just off the press.



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Please send me free of charge your instruction sheet on the amplifier I have checked below:

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THE aim of the Radio Broadcast Laboratory Information Sheets is to present in a convenient form, concise and accurate information in the field of radio and closely allied sciences. It is not the purpose of the Sheets to include only new information, but to present practical data, whether new or old, that may be of value to the experimenter, set builder or service man. In order to make the Sheets easier to refer to, they are arranged so that they may be cut from the magazine and preserved, either in a blank book or on 4" x 6" filing cards. The cards should be arranged in numerical order.

Since they began, in June, 1926, the popularity of the Information Sheets has increased so greatly that it has been decided to reprint the first one hundred and ninety of them (June, 1926–May, 1928) in a single substantially bound volume. This volume, "Radio Broadcast's Data Sheets" may now be bought on the newsstands, or from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Inside each volume is a credit coupon which is worth $1.00 toward the subscription price of this magazine. In other words, a year's subscription to RADIO BROADCAST, accompanied by this $1.00 credit coupon, gives you RADIO BROADCAST for one year for $3.00, instead of the usual subscription price of $4.00.

—THE EDITOR.

No. 241 RADIO BROADCAST Laboratory Information Sheet December, 1928

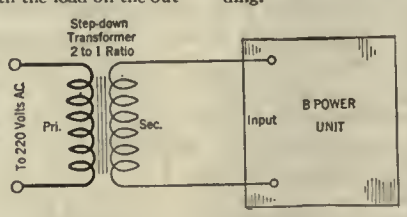
Supplying Power Devices from 220 volts A.C.

USE OF STEP-DOWN TRANSFORMERS

LETTERS are received frequently from readers in which the following question is asked, "I live in a district in which the only a.c. supply is 220 volts. How can I adapt a 110-volt B-power unit for operation on a 220-volt line?"

There are two methods by which this may be accomplished. First, a resistance of such a value as to produce a drop of 110 volts and leave remaining 110 volts for the power unit may be connected in series with the 220-volt line. This method is not very satisfactory, however, for the value of resistance which must be used varies considerably with different power units and with the load on the output of the power unit. Also, unless one has available instruments for measuring the a.c. voltages there is no simple means of determining what value of resistance must be used in order to reduce the line potential to 110 volts. If one has available an a.c voltmeter this method can, of course, be used quite readily. The variable resistance is connected in series with one side of the line, the voltmeter is connected directly across the input terminals to the power unit, and the resistance then adjusted until the voltmeter reads 110 volts.

The second method of adapting 110-volt B-power units for operation on a 220-volt line is somewhat more expensive, however, it is much simpler and does not require that any voltage measurements be made. This system of reducing a line potential to 110 volts calls for placing a separate power transformer between the power unit and the line. The transformer should have a step-down ratio f 2 to 1 so that with 220 volts across its primary 110 volts will be developed in the secondary winding.



The secondary is connected directly across the terminals of the B-power unit as indicated in the diagram. The same transformer may be used with any B-power unit so long as the input power to the B-power unit does not exceed the power rating of the step-down transformer. Such transformers are now made by several manufacturers.

No. 242 RADIO BROADCAST Laboratory Information Sheet December, 1928

Resistance-Coupled Amplifiers

PREVENTING DISTORTION

AT VARIOUS times letters asking how to reduce distortion have been received from readers, who have constructed resistance-coupled amplifiers. The correspondent usually explains that the amplifier produces considerable distortion unless the volume is kept down very low. In this sheet we have endeavored to indicate what we consider the causes of the distortion.

As proof that a resistance-coupled amplifier, when properly constructed and operated, is capable of giving excellent results, we might refer to the use of such an amplifier in the demonstration of television by the Bell Telephone Laboratories. In this work an amplifier of this type was used to amplify the output of the photo-electric cell and it was essential that the audio response curve be practically flat over a very wide frequency band. Distortion in an amplifier of television signals would be much more serious than similar distortion in the amplification of music, the eye being a much more critical judge of quality than the ear.

What, then, is the probable cause of the distortion which many notice when using such an amplifier? The answer is, first overloading of the amplifier, and secondly, common coupling in the plate-voltage supply, be it batteries or a power unit, although, of course, such coupling generally will be more serious in the latter case.

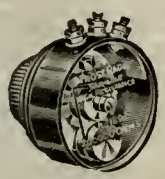
If any of the tubes in a resistance-coupled amplifier are overloaded so that the grid of one or more tubes goes positive, some grid current will flow and produce so-called "blocking." If the overloading is very slight, the blocking may not be noticeable as such, but the amplifier will distort. The important point is that the blocking does not affect only the signal which *caused* the blocking but will also affect the following signals until the blocking current leaks off through the high-resistance grid leak. If the signals were fed into a transformer-coupled amplifier some overloading might occur but the tubes would not block because the transformer windings are of low resistance in comparison with the resistance of the grid leaks used in a resistance-coupled amplifier.

The resistance-coupled amplifier is, therefore, much more critical with regard to overloading, than a transformer-coupled amplifier, and in the operation of the former type of amplifier the signal input *must* be kept down to a level at which no overloading occurs.

Laboratory Sheet No. 243 discusses a second cause of distortion in resistance-coupled amplifiers, i.e., common coupling in the plate-supply circuits.

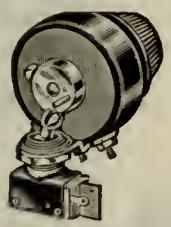
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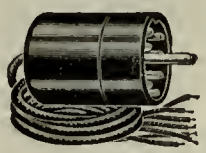
FROST VOLUME CONTROL WITH D. C. SWITCH

Equipped with sturdy German silver switch mounted on Bakelite panel, and with switch points fitted with sterling silver contacts, this Volume Control gives quick operation, positive-locking off position and saves space. For battery operated sets. $2.35.



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Identical with our standard size Volume Control units except in size. Gem units are only 1⅝ in. in diameter, and ⅝ in. thick. Great space savers. $2.25 and $2.50.







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Terminals cannot work loose even when overheated. Color code moulded into Bakelite. Best quality cable, with colored rubber insulation on wires. Has 5 ft. seven-strand braid covered cable. Plug and cord only, $2.25. Baseboard or sub-panel socket, 75c.



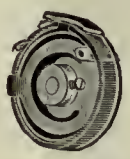
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Simply turn the slotted head shaft with screw driver to regulate. Smoothes the ripple out of A.C. current. Precision built. $1.00.



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Made to deliver a service that is not usually expected from little rheostats like these. Mighty good little rheostats, taking up little space and supplied either plain or with D.C. switch. Easy to solder to. Plain, 75c. With switch, $1.00.



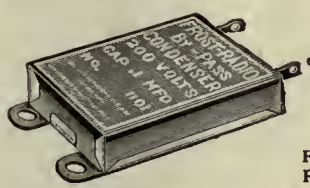
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...and it ought to be—here's why

THE finest materials skillfully employed by able craftsmen and the foremost laboratory experts give CeCo marked advantages over other tubes.

They have not only a purer, clearer, more pleasing tone, but a longer, more serviceable life.

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CeCo Mfg Co., Inc. Providence, R. I.

CeCo *Radio Tubes*

No. 243 RADIO BROADCAST Laboratory Information Sheet December, 1928

Resistance-Coupled Amplifiers

EFFECT OF COMMON COUPLING

LABORATORY Information Sheet No. 242 gave some data on distortion in resistance-coupled amplifiers due to overloading. A second cause of distortion (which applies to this type of amplifier as well as to any other type of amplifier) is that due to common coupling between the plate circuits of the various tubes. This form of coupling is generally due to the resistance or reactance of the plate-supply device.

In a resistance-coupled amplifier the phase relation of the input voltage and the output voltage is practically 180 degrees, and, therefore, if any signal voltage from the plate circuit is returned to the grid circuit in any way, this feed-back voltage will be in exact opposition to the original input voltage and will tend to decrease the amplification. In a multi-stage amplifier the various feed backs from the different circuits combine; in some instances they may neutralize each other but more frequently they produce regeneration or anti-regeneration, either of which distorts the frequency characteristic of the amplifier so that good quality is not obtained.

To prevent common coupling in the plate-supply unit it is essential that the grid and plate circuits of each of the amplifier tubes be filtered so that none of the signal currents have to pass through the plate supply unit. In this way common coupling and its effects are prevented.

Laboratory Information Sheet No. 193 illustrated a circuit for preventing resistance-coupled amplifiers from motorboating. The circuit presented afforded a means of thoroughly filtering the plate circuit to the detector tube and it was found by experiments in the Laboratory that such a circuit will almost invariably prevent an amplifier from motorboating. This circuit can also be used advantageously with transformer-coupled amplifiers, it frequently being found that oscillations in amplifiers of this type can be prevented easily by this means.

In a later Laboratory Information Sheet we will illustrate a resistance-coupled amplifier with filter circuits in each of the various plate and grid leads. This sheet will explain what determines the values of resistance and capacity generally used in such filters.

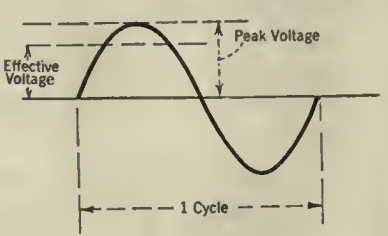
No. 244 RADIO BROADCAST Laboratory Information Sheet December, 1928

Alternating-Current Ratings

EFFECTIVE VS. PEAK VOLTAGES

AT THE present time there are several devices used in radio receiving sets, such as power transformers, filament transformers, filter condensers, etc., which are rated in terms of a.c. voltages. References are made frequently to the peak value of an alternating-current voltage, to the effective value of such a voltage, and to the r.m.s. value of the voltage. The significance of these various terms is explained in this sheet.

The first and most important point is that alternating-current apparatus almost invariably is rated in terms of effective voltage, and effective voltage has *exactly* the same meaning as the r.m.s. voltage so that these two terms may be used interchangeably. If the secondary of a power transformer is rated at 350 volts it means that the effective value of the voltage is 350. Power lines in homes generally have an effective value of voltage of about 110 volts. The filaments or heaters of alternating-current tubes are rated in terms of effective voltage.



The letters r.m.s. are an abbreviation for root-mean-square, this value of an alternating voltage being such that it gives exactly the same heating effect as a direct current of the same potential. It is for this reason that the r.m.s. value of an alternating voltage is termed the effective value.

The peak value of an alternating voltage is the maximum value to which the voltage rises during any part of the cycle. The shape of a.c. voltages with which one ordinarily deals are such that the potential is proportional to a sine of an angle and it is for this reason that we frequently hear the term "sine wave." If the voltage wave has such a form then the peak value is equal to 1.4 times the effective or r.m.s. value.

No. 245 RADIO BROADCAST Laboratory Information Sheet December, 1928

Power Output

HOW MUCH IS REQUIRED

IN THE last audio stage of one's receiver there are more than half a dozen arrangements that can be used. We might use a single 171A or two of these tubes in push-pull, but perhaps some prefer a single 210, a single 250 or either of these tubes in push-pull. From these and other combinations one can obtain equally good quality provided the tubes are not overloaded. The question one naturally asks is what tube or combinations of tubes he should use? How much power output does one need for ordinary home reproduction? These are questions about which we all want definite information, but which unfortunately cannot be answered very simply.

How much power is available from any one tube or combination of tubes can be determined by referring to the table published on Laboratory Sheet No. 246. Although opinions differ as to how much power is required for ordinary home reproduction, George Crom, Engineer of the Amercian Transformer Company, in a recent paper read before the Radio Club of America, states that for a sound level slightly above normal, using a good loud speaker, from 1 to 1.5 watts input power is required. By referring to the table on Laboratory Sheet No. 246 it would appear, therefore, that to obtain a power output of about 1.5 watts we must use either a single 210-type tube, a 250-type tube operated at low voltage or lower power tubes, such as the 171A operated in push-pull or parallel.

The phrase "normal output" referred to in the preceding paragraph is obviously a rather ambiguous one, and, since the ear is not especially sensitive to variation in power, it is probable that an increase or decrease of 3 TU would not affect seriously the loudness as heard by the ear. 3 TU corresponds to a power ratio of approximately 2. In other words, variations from 1 to 2 watts in the power available in the output circuit would not produce very great changes in volume.

The table given on Laboratory Sheet No. 246 will also be helpful in determining the power output of any power amplifier that one may have or may contemplate purchasing. For example, if the power amplifier uses two 171A-type tubes in push-pull, then the power output will be about three times that of a single tube or 2100 milliwatts. Large power amplifiers are used frequently to supply several loud speakers in an auditorium, hotel, etc. An approximate determination of the number of loud speakers which such an amplifier can supply may be obtained by remembering that each loud speaker requires approximately 1.0 watt, and then the number of loud speakers which can be supplied may be determined easily.

VELVET Socket-B power for your Radio



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Raytheon Foto-Cell

The long-life television sending tube, in either hard-vacuum or gas-filled types, and in two sizes of each.

Information and Prices upon application

Correspondence is invited from all interested in television

RAYTHEON MFG. CO.
CAMBRIDGE · MASS.

No. 246 RADIO BROADCAST Laboratory Information Sheet December, 1928

Power Output Characteristics of Vacuum Tubes

A USEFUL TABLE

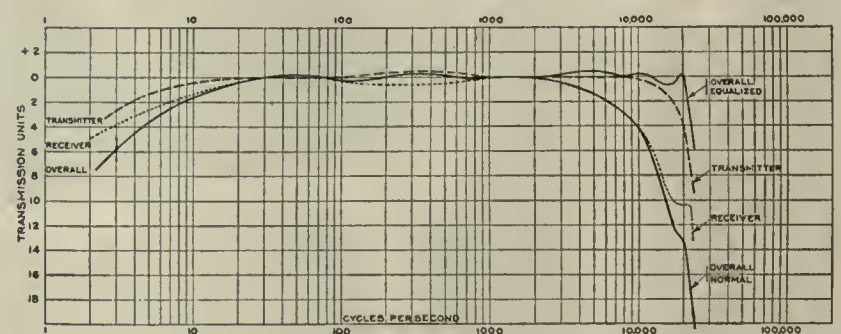
THE table below gives the power output of the various types of power tubes used in radio receiving sets. The table has been arranged in order of power output, starting with the 120-type tube with a power output of 110 milliwatts and ending with the 250-type tube with a power output of 4650 milliwatts. If two tubes are used in a push-pull amplifier, then the power output of the combination will be equal approximately to three times the power output of a single tube. Two more or tubes used in parallel will have a power output equal to the power output of a single tube multiplied by the number of tubes used.

Tube	Plate Voltage	Negative Grid Voltage	Milliwatts* Power Output	Tube	Plate Voltage	Negative Grid Voltage	Milliwatts* Power Output
120	135	22.5	110	250	250	45	900
112A	135	9	120	210	350	27	925
171A	90	16.5	130	210	400	31.5	1325
112A	157	10.5	195	250	300	54	1500
171A	135	27	330	210	425	35	1540
210	210	18	340	250	350	63	2350
210	300	22.5	600	250	400	70	3250
171A	180	40.5	700	250	450	84	4650

*1000 milliwatts is equal to 1 watt of energy.

No. 247 RADIO BROADCAST Laboratory Information Sheet December, 1928

Frequency Characteristics of Television Amplifier Developed by the Bell Telephone Laboratories



No. 248 RADIO BROADCAST Laboratory Information Sheet December, 1928

Television

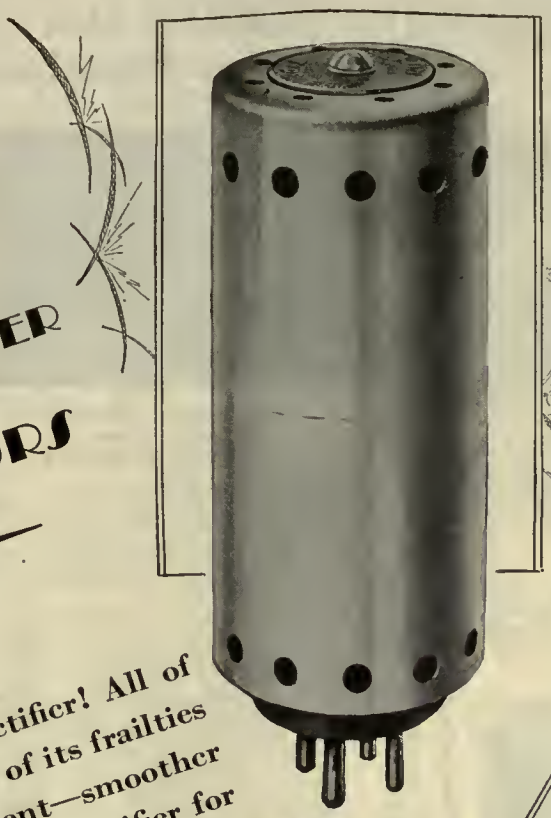
AMPLIFIER CHARACTERISTICS

ON LABORATORY Sheet No. 247 are published a group of curves taken from the October, 1927 *Bell System Technical Journal* where the apparatus used in connection with the demonstration of television made by the Bell Telephone Laboratories was described. In this demonstration a complete radio system was used. The television transmitter was located at the transmitting station and the output of the television transmitter, after being amplified, was sent over the air, the frequency of the radio transmitter being 1450 kilocycles. A superheterodyne receiver was used at the receiving end, and the television signals, after being detected, were sent through the necessary amplifiers and finally made to modulate the neon tube used in the television receiver. In order to insure that the reproduction of the picture might not suffer distortion careful frequency measurements were made on all of the apparatus and the results of these tests were plotted and are reprinted on Laboratory Sheet No. 247. The dash curve gives the characteristic of the radio transmitter and it is evident from the curve that the frequency characteristic of this system is excellent. There was practically no loss down to 10 cycles and only a 4 TU loss at 20,000 cycles.

The receiver characteristic is indicated by the dotted curve. At 10 cycles there was a loss of about 1.5 TU. At 10,000 cycles there was a loss of about 4 TU and at 20,000 cycles a loss of 10 TU. The "overall normal" curve indicated as a solid line shows about 1.5 TU loss at 10 cycles and a loss of about 13.5 TU at 20,000 cycles. This characteristic was unsatisfactory since the engineers had determined previously that it was desirable that the frequency characteristic be constant within about 2 TU. up to 20,000 cycles.

The necessary improvement in the characteristic was obtained by the use of equalizers and the final curve of the equalized system is indicated by "overall equalized." This overall curve is down about 1.5 TU at 10 cycles and there is 0 TU loss at 20,000 cycles. Between these two limits there are slight variations in the curve although none of these variations are as large as 1 TU.

THE NEW 5000 HOUR ELKON METALLIC RECTIFIER FOR "B" ELIMINATORS





At last a *dry* high-voltage rectifier! All of the advantages of a tube—none of its frailties—much longer life—more efficient—smoother power—no noise—now as perfect a rectifier for the "B" end as the Elkon "A" Rectifier—standard with "A" Eliminator manufacturers. And the Elkon Rectifiers are Self-Healing—line surges or accidental overloads are automatically taken care of—no permanent injury is done.

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Illustrated herewith are the Weston Portable A. C and D. C. instruments which are extremely popular for general radio service and make ideal personal instruments.

Three-Range Instruments for A. C. and D. C. Operated Sets



The fine workmanship, excellent characteristics and dependable performance of these models—No. 528 A. C. and No. 489 D. C.—merit an unqualified preference over all other makes. Moderate in price, too. Enclosed in beautifully finished bakelite cases—black for D. C. and mottled red and black for A. C. instruments. 750/250/10 volts (1000 ohms per volt resistance) for D. C. service, and 150/8/4 volts for A. C. testing.



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These same models, identical in size and appearance to the above and enclosed in the same bakelite cases, are also furnished as D. C. double-range Voltmeters—(with either 1000 or 125 ohms per volt resistance) and as single and double-range Ammeters. For A.C. testing they are supplied as single-range Ammeters and Milliammeters and double-range Voltmeters.

All instruments of the Weston Radio Line are completely described in Circular J—just off the press. Write for your copy.

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TYPE 3-B



For Broadcasting, Electrical Recording, and Power Speaker Systems

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The incoming circuits may consist of condenser transmitters, carbon microphones, telephone lines or low impedance phonograph pickup devices, in practically any combination. When a single input circuit of extremely low level is encountered, the positions not in use may be cut entirely out of the system, thus causing no loss whatever to the weak incoming signal.

The panel is 5/16 black sanded Bakelite, 19 in. wide and 12½ in. high. Detailed information and circuit is shown in bulletin No. 7, which we will be glad to mail to you. The net price in the U. S. A. and Canada is $275.00, F. O. B. Chicago.

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Type "BX" Input Transformer has extremely high primary inductance. Secondary accurately divided.

Price, each.....$6.50

Type "GX-210" Output Transformer. Especially designed for push-pull amplifier using UX-210 or CX-310 tubes. Secondary connects directly to moving coil of dynamic speaker.

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Type "HX-171" Output Transformer. Same as above except impedance matches UX-171, CX-371, or UX-250, CX-350 tubes.

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SANGAMO

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Springfield Illinois

Letters from Readers

As a Few Readers See It

EVERY editor is delighted when he receives unsolicited praise from readers of his publication, and we are not exceptions to this rule. However, some forms of appreciation have a much deeper meaning than others. For example, a compliment, which is often found in a letter making a request, often is included to make the communication as courteous as possible. On the other hand, a letter which is written solely for the purpose of expressing an opinion on an article or the publication in general, is considered much more sincere.

This month's mail has contained a great number of letters that have made us feel warm all over. This correspondence shows us that many of our readers are not only in sympathy with our editorial policy, but are enthusiastic about it. These are facts we like to know, but we are interested equally as much when a letter can offer constructive criticism, or suggest a means of improving the magazine.

The following is a letter from a set builder in Nova Scotia, Canada, who has just finished reading his first copy of RADIO BROADCAST:

To the Editor:

I am a set builder and greatly interested in everything pertaining to radio. I read most of the radio magazines that come down this way, but, strange to say, I never read RADIO BROADCAST until to-day. Of course, I need not tell you that I was greatly chagrined to see what I've been missing, and, to guard against any further vexation on this account, I told the clerk in the book store at Sydney to save a copy for me every month.

I find your "Home-Study Sheets," "Laboratory-Information Sheets," and "Service-Data Sheets on Manufactured Receivers," very interesting, and more instructive than anything I have seen in any of the other radio magazines. About all that RADIO BROADCAST needs to put it head and shoulders over all the other radio magazines is a good trouble-shooting page. If you were to take the receivers described in your "Service-Data Sheets on Manufactured Receivers," and trouble shoot them from input to output, I believe you would be doing the service men, set owners, and readers an inestimable service and greatly increase the circulation of your magazine.

M. H. MCDONALD.

Another radio service man who derives much pleasure and information from reading our columns is H. R. Happoldt, of Savannah, Ga. In his letter he also suggests that we devote more space to problems in radio servicing.

To the Editor:

It gives me great pleasure to make myself known as a regular reader of RADIO BROADCAST, and to say the following: I have been connected directly with radio for more than 11 years and I read all radio magazines. I can say truthfully that your magazine proves of greater interest and benefit to me than any other. My greatest interest is in the radio servicing work, and I would like to see even more space in your valuable publication given over to this end.

H. R. HAPPOLDT,
Chief Radio Operator, *S. S. Gloucester.*

For some time we have had in mind inaugurating a special section for the radio service man and such a department, "The Service Man's Corner," is started on page 101 of this issue. It will appear regularly in the future.

Excerpts from two other letters which express opinions on our editorial policy follow:

To the Editor:

I am an electrical control engineer. One of the

(*Continued on page 139*)

Tyrman Imperial "80"
Custom-Bilt Shielded Grid

A-C Shielded Grid Tubes

Short Wave Plug-in Coils



310 or 350 Power Amplifier Tube

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Tyrman "80" full A-C Socket operation using (3) A-C Shielded Grid (4) 327 (2) 381 (1) 350 or 310 Tubes. Dimensions 8" x 21" x 11½". One Spot-10 K. C. Separation. "The year ahead receiver."

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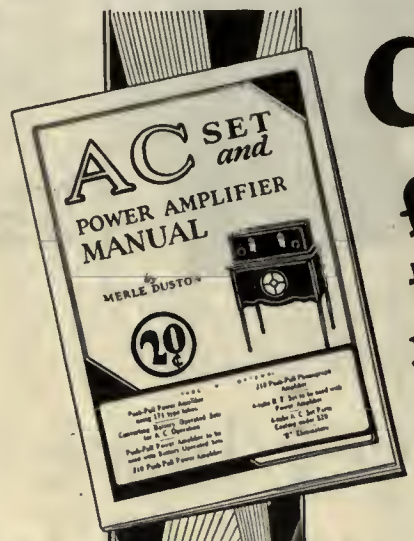
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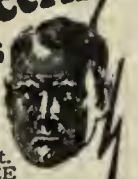
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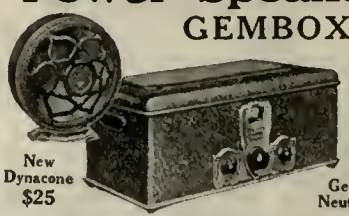


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Genuine Neutrodyne

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CROSLEY

THE CROSLEY RADIO CORPORATION
Dept. 20

Powel Crosley, Jr. Pres. Cincinnati, Ohio

Montana, Wyoming, Colorado, New Mexico and west prices slightly higher

Prices of Crosley receivers do not include tubes

A Small Part with a BIG JOB

AMPERITES take little space, but they control the very life blood of your receiver by *automatically* regulating the tube filaments.

It pays to use AMPERITE—*the only self-adjusting resistance for "A" current.* Maintains filament temperature at proper voltage despite variations in supply. Essential with eliminators. Entirely unlike fixed resistors. Instantly interchangeable. Banishes hand-rheostats. Beautifies panel layout. Saves wiring. A type for every tube—battery or A. C. $1.10 with mounting (in U.S. A.), at all dealers.

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AMPERITE
REG. U.S. PAT. OFF.
The "SELF-ADJUSTING" Rheostat

Letters from Readers

(*Continued from page 137*)

reasons I am a subscriber to RADIO BROADCAST is because of its clear, complete, concise articles of real developments in radio backed by a fearless conservative editorial policy.

H. H. HORNING, Pottsville, Pa.

To the Editor:

I wish to express my earnest appreciation of your new feature, the "Home-Study Sheets." The neatness with which they are printed and the useful information they contain are certainly a great aid to your publication. What we want is experimental and physics side of radio, not the program discussion side.

VINCENT V. GARZIA, JR., Elmhurst, L. I.

The Sea-Going Tube Again

SOME time ago we published an interesting account of the travels of a sea-going vacuum tube. The article, it will be remembered, stated that the vacuum tube passed from one ocean to the other through the Panama Canal, which resulted in considerable discussion among our readers. In this department in our August issue R. S. Fulton, radio operator on the S. S. *Hechelega*, tried to show how it would be impossible for a small object to pass through the Canal. Now we print another letter which takes the affirmative side of the controversy. You take your choice!

To the Editor:

It is quite possible for any small article to pass from one ocean to the other through the Canal, as I shall endeavor to demonstrate. A vessel in passing from the Atlantic to the Pacific approaches and enters the lock at sea level, floating in salt water. The gates are closed behind her, water from the lake is allowed to enter the lock until the vessel has been raised to the level of the lake. Any small article, such as a vacuum tube, which happened to be near the outer gates of the lock at the time the vessel entered would be drawn along into the lock by the slight following current always created by the movement of a vessel, and would be raised to the lake level along with the vessel, and likewise probably would be drawn along with her into the lake when the inner gates were opened for her passage.

Once in the lake, the tube's course would be determined by the number of vessels passing through the canal. If south-bound vessels predominated, the currents in the lake would be stronger in the direction of the locks on the Pacific side, whereas if more north-bound vessels passed through, the tube probably would be carried out to the Atlantic again, through the lock through which it entered. Of course, most of the water used in raising and lowering vessels in the locks comes from the lake, but every time a vessel passes from sea level to lake level some sea water enters the lake. If Mr. Fulton doubts this let him taste the water in Gatun Lake, which is fed by fresh-water streams, and he will find that it has a distinct brackish flavor, due to the sea water entering through the locks. It is almost a case of water flowing up hill.

E. D. PREY, Ellendale, Del.

Short-Wave Hints from the Tropics

To the Editor:

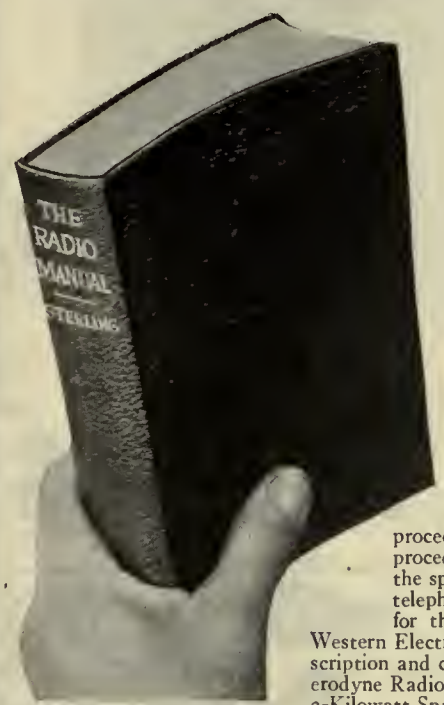
As a point of interest to short-wave receiver constructors, the following data has been used in avoiding the usual obstreperous "body capacity" found in most regenerative short-wave receivers. When building, use a heavy metal sub-panel bracket—or rather, a pair of them. Use the positive or negative filament to "ground them out," and the body capacity becomes a thing of the past as far as causing the set to go into oscillation is concerned. This point has made the building of short-wave receivers in this part of the Americas a success where otherwise it was a failure. For all-year reception, short waves are the only answer here. The standard receiver is a

(*Concluded on page 141*)

Radio Will Be Different in 1929

The Only Handbook Prepared for the Change Is

THE RADIO MANUAL



Here is the most complete, most up-to-date handbook in the radio field. It deals with every problem of principle, method, or apparatus involved in radio transmitting and receiving. It meets every need of student, amateur, operator and inspector. It presents in a single volume, a complete course in radio operation developed simply and clearly, yet in complete technical detail. The beginner with no knowledge of electricity will find all he needs either for amateur operation or to qualify for government license. The professional operator or inspector will use it as a daily reference guide.

A Wealth of Information Never Before Made Available

The accepted practise as adopted by the International Radio Telegraphic Convention effective January 1, 1928, is completely recorded—the New International "Q" signals; procedure for obtaining a radio compass bearing; procedure when SOS call is transmitted or when the spoken *expression Mayday* is heard from a radio telephone station; etc., etc. There is also presented for the first time a complete description of the Western Electric 5 Kilowatt Broadcasting Transmitter; description and circuit diagram of Western Electric Superheterodyne Radio Receiving Outfit type 6004-C; Navy standard 2-Kilowatt Spark Transmitter, etc., etc. Every detail up to the minute.

16 Chapters Cover

Elementary Electricity and Magnetism; Motors and Generators; Storage Batteries and Charging Circuits; The Vacuum Tube; Circuits Employed in Vacuum Tube Transmitters; Modulating Systems; Wavemeters; Piezo-Electric Oscillators; Wave Traps; Marine Vacuum Tube Transmitters; Radio Broadcasting Equipment; Arc Transmitters; Spark Transmitters; Commercial Radio Receivers; Radio Beacons and Direction Finders; Radio Laws and Regulations; Handling and Abstracting Traffic.

Prepared by Official Examining Officer

The author, G. E. STERLING, is Radio Inspector and Examining Officer, Radio Division, U. S. Dept. of Commerce. The book has been edited in detail by ROBERT S. KRUSE, for five years Technical Editor of QST., the Magazine of the Radio Relay League. Many other experts assisted them.

Special subjects such as Radio Control operating have been contributed to by Carl Dreher of the National Broadcasting Co., and the treatment of the stabilization of radio frequency amplifiers is by Dr. Lewis M. Hull, the well-known authority.

The Whole Subject in One Volume

Never before has so complete a treatment of radio theory and operation been compressed into a single volume. Here is information that otherwise you could secure only by consulting many different books. And every detail is vouched for by authorities of the first rank. The Manual is profusely illustrated with photographs and diagrams. There are 700 pages, bound in flexible fabrikoid that is extremely durable. The immediate demand for so valuable a handbook has already nearly exhausted the second large edition. To be sure of receiving your copy without delay, order at once.

FREE EXAMINATION

Use This Coupon

D. VAN NOSTRAND CO., Inc.,
8 Warren St., New York

Send me THE RADIO MANUAL for examination. Within ten days after receipt I will either return the volume or send you $6.00—the price in full. (Radio Broadcast 12-28)

Name.....

St. & No.....

City and State.....

Set Builders
Circuit Designers
Radio Engineers

Here is a Book You Need!



Send for it Today

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APPROVED RADIO PRODUCTS

When the leading set manufacturers of the country choose Yaxley parts there is something more than even an outstanding reputation at work.

Yaxley parts are used in vital places; if they were not entirely dependable, these set manufacturers would not stake trade and customer satisfaction on their performance.

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Chicago, Ill.

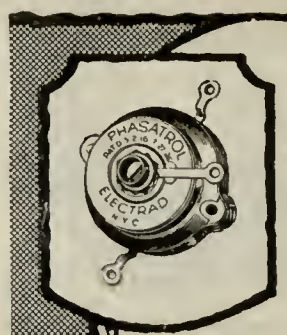
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Polymet condensers and resistances for Radio and Television are carefully made—carefully tested, and accurately rated—is it any wonder they are the choice of 2/3 of the R. C. A. licensed manufacturers.

Send for the Polymet Catalogue
POLYMET MANUFACTURING CORP.
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Licensed by Rider Radio Corporation. Patented 5-2-'16; 7-27-'26. Pats. Pending

Suppress Oscillations

PHASATROL

A True Balancing Device for Radio Frequency Amplifiers

PHASATROL is an unusually efficient device for controlling radio frequency oscillations and thus eliminating the disturbances to reception which they cause. Adapted to any type of receiver using R.F. amplification. A wonderful improvement for the new A.C. circuits where the elimination of noise is often a problem. Price, $2.75 each.
Electrad specializes in a full line of Controls for all Radio Purposes including Television.

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Braidite
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"THE BRAID SLIDES BACK"

An Amateur Set Builder Says

"As an amateur who has built quite a number of sets, I can honestly say that Braidite is the fastest and easiest hook-up wire to work with and it also makes the neatest and most workmanlike looking job. I like the way the insulation on Braidite slides right back into place after making a connection, thus leaving no exposed sections of bare wire."

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TRUE TONAL VALUES

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AUDIONS

FOR those who appreciate better radio reception, the *new, perfected* De Forest Audions —the latest achievement of Dr. Lee De Forest—assure the true tonal values of reproduction which add so much to radio enjoyment.

Sold by leading dealers everywhere

DE FOREST RADIO CO.
Jersey City, New Jersey



DE FOREST AUDIONS

Letters from Readers

(*Continued from page 139*)

5-tube, push-pull outfit, using two straight 6:1 stages of audio, followed by push-pull.

Incidentally, as a matter of information, *for use in the tropics* the Samson transformer is the only 100 percenter we have found in the commercial type to withstand humidity, etc. This is a tip for any jungle parties or other expeditions expecting to use States' constructed receivers in this territory. Of the commercial sets Atwater Kent's special Tropical Model receiver is the only one to meet with existing conditions in the tropics.

L. C. LEIGHTON,
Cristobal, Canal Zone.

Advertising Circulars

OUR contributor Robert S. Kruse has been an amateur for a number of years and, as a result, his name and address have been listed in many radio call books. Persons whose hobby is made public in this manner always receive a great deal of advertising in their mail, and this is often considered an annoyance, particularly when two or three circulars on the same subject are received. Judging from his letter, Mr. Kruse is evidently the victim of considerable high-powered publicity of this sort.

To the Editor:

It is possible to do the industry a service by stating publicly that the mailing list of radio amateurs employed by several prominent New York mailing firms is of the same vintage as the water that floated the ark. Advertisers are paying good money to have circular matter sent to stations that were dead three years ago. I, for instance, am constantly receiving such matter addressed to a station at Silver Lane, Conn., which has not existed for four years, and one at Washington, D. C., which has been dead for eight years, and even one at Lawrence, Kansas, which took out its last license in 1914!

ROBERT S. KRUSE, West Hartford, Conn.

Short Wave Stations

MANY radio listeners equipped with short-wave receivers are anxious to pick up the signals of experimental telephone stations operating on frequencies within the range of their set. In this connection RADIO BROADCAST has endeavored to prepare a schedule of short-wave transmissions, but it has been found that the hours of operation of these stations is varied from day to day. The list which is printed below contains as much accurate data as it is possible to publish at the present time. The principal stations of the world, which may be heard regularly in this country with a simple short-wave receiver, are listed in the order of their assigned wavelengths.

Call Letters	Location	Wave Length
AGC	Nauen, Germany	17.2
PCLL	Kootwijk, Holland	18.0
WOWO	Fort Wayne	22.8
5SW	Chelmsford, England	24.0
2XAB	New York	24.0
2FC	Sydney, Australia	28.5
2ME	Sydney, Australia	28.5
PCJJ	Hilversum, Holland	30.2
2XAL	New York	30.91
2XAF	Schenectady	32.7
JB	Johannesburg, S. Africa	32.0
PCLL	Kootwijk, Holland	32.0
6AXR	San Francisco	33.0
3LO	Melbourne, Australia	32.0
2XAI	Newark	43.0
WBZ	Springfield	50.0
WTFF	Mt. Vernon, Va	56.0
AJG	Nauen, Germany	56.7
WLW	Cincinnati	52.02
2XE	Richmond Hill	21.1
GC	Paris, France	60.0
3XL	Bound Brook	60.0
9XU	Council Bluffs	61.06
KDKA	Pittsburgh	62.5
2XBA	Newark	65.18
WBZ	Springfield	70.0

HAVE YOU HEARD IT?

New 1929

Browning-Drake

EIGHT-IN-LINE



Eight tubes in line—aluminum construction throughout—all power equipment an integral part of chasis—this year's masterpiece of mechanical construction.

Browning-Drake dealers know the value of tonal perfection, and what it means to their customers. Listen to a 1929 type receiver and understand why there are a million Browning-Drake fans.

BROWNING-DRAKE CORPORATION
Cambridge, Mass.

BROWNING-DRAKE RADIO

BOOKS
in a minute
by TELEGRAPH
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New York Newark Toledo
Kansas City Cleveland St. Louis

More "A" Power For Less Money!

With the Set Builders *discount* card you can purchase a

KNAPP "A" POWER KIT

at a liberal discount.

Write me today for full details telling about this new money-saving plan for set builders.

DAVID W. KNAPP, Pres.
Knapp Electric, Inc. Room 414
Division of P. R. Mallory & Co., Inc.
350 Madison Ave. New York

AT LAST!

Matched Tubes

the Only Assurance of Maximum Efficiency and 100% Satisfaction from any Tuned Radio Frequency or Super Heterodyne Circuit.
This is the first time matched sets of Cunningham or R. C. A. tubes have been offered at list price. Tested and matched seven ways on our specially designed testing panels. All tubes plainly marked with characteristics.
Order today. Pay the postman the list price plus 5c each for packing and shipping.

LIST PRICE

112A	$2.75	210	$9.00
120	2.50	222	6.50
171A	2.75	226	2.25
199	2.25	227	4.00
200A	4.00	240	2.00
201A	1.50		

H. M. HEWSON, Merion, Pa.

Com pen .sat ing

AUDIO TRANSFORMER

Brings Out the LOST NOTES In Any Receiver



ANY radio set can be improved from 25 to 100% in tone range. That is a flat, simple, direct statement from Remler—a firm famous for ten years of radio reliability.

The new Compensating Transformer, No. 905, replaces the first audio transformer in your receiver. This easy change is quickly made—and results are amazing. Especially when used with a dynamic speaker, the new Compensating Transformer proves its worth by delivering energy over the complete range of the speaker. Use it to get the most out of your Dynamic Cone. Not an experiment—proved and tested in every popular set and circuit. A special pressed-steel demonstrating base makes it easy for the dealer or set-builder to demonstrate the difference to clients. Sign the coupon for full details.

Remler Division, Gray & Danielson Mfg. Co.
260 First Street, San Francisco, California.

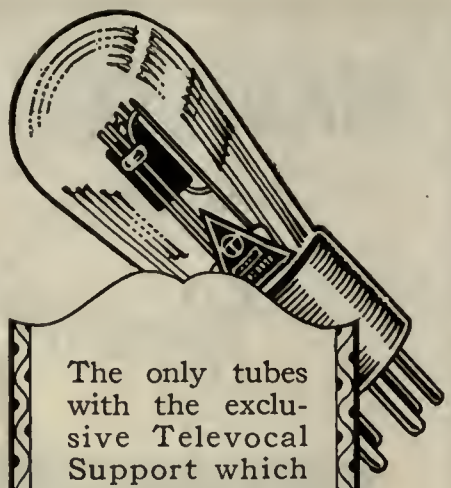
Gentlemen: Please send me complete information on

☐ New Compensating Transformer.
☐ Demonstrating Base.

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The only tubes with the exclusive Televocal Support which eliminates microphonic noises. Made in all standard types. Ask for them at your dealers.

Televocal Corporation
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Televocal
Quality Tubes

Potter Condensers

Quality
Long Life
Uniformity
Economy



Leading manufacturers have selected Potter Condensers for the finest radio sets. Why not follow their good judgment.

Insure the operation of your radio set and power amplifier with the use of this high grade product.

Potter T-2900 Condenser Block for the single 250 type tube amplifier—$20.00.

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Potter By-Pass and Filter Condensers are available in all capacities and working voltages.



POTTER
Interference Eliminator

Your radio broadcast programs need no longer be spoiled by interference from oil burners, ice machine motors, vacuum cleaners, violet rays, etc.

The remedy is to connect a Potter Interference Eliminator to the interfering device.

Potter Manufacturing Co.
North Chicago, Ill.
A National Organization at Your Service



$2.00 *Insures Your A.C. Tubes*

The Vitrohm 507-109 Unit costs $2.00. Installed on your radio set, it lengthens a. c. tube life by automatically lowering filament voltage.

Attached in a moment—Nothing combustible — Nothing to wear out—Does not get excessively hot.

It consists of a Vitrohm Resistor mounted within a perforated metal cage, a plug, and a receptacle.

Write for free information on this and other Ward Leonard Radio Products.

WARD LEONARD ELECTRIC CO. MOUNT VERNON NEW YORK



Write for this Discount Card NOW!

It will enable you to purchase the New and Improved

KNAPP "A" POWER KIT
at a liberal discount

The new Knapp "A" is the finest and most complete kit ever offered. It is the only "A" Power adaptable to Short Wave—Super Heterodyne aod Televisioo reception.

Take advaotage of the wonderful offer today—write

David W. Knapp, Pres.
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NEWS to Set Builders

Barawik offers set builders bigger bargains — bigger opportunities to make money this season. New sets, new kit ideas, all the leading parts, dynamic speakers, supplies, etc. Lowest rock-bottom prices. Bigger stocks, quicker service. Send for **Big Bargain Book** today—free.

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Consultant and Technical Writer
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Until you have heard the NEW VICTOREEN

"A.C." or "D.C."

You cannot realize the marvelous development in Radio Reception



The new Victoreen is simply wonderful—that is the only way to describe it. It has *wonderful* tone—wonderful selectivity, *wonderful* sensitivity. It is wonderfully simple to assemble, wonderfully easy to operate. Anyone who has the slightest "knack" can assemble in a few pleasant hours a set which, from every standpoint, simply cannot be surpassed.

This is a season of wonderful radio programs. With a Victoreen you can enjoy them from coast to coast. If a Victoreen can't get a station it can't be had.

Victoreen R. F. Transformers have been greatly improved—the circuit has been still further developed—many other radical improvements have been made which make Victoreen more than ever, the world's standard "Super."

Write for complete Victoreen story and the *FREE Blue Print* giving constructional data and full directions. You'll have a set that you can boast about, when you have a Victoreen.

The Blue Print is FREE

Victoreen Power Amplifier and "B" Supply

makes any good set better



Supplies 45, 90, 180, and 450 volts, using a UX210 or 250 in the last stage. Contains two voltage regulator tubes so that the 90 and 180 volt taps are supplied with a constant volt potential. It is the last word in "B" Supply. For the most satisfactory results you MUST have it.

FREE BLUE PRINT with list of parts and complete assembly instructions, will be sent upon request.

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Victoreen



Push-Pull Power Stage *for* Dynamic Speakers

For best results, every dynamic type speaker should be preceded by a push-pull amplifier. This is particularly true because they reproduce frequencies as low as 30 cycles and the attendant hum from raw AC on the filaments of power tubes is greatly pronounced unless filtered out by a push-pull amplifier.

The AmerTran completely wired push-pull power stage has been specially designed for dynamic speakers. Consists of type 151 input and output transformers (200 for working out of 210 type tubes or type 362 for 171 type tubes). Both the 200 and the 362 have the secondary designed for connecting directly to the moving coil of the speakers. Completely wired with sockets and resistances. Also available for cone type speakers and for both 210 and 171 tubes.

Licensed under patents owned or controlled by RCA and may be bought with tubes.

Price complete (without tubes) $36.00
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Write us for hook-up of this remarkable instrument.

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For the UX250 Power Tube



Type 565-B Transformer

(200 Watts)

Price - - - - $13.50

The success of a high-quality amplifier depends largely on the power supply. The General Radio Type 565 Power Transformers are especially designed for use in plate-supply units intended for the 250 type of power tube. The type 565-B Transformer illustrated consists of a center-tapped 1,200 volt secondary and two 7.5 volt secondaries. It is designed for 105 to 125-volt, 50 to 60-cycle lines.

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16.50 Complete with 5 coils



Dresner Shielded SHORT WAVE CONVERTER

The Only Unit With a Wave Length Range of 15 to 550 Meters

Introducing another triumph for SHORT WAVE reception. Highest efficiency at an amazingly low price, made possible by economic production. Now, all can afford to get the best entertainment of the air being broadcast on short waves by many powerful stations thruout the U. S. and Europe.

EASY TO ATTACH AND OPERATE

The new model, Dresner Shielded Short Wave Converter is completely assembled, and may be used on any set. It is built in a beautiful mahogany finished metal cabinet. Efficiently covers a wave band of 15 to 550 meters.
GUARANTEED to give you highest satisfaction. Take advantage of this special offer at once. If your dealer cannot supply you, SEND MONEY ORDER DIRECT and we will ship at once.
(When ordering unit, be sure to specify whether it is to be used on AC or DC set).

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Remarkably Low Price

SET BUILDERS
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Discount Card

Enabling you to purchase the new and Improved Knapp "A" Power Kit at big discount—Write for full particulars.

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CUSTOM SET BUILDERS

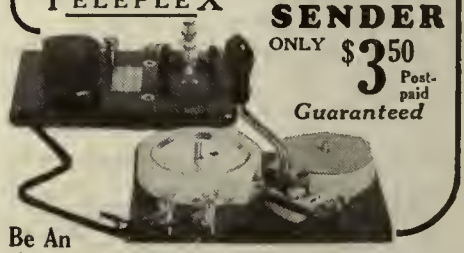
Browning-Drake has an interesting and unusual proposition. Take advantage of the fact that more Browning-Drakes are built than any other. Write today.

BROWNING-DRAKE CORP.
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Be An Expert RADIO OPERATOR! Travel. Adventure. Good pay. This amazing instrument teaches you to read code in half the usual time. *Reproduces actual sending* of expert operators. Sends you messages, radiograms, etc., anywhere, any time, any speed. You'll be amazed when you hear it. Just like having an expert operator in your home. *Code lessons* recorded on strong, waxed-tape records make everything *simple* and *clear*. Send only $3.50 for Midget Teleplex with lessons; or $5.50 complete with high-frequency key and buzzer. *Satisfaction guaranteed.* Money back if not delighted. Send today.

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The NEW 1929 catalog is crammed full of the FINEST, NEWEST, Nationally known A. C. sets, consoles, cabinets, dynamic speakers, kits, eliminators and accessories at LOWEST PRICES. Largest stock of radio parts Prompt delivery. *No delay.*

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simplified!

CONTROLLING the receiver scanning disk—that's the big problem in television. Yet there is nothing to it when you have the

SPEED CONTROL CLAROSTAT

REG. U. S. PAT. OFF.

You can bring the scanning disk to speed and hold the image on the screen as easily as you steer your car.

A handsome and useful device, this SPEED CONTROL CLAROSTAT. Controls any variable speed motor of ½ h.p. or less, from standstill to practically full speed in several turns of knob. Push button for quick starts and for momentary acceleration. Heavy metal case. Properly ventilated. Protected screw terminals. 25 to 500 ohm resistance range. 80-watt rating. Readily mounted. Convenient. *And it sells for $5.00.*

Ideal for television. *But that's only half the story.* The SPEED CONTROL CLAROSTAT has no end of applications in radio and electrical work where a variable or fixed heavy-duty resistance is required.

WRITE for literature regarding the SPEED CONTROL CLAROSTAT as well as other Clarostats for every radio purpose. Better still, send 25c for "The Gateway to Better Radio"—the best investment you ever made in radio.

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FERRANTI
Audio Frequency Transformers



are specified for the

SKYSCRAPER

A remarkable radio receiver using two 222 type tubes in the radio stages. A real engineering job with unusually high gain and selectivity. Tone quality unsurpassed.

Complete instructions for building the Skyscraper will be sent for $1.00 net.

Send 15c in coin for copy of the 1929 Ferranti Year Book

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Now...4 or 6 Volts with the Improved Knapp "A" POWER



Operates on 105 to 120 volts, 50 to 60 cycles.

10 Improvements

1. Two taps for 4 or 6 volts operation.
2. Larger filter system.
3. Three Elkon Dry Condensers instead of two.
4. Improved Choke Coils.
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10. Die Cast Base Plate instead of wood.

The only "A" Power Suitable for all Sets

— Irrespective of number of tubes — including SuperHets, Short Wave and Television receivers

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David W. Knapp, Pres.

KNAPP ELECTRIC, Inc.
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350 Madison Ave., New York City

See your dealer today

Go to your dealer today. Most of the good ones carry the Knapp in stock. Do not accept a substitute—because only in the Knapp will you get full satisfaction as typified by the famous Knapp "A" Power. If your dealer cannot supply you send the coupon.

Mr. David W. Knapp, Pres.,
Knapp Electric, Inc., Dept. K-21
350 Madison Ave., N. Y. C.

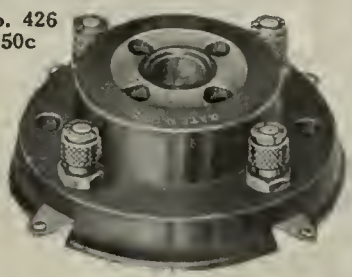
Send me complete information on the Knapp "A" Power.

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NA-ALD SOCKETS— PICKUP— ADAPTERS

No. 426
50c



Two outstanding NA-ALD products. Above:—The No. 426 Socket at 50 cents is one of a family of fourteen stationary and spring mounted sockets designed for every purpose. Note the *copyrighted* colored locater ring. It is an exclusive NA-ALD feature. Below:—The NA-ALD Electric Pickup priced so every radio set owner can enjoy the wonderful tone quality of music electrically amplified from any phonograph through their radio set or power amplifier. GET YOURS TODAY. TRY IT FOR THREE DAYS and if not satisfied your money will be refunded.



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ELECTRIC
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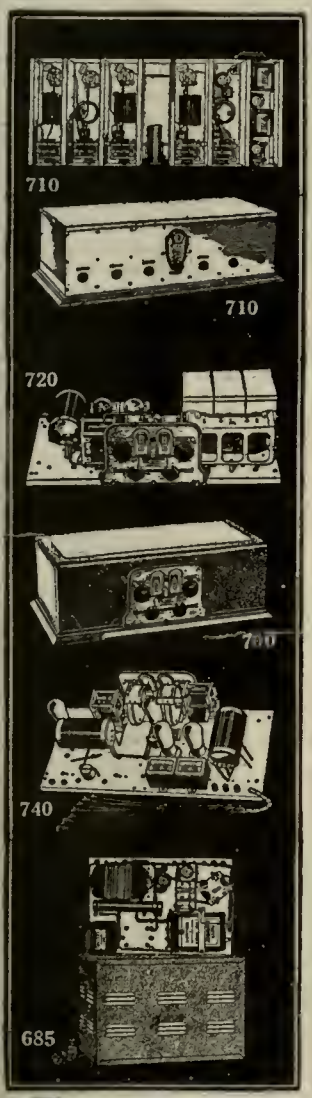
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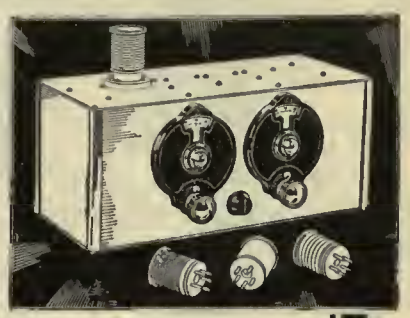
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JANUARY, 1929

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Vol. XIV. No. 3

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The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. . .

THE next—the February—issue of RADIO BROADCAST will appear figuratively in new clothes. A famous designer is at work on an attractive new cover which will make RADIO BROADCAST more easily recognizable when you try to pick it out of the mass of others on the newsstands. The text will be set in a type which is easier to read and which presents a more attractive appearance than the type we now use. For those who are interested in such things, the present type face is Cadmus and the new RADIO BROADCAST will be set in Bodoni. Bodoni is a decorative type also notable because it is "easy on the eyes." The contents is in for some improving at the same time and we shall ask you to await the February issue for a complete announcement of that.

TELEVISION occupies a good part of radio discussion these days and we want to be sure that our attitude on the subject is clear. "Television," unfortunately, means one thing to one man and something altogether different to the next. Television, like radio broadcasting, may be considered experimentally or in respect to its entertainment value—something the general public will find satisfactory. Television of entertainment value is certainly *not* here and is not in prospect for some little time. Articles in this magazine have outlined the difficulties to be overcome before "program television" can be attained. On the other hand, *experimental* television *is* here. What most people mean when they say the word now is merely experimental television. We do not intend to fill this magazine with articles on the subject when there isn't much to say, but we shall not fail to give those who are interested in experimenting with it as much useful information as we can. We certainly do not discourage experimenting, but in television it should be made perfectly clear that such it now is, and that on a limited scale.

NO NEW feature we have added to RADIO BROADCAST in the six years of its history has created anything like the favorable response that the special pages for the radio service man have produced. Many interesting manuscripts have been received and we hope that others who also have ideas which should be set down on paper and sent on for our consideration will become suddenly ambitious and send us their contributions.

THE present issue contains a wide selection of articles of interest: Boyd Phelps on "Unscrambling Television," Joseph Morgan on dynamic speakers, K. W. Jarvis on receiver performance, the Laboratory Staff on an a.c. operated tube tester, "The Service Man's Corner," Carl Dreher on "Sound Motion Pictures," and "Photographic Data for Broadcasters," Kruse on short-wave topics, the push-pull a.c. P. A. amplifier, are some of the most important. We are proud to offer these articles for they are all exclusive, interesting, and accurate to the last degree.

FEBRUARY RADIO BROADCAST will contain, among other things, an article by Dr. L. M. Hull on "Overall Measurements on Broadcast Receivers," a striking story by Boyd Phelps on how amateur television has been accomplished, a remarkable story by the Labaratory on the value of filtering in audio amplifiers, several valuable experimental articles on short-wave work and—a host of other features.

—WILLIS KINGSLEY WING.

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A Kite Antenna Used in Early Radio Experiments

This picture shows an unusual piece of radio apparatus which was used by Guglielmo Marconi during his trans-Atlantic radio tests in December 1901. The large kite which is held by G. S. Kemp, Marconi's first assistant, was employed to elevate the long receiving antenna which was used at Signal Hill, Newfoundland. The signals which were received during this experiment were sent from a station installed at Poldhu and was an event of the greatest historical importance.



PHELPS' EXPERIMENTAL TELEVISOR

Unscrambling Television

By BOYD PHELPS

RECENTLY the radio listener has heard many peculiar sounds from his loud speaker, and, if he plays around on short waves, he probably is familiar with an unusual noise which may be identified as a television signal. To the untrained ear these transmissions all sound alike—a terrible racket; to the experienced television experimenter the sounds often give a fair idea of the picture, even to permit recognizing the "sound" of faces of the immediate laboratory staff. For the somewhat less experienced, a little practice with the speaker and televisor operating simultaneously will enable him to pick out important characteristics of the signal, as, for example, an abrupt change in tone quality when the picture contains two figures, as two individuals side by side.

The experimenter who intercepts a television program of unknown origin has before him the intensely interesting problem of deciphering these signals and determining the number of scanning holes and the speed of the disc, for this may be obtained from laboratory tests. In this connection this article relates the author's experience in unscrambling mysterious television signals which were heard regularly on Long Island.

The lowest frequency in a television signal cannot be classed as a musical tone; it is a rapid series of thumps coming at the rate of 7½, 10, 15 or 20 times per second. This represents the number of complete pictures per second. A picture rate below 15 generally causes a noticeable flicker to the eye, like moving pictures projected at a slower speed than normal.

THE SCAN FREQUENCY

THE audio tone which seems to be the loudest single frequency in a complex television signal represents the scan frequency which is the mathematical product obtained by multiplying the number of holes or scan lines by the number of complete pictures per second. This product is usually 360, 450, 480 or 720 cycles per second, or intermediate values. This pitch seems especially loud because it is in a sensitive range of the ordinary amplifier and speaker, and because it is pure, regular and continuous. It corresponds to a musical note near the middle of the piano key-board somewhat above middle C.

In television amplifiers, contrary to speech and music amplifiers, all audio tones below the scan frequency can be eliminated in many cases and quite good quality will remain. This feature is useful if a B-power unit is used to supply plate power for the amplifier, as a scarcely noticeable power-frequency hum in the speaker manifests itself on the picture as light and dark bands. When a power frequency of 60 cycles is used, four light bands appear if the disc is running 900 r.p.m. (15 pictures per second) and eight bands appear if 450 r.p.m. (7½ pictures per second) is the disc speed, for example, with 3XK and WRNY, respectively. If these bands creep slowly up or down while the picture is held correctly framed it is an indication that synchronizing by the direct mounting of the disc on a synchronous motor would not be feasible, as was discussed in last month's article by the writer. Therefore, if the amplifier has a sharp low-frequency cut-off above 120 cycles, the interference caused by the a.c. hum is eliminated. The only exception to this statement would be a case where the a.c. modulation varies the overall efficiency of the amplifier, for if the desired signal frequencies are choked off 60 times per second a high-pass filter will not help this. An example would be low-current filaments operated on a.c. much below their correct temperature where the emission varies rapidly with small changes in filament voltage. But a good amplifier underloaded should amplify weak or strong signals proportionately, whereas stray a.c. hum picked up in any stage, if passed to the next tube at high loss, does not assume great magnitude or appreciable nuisance in the television amplifier considered above. The writer has recently thrown together a three-stage transformer-coupled amplifier in which practically all the iron in the cores has been removed and the flat section of the curve moved up considerably, which seems promising although curves have not been run as yet.

We now come to the complex picture frequencies of a television signal which are the result of the detail of the image. If the picture were divided vertically into one light and one dark section we know the frequency would be 720 cycles in the case of the better forms of common television, therefore, it does not take much imagination to appreciate the fact that the details of a face—eyes, nose, moustache, etc.—may produce frequencies that will run well into the thousands of cycles For example, impulses crosswise of the picture, equivalent to the none-too-good detail represented by 48 vertical lines, at speed near the flicker point would be represented by a frequency of 48 x 48 x 15 which works out to be 34,560. Although decently recognizable faces can be produced without such high frequencies, the change from light to dark at the sharp contrast points, as the pupils of the eyes or edge of coat sleeve, is quite a ways from instantaneous, and in the received image the shaded gray area at these points may be several scan holes in width, although the photo-electric cell at the transmitter may be making its maximum change in a one-hole width of the picture. But, in photography, portraits usually have their sharp harshness removed by an intentional diffusion. Television

limited to frequencies below 5000 cycles is, in the writer's opinion, far from hopeless. It is far easier to ruin a picture with improper adjustments of the amplifiers at the transmitter or receiver.

THE PROBLEM

NOW we come to the problem of figuring out what kind of a disc the transmitting station is using by listening to it, and the writer has had some experiences along this line that may be of interest to recount. This form of "radio sleuthing" originated early in March, 1928, when an attempt was made to unscramble the signals sent by the Baird Laboratories in London to the *Berengaria* in mid-Atlantic. The details of this adventure were in the newspapers at the time and included such features as banging the characteristic notes on a piano and sending them over a telephone line to a piano tuner who was called out of bed to sound his tuning forks on the other end of the line to determine the absolute scan frequency. W2BUO, who assisted in this escapade, procured a fairly flat square brass disc of power-house flywheel proportions. In the haste to get the apparatus operating before the next nightly schedule, the corners were not even cut off. No further signals were transmitted, however, so it was never learned how accurately the number of holes and revolutions were calculated. A phonograph record was made of the signals as it is possible to preserve moving pictures this way.

Recently a near-by station was secretly sending short television schedules that have been shrouded in a similar deep mystery. Trial on all discs and speeds produced nothing intelligible, yet the sounds apparently were genuine and had the characteristic variations of a person moving around or the scene shifting. The characteristic scan frequency was quickly found to be B above middle C on the piano, which, according to international pitch scale, would be 488 cycles. The pitch of the piano in question is according to standards that pianos assume that have not been tuned since radio became popular—usually lower. However WRNY "tuned in" on G above middle C and their scan frequency is close to 360 cycles. (The keys now look like a log of Who's Who in Television.) Dust was blown off the old college physics book and the ratio of the two notes was found to be 4 to 5. The two musical notes on the piano still being good chords, both having lowered the same amount, the ratio was applied and a scan frequency of 450 determined.

Now, as the scan frequency is the product of the number of holes and the speed of rotation per second, and neither of these factors were known, the problem was still quite a way from complete solution. Some slide-rule computations reduced the unlimited possibilities to the following probabilities: 60 holes at 7½ r. p. s., 50 holes at 9 r. p. s., 45 holes at 10 r. p. s. or 30 holes at 15 r. p. s. Any of these cases would give the characteristic 450-cycle scan-frequency note. It was assumed that even speeds were used with no "fractional" holes or trick arrangement of holes.

A NOVEL FREQUENCY COUNTER

THE next step was to measure the picture frequency which is strong in cases where an unmodulated series of scan lines exist, as for example, the margin above the head of an individual being scanned, or other irregularities appearing once in each complete picture. In the case of the unknown signals in question they were too fast to count—one can count to almost 12 in a second—so a device was invented for the purpose. The device consisted of a hand drill, a saucer and a bent nail. The gear ratio of the hand drill was such that the bent nail in the chuck made four taps on the saucer for every turn of the handle. The handle was turned at such speed as to have the taps on the saucer in step with the picture frequency, and the counting of the handle turns was easy. Thus, in a ten-second run a count of handle turns of 22½, 25 or 37½ would establish whether the picture frequency was 9, 10 or 15 per second or if not it would probably be a near-by value.

The second time the signals were heard this was tried and every trial turned out very close to 37½ so it was a safe enough assumption that the transmitter was using 30 holes in a disc running 15 r. p. s. (900 r. p. m.) A vibrating reed was used, and a variable-speed 48-hole disc produced stationary specs of the image at 15 r. p. s.; all checked the bent nail observation closely.

Much has been written concerning the design of television discs so only the final data will be given here. A spiral inside an existing 48-hole spiral was laid out. In a 30-hole disc a maximum radius of slightly over 7" gives an image 1½" wide at the top. A picture height of 1½" was convenient as this gave exactly 20 scan lines per inch. These scan lines, while 0.05" wide in theory, were made with a round drill of larger size calculated on circle overlap such that inscribed squares would be edge to edge. The sides of the theoretical square being 0.05", the diagonal (also circle diameter) figured 0.0706" and the nearest drill size was No. 50 having a diameter of 0.0700."



REAR VIEW OF TELEVISOR

ONE of the most ingenious experimenters in radio to-day is Boyd Phelps. His work represents in our mind a proper example of genuine "amateur" experimenting. This article, describing experiments in sorting out television signals in which every factor but transmission frequency was unknown, will be found worthy of the reader's attention—not only because the work represents an extraordinarily ingenious procedure but because it indicates very definitely the difficulties of achieving results of any account at all in television experimenting.

—THE EDITOR.

THE RESULTS

IT WAS the morning of the third day when the disc was tried out and the interesting pictures watched with a thrill of one eavesdropping in on something unusual—like watching the antics of a comedian practicing in supposed solitude. This key-holing being absolutely a one-way affair added to the charm, due to security from detection. The question now arises, if I describe what I saw would I be violating my oath of secrecy sworn to on the back of my operator's license and the law not to divulge or publish the contents of any message not addressed to me or which I am not the authorized agent to forward? It was quite obviously not broadcast for public consumption, has had no advertising or publicity, and was preceded by a weak announcement, "Station 2X? conducting a test." The days of only a code operator being able to receive and divulge a radio message are over. Perhaps the oath of secrecy should be administered to the whole public and thereafter to all infants within 90 days of birth.

The pictures on these pages show the apparatus used in the experiments described in this article. The front view of the televisor reveals that the container was once a phonograph cabinet—pioneering now in television as it did in broadcasting at 9 ZT, when the writer sent its music to Minneapolis amateurs in 1921. Below the speed-control knob and shaft may be seen the bias resistor for the power tube. This resistor, which is common to the plate supply and the grid returns, is employed to regulate the brilliancy of the picture on the neon tube which is connected directly in series with the plate circuit of the 210-type power tube. The double-throw switch behind the bias resistor makes possible a change from ear to eye "entertainment."

An interesting feature of the televisor is the flivver speedometer which is mounted on the front panel. This instrument, having been taken apart and calibrated in r. p. m., is employed as a tachometer.

The second picture shows the mechanical arrangement of the scanning disc assembly. A synchronous motor providing uniform speed is belt connected to a countershaft having friction drive to the back face of the scanning disc. The knob to the left turns a threaded brass rod that moves the countershaft assembly radially to frame accurately the picture and compensate differences in scanning speeds of various transmitters. The pulleys have additional small flanges (not shown) which quickly take a shorter belt for slower speeds. The neon tube is shown opposite the 30-hole spiral described in this article, but it can be raised easily to the level of the 48-hole spiral. Many methods of speed control have been tried but this system has provided the best results.

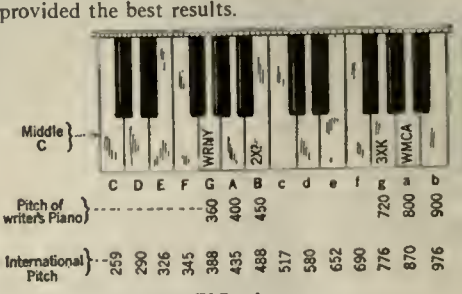


FIG. 1

How Television Signals "tune-in" on the writer's piano



All about the DYNAMIC *Loud Speaker*

By JOSEPH MORGAN

International Resistance Company

IT IS the purpose of this article to set forth clearly, simply, and without prejudice, the application, performance, method of use, advantages, and disadvantages of the modern dynamic loud speaker.

The arrival of a new and successful device upon the market is always attended by exaggerated claims and general misinformation as to its use and operation. This is not so much due to the desire of the manufacturer to further the sale of his product, as to the misguided enthusiasm of the radio fan. That such a condition should exist is deplorable, since the new device is often improperly employed and its good characteristics are discredited.

No new instrument is a panacea. Perfect design in a vacuum tube cannot compensate a defective rheostat. A perfect loud speaker cannot even slightly ignore the defects of an overloaded amplifier. In fact, the reverse is more nearly true—a poor loud speaker can, to a remarkable extent, overcome such defects!

Before considering the dynamic speaker in detail, the reader should have a knowledge of the general problems of loud speaker application and design, as well as the specific principle upon which the dynamic type is based. For this purpose the reader is referred to the article by the present writer, titled "All About Loud Speakers" which appeared in the August, 1928, RADIO BROADCAST.

The three most important properties to be considered in the discussion of the technical merits of a loud speaker are:

(1) The frequency-response characteristic
(2) The efficiency
(3) The load capacity

We will consider first the frequency-response characteristic. The dynamic type of loud speaker, using a free-edge paper cone, is essentially what is called an "inertia-controlled diaphragm" loud speaker. This means that throughout the important frequency range the electrical driving force is expended in accelerating the mass of the diaphragm. In other words, the moving structure, which consists of the voice coil and the sound-radiating paper cone, acts as a solid piston. If it were true that the dynamic loud speaker behaved solely in this manner throughout the entire audio-frequency range, the frequency-response curve would be very nearly a straight line with the response gradually falling off at the higher frequencies. However, there are a number of secondary factors which must be considered in the determination of the response of such a loud speaker.

MANY months ago, in "Strays from the Laboratory," we predicted that the "dynamic" loud speaker would probably be predominant in the radio field during this season. That prediction has been amply borne out. Subsequent comment in "Strays" has compared the performance of these reproducers with other types and presented some information on their operation. This article, written by Joseph Morgan, an engineer in whom we have the highest confidence, does answer practically all of the questions which arise. A careful reading will enable those who are using this type of reproducer to make it better serve their needs and will clarify the minds of those who now feel they are pretty cloudy on the whole subject.

—THE EDITOR.

We shall consider first the mechanical factors. Due to the fact that the moving coil must be supported more or less rigidly with respect to its concentric position in the air-gap of the magnetic field, two or more thin flat metal restraining springs are used, both to maintain the centering of the moving coil and to act as conductors of current to this coil. Further, the base of the cone is fastened to the metal supporting ring by means of a flexible annular ring or washer usually made of leather. These springs together with the leather ring, hold the moving structure quite rigidly with respect to radial movement, but permit very free axial motion.

The combination of paper cone, moving coil, and metal springs has its own natural frequency of vibration. Advantage is taken of this natural frequency to obtain a large response at the low-frequency end of the scale, where much energy is required to produce sufficiently intense sounds, due, in part, to the fact that much of the associated apparatus, such as amplifiers, have inadequate low-frequency characteristics. This natural frequency usually occurs somewhere between 20 and 70 cycles per second and varies not only with the make of the loud speaker but also from one loud speaker to another of the same make. In one well-known make of dynamic loud speaker tested by the writer, the resonant frequency in six loud speakers chosen at random varied from 40 to 65 cycles per second. If the resonant frequency were kept within the range mentioned it would have practically no influence upon the response of the loud speaker above 100 cycles per second.

THE CHANGE AT 3000 CYCLES

AT ABOUT 3000 cycles per second, the moving structure ceases to act as a solid piston and begins to behave as a conical diaphragm with a fixed outer edge. In that part of the sound spectrum in which the transition takes place from free-edge to fixed-edge action, large irregularities in response are likely to occur, and in the band of frequencies in the fixed-edge region the response is, in general, greater than in the free-edge region. This is due in part to the conical



FIG. 1

shape of the diaphragm which acts as a horn for these higher frequencies.

The conical shape is chosen because it gives a maximum of rigidity with a minimum of weight. The angle of the cone varies in different instruments from approximately 75 degrees to 150 degrees. The maximum rigidity is obtained with a 90-degree angle at the apex. If the angle is increased beyond 90 degrees, less rigidity is obtained but a somewhat better frequency-response characteristic results. It is a difficult problem to obtain the best compromise.

The material and tension of the annular supports are very important. The ring must be stiff enough to hold the outer edge of the cone concentrically and to prevent the edge of the cone from whipping. At the same time it must not interfere with free axial motion.

The cone itself is usually made of stiff paper to obtain maximum strength with minimum weight. The paper must be carefully chosen so that it will not alter in texture, shape, or size with changes in atmospheric conditions such as temperature and humidity. In some makes of loud speakers, corrugated cones are used. It is claimed by some manufacturers of these loud speakers that a more even frequency-response characteristic results. However, after a number of tests, the writer has been unable to verify this statement.

A very important factor which influences the frequency characteristic of any loud speaker is the impedance of the voice coil. It is important to know the value of this impedance, its alteration with change in voice frequency, and the relative values of its resistance and reactance components. The ideal loud speaker would have a constant impedance of pure resistance. This ideal, while not realized in practice, is more closely approached in the dynamic type of loud speaker than in any other. The impedance increases with the higher frequencies, thus reducing the electrical input at these frequencies. Individual makes utilize voice coils having from one to as many as several thousand turns. In American practice the impedance of the moving coil, which usually is wound with 100 to 200 turns of fine wire, is of the order of magnitude of 10 ohms in the lower frequency range. There is on the market at least one loud speaker with a voice coil consisting of a single turn of thin copper ribbon, having an impedance of less than 0.001 ohm.

TRANSFORMER NEEDED

THE very low impedance of these voice coils necessitates the use of a step-down transformer to feed into the voice coil, in order that the ratio of last-stage plate-circuit impedance to voice coil impedance shall be maintained at the proper value, usually 1:2. These transformers are usually built right into the loud-speaker housing, although there are obtainable on the market to-day specially constructed transformers to be used in place of those built into the loud speaker [See table on page 194 of this issue.—*Editor*]. Under certain conditions more efficient results can be obtained by the use of these special transformers.

In the case of the dynamic loud speaker, the method of mounting is very important, with respect to the reproduction of the lower frequencies. An entirely unmounted dynamic loud speaker radiates very little energy below 300 or 400 cycles. Therefore, in order to take advantage of the excellent low-frequency characteristic of this device, it is necessary to mount the loud speaker either in a suitable cabinet or baffleboard. If it is desired to reproduce frequencies down to about 100 cycles per second, the speaker may be mounted in a small inclosed cabinet with vent holes at the back. Sometimes annoying resonances are set up in these cabinets which cause the loud speaker to chatter at certain frequencies. Proper arrangement of the vent holes together with sound-absorbing padding inside of the cabinet will usually correct this trouble. However, if full advantage is to be taken of the low-frequency characteristic of the loud speaker it should be mounted in a large baffleboard or in a wall. In order successfully to radiate low tones, the distance from the front edge of the cone to the back edge by the shortest mechanical path through the air around the baffle should be at least one quarter the wavelength of the lowest note to be reproduced; 32 inches for 100 cycles, 110 inches for 30 cycles. An ideal method of mounting this type of loud speaker is to set it in a large wall above the level of the listener's head. Such a wall is in effect, an infinite baffle and will permit the speaker to radiate the lowest tones which it is capable of generating.

The tendency towards excessive response in the frequency range from 3000 to 5000 cycles has been mentioned before. In the reception of radio signals where the side bands are somewhat suppressed, due to too great selectivity, this excess actually improves the overall reproduction but in those cases in which there is no such cutting of the side bands, it is necessary for the best results to find some means of attenuating this excess high-frequency response.

For this purpose some manufacturers employ an equalizer-filter which tends to suppress this excessive response. This filter is usually connected across the input of the tube-to-coil transformer. They are called "band-suppression filters." In Fig. 1 are shown the frequency-response curves of three typical dynamic loud speakers without filters, designated as A, B, and

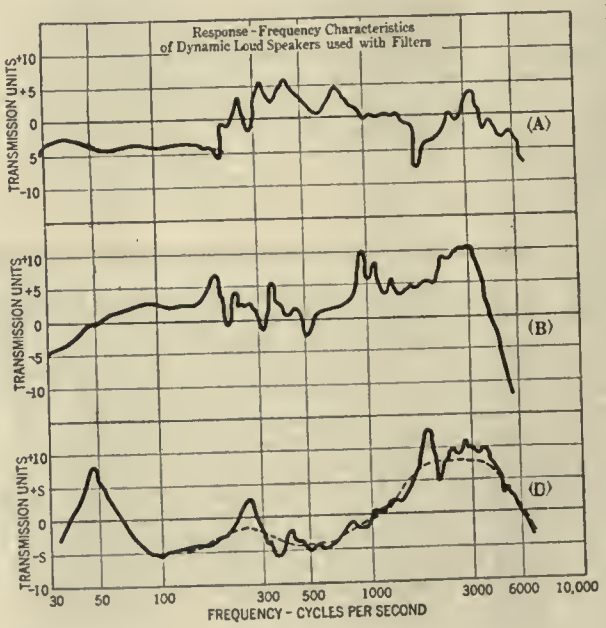


FIG. 2

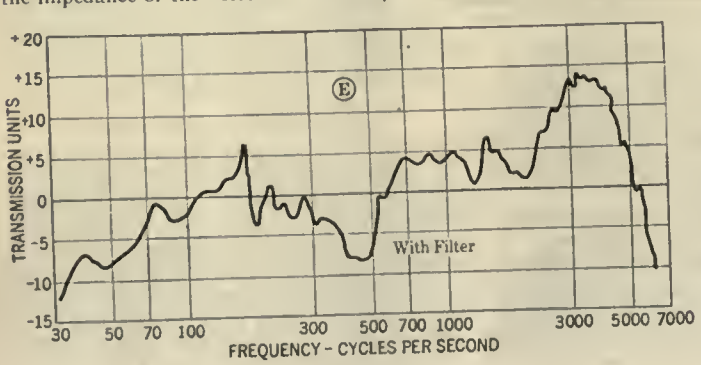


FIG. 3

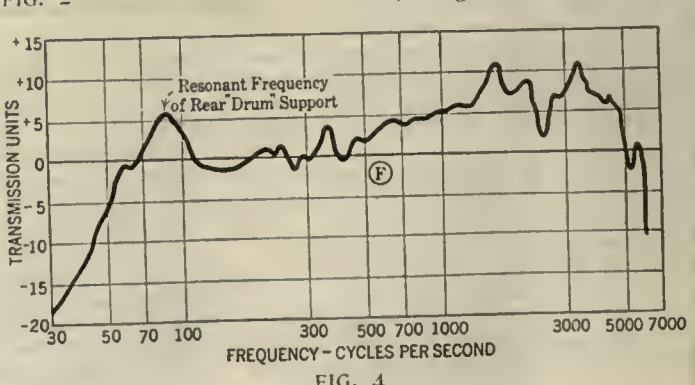


FIG. 4

C. It will be noted that A and B have markedly increased response at the higher frequencies, while C has not. In Fig. 2 are shown these same loud speakers, A and B, when the filters are used. The response of a fourth loud speaker, D, is also given. The frequency-response characteristics of two other dynamic loud speakers are shown in Figs. 3 and 4.

[In analyzing these response curves the many small irregularities can be neglected, since, in general, they will not be audible to the ear. A good idea of what we might term the "average" response curve of the loud speaker can be obtained by drawing a smooth curve as we have indicated in dotted lines on curve D of Fig. 2. Note that the curves are plotted in TU. With pure single-frequency tones the minimum change in response audible to the average ear is 2 TU, but

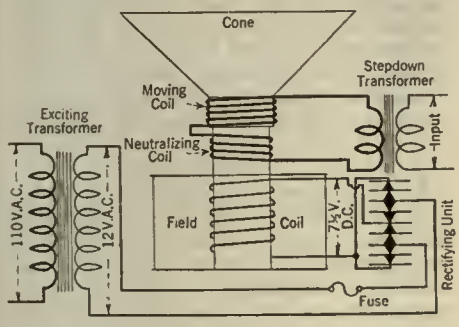


FIG. 5
Circuit of A.C. Dynamic loud speaker

when the tones are complexed as they are in speech or music a variation of 3 TU will not generally be audible to the untrained ear.—*Editor.*]

EFFICIENCY

THE second item to be considered is the question of efficiency. By efficiency is meant the ratio of the output power in sound to the input electrical power. It is well known that the efficiency of the average loud speaker is very low. In the better makes of horn and fixed-edge cone loud speakers, the efficiency rarely exceeds 1 per cent. In other words, 99 per cent. of the electrical output power of the amplifier is thrown away and only 1 per cent. converted into useful sound energy. In a good dynamic loud speaker, the efficiency is somewhat greater, and may be as high as 4 or 5 per cent. [In other words, for a given electrical input a good dynamic will turn out four or five times as much sound power as an ordinary cone, or conversely with about one-fifth the input the same output can be obtained from a good dynamic as from a cone.—*Editor.*] It is very important to have high efficiency since the higher the efficiency, the smaller the amplifier and associated apparatus necessary to produce a given volume of sound without distortion. In considering the efficiency of a dynamic loud speaker it is usual to neglect the power required to excite the electro-magnet, since this energy is readily obtained without the use of elaborate or expensive apparatus.

In order to obtain high efficiency it is first necessary to have a strong magnetic field. This is obtained by using large electro-magnets wound with many turns of wire. The limits to the intensity of the field which may be produced are the allowable heat developed in the field winding, the saturation of the magnetic circuit and the size of the air-gap across which this field must exist. There are three ways in common practice of exciting these fields. Choice among them is largely a matter of convenience, the final result being very much the same with all methods. The most common method employs a 6- to 12-volt storage battery for the excitation of the field. The second method utilizes the field as a choke coil in the filter system of the high-voltage d.c. power-supply device. This method is very economical since the energy dissipated in the field would otherwise go to waste. The third method, which is becoming more common, employs a transformer and rectifier so that 110 volts a.c. may be used as a source of field supply. The line voltage is stepped down by means of the transformer and is then rectified in order to give a pulsating direct current for the field. In some makes of loud speaker a compensating coil is used to reduce the hum which would otherwise result from this pulsating field current. If, however, the field magnets are thoroughly saturated, the hum may not be sufficient to cause trouble.

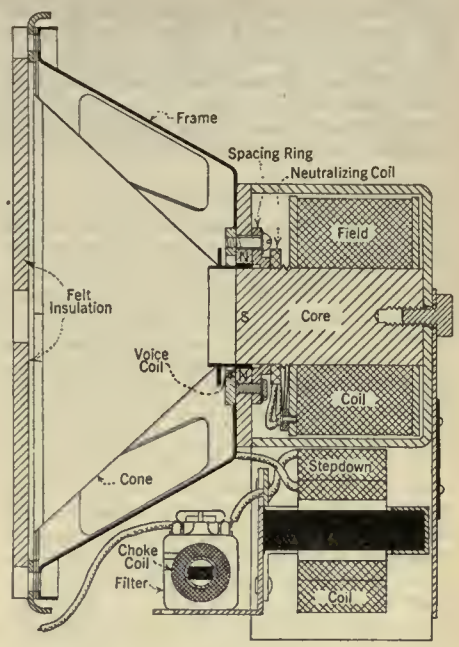


FIG. 6
Construction detail of a standard Dynamic loud speaker

In order to maintain a high field strength it is necessary to have as small an air-gap as possible. Since the voice coil moves *along*, rather than *across* the air-gap, it is necessary to have only sufficient space for clearance between the coil and the iron. This clearance is made as small as possible consistent with the free motion of the coil along the gap. Its value is usually about 0.005 inch.

Needless to say, the lighter the weight of the entire moving structure, the greater will be the efficiency of the loud speaker, since it is desirable to use as much of the electrical energy as possible to accelerate the air in front of the cone and as little as possible to accelerate the mass of the moving structure itself. The spring suspension

Mechanical and Electrical Data for Dynamic Speakers

Name	Cone			Voice Coil			Transformers			Magnetic Field		
	Diameter	Thickness	Angle	Impedance	No. of Turns	Wire Size	Ratio	Primary	Secondary	Volts	Watts	Flux Density
A_1	8″	0.008″	90°	5.95 ohms at 100~	105		$\frac{3}{1}$			6 d.c.	2.4	12000 lines/sq. cm.
A_2	8″	0.008″	90°	5.95 ohms at 100~	105		$\frac{3}{1}$			110 d.c.	3.5	12000 lines/sq. cm.
A_3	8″	0.008″	90°	5.95 ohms at 100~	105		$\frac{3}{1}$			110 a.c.	4.2	12000 lines/sq. cm.
B_1	6½″	0.008″	90°	6.4 ohms at 100~ 6.7 ohms at 500~ 26 ohms at 5000~	100	33	$\frac{3}{1}$	4000 No. 35	120 No. 19	6–12 d.c.	3.9–15.6	
B_2	6½″	0.008″	90°	6.4 ohms at 100~ 6.7 ohms at 500~ 26 ohms at 5000~	100	33	$\frac{3}{1}$	4000 No. 35	120 No. 19	100 to 200 d.c.	4–8	
C	9″		135°	less than 0.001 ohm	1		$\frac{4500}{1}$	4500	1	110 a.c.	10	14000 lines/sq. cm.
D_1	8″			13.5 ohms at 100~	140	34	$\frac{3}{1}$	3600	180	6 d.c.	5.5	
D_2	8″			13.5 ohms at 100~	140	34	$\frac{3}{1}$	3600	180	90 d.c.	4.2	
G	6½		110°	0.5 ohms at 100~	29		$\frac{1}{5}$			6 d.c.	6	10,000 lines/sq. cm.

Note: Loud speakers A_1, A_2, and A_3, have characteristics which correspond to curves A of Figs. 1 and 2. The only difference between loud speakers identified by the same letter is in the design of the field winding.—THE EDITOR.

previously referred to must be made light and flexible so as to expend a minimum of energy in the flexure of these springs.

The ohmic resistance of the voice coil should be kept low in order to reduce the heat loss in the copper to a minimum, for a given voice-coil current.

LOAD CAPACITY

THE third item is the load capacity of the loud speaker. This is limited by several factors. First, the tendency of the paper cone to buckle and rattle at the higher frequencies if too much energy is supplied to the speaker. Second, the tendency of the loud speaker to be thrown into violent motion at its low resonant-frequency point. The third limitation is that due to what is called "non-linear distortion." This means the introduction of frequencies into the sound radiated which were not present in the electrical input to the loud speaker. This may be due to a number of causes and this type of distortion distinctly limits the load capacity of the speaker, since such distortion increases greatly with the quantity of sound energy radiated. The major cause of this distortion is due to the inequality between the propelling and restraining forces acting on the moving structure. A well-constructed dynamic loud speaker, however, is capable of fairly large sound output without such distortion becoming apparent to the ear, and the writer has found that with most of the dynamic loud speakers on the market, the sound output capacity is limited by paper and spring rattles at the higher frequencies. The fourth limitation, which is seldom reached in the ordinary dynamic loud speaker, is that of the production of heat in the moving coil. In other words, if all three of the previous capacity limiting factors were absent, the capacity of the loud speaker would still be limited by the amount of heat which can be safely radiated from the voice coil.

In order to obtain a maximum of energy in a minimum of space with the greatest allowable temperature rise, one manufacturer uses a single-turn voice coil which permits a very small ratio of insulation to conductor thereby increasing the capacity of the loud speaker.

It will be seen from the above description that the design, construction, and application of the dynamic loud speaker is a problem involving many factors, consequently a great variation in the products of different manufacturers is to be expected. The writer has found this to be true, and has examined some which were excellent, some which were fair, and some which were very poor. It is not sufficient to have a good theoretical principle. The design, construction, and application based upon this principle determine the quality of the actual product.

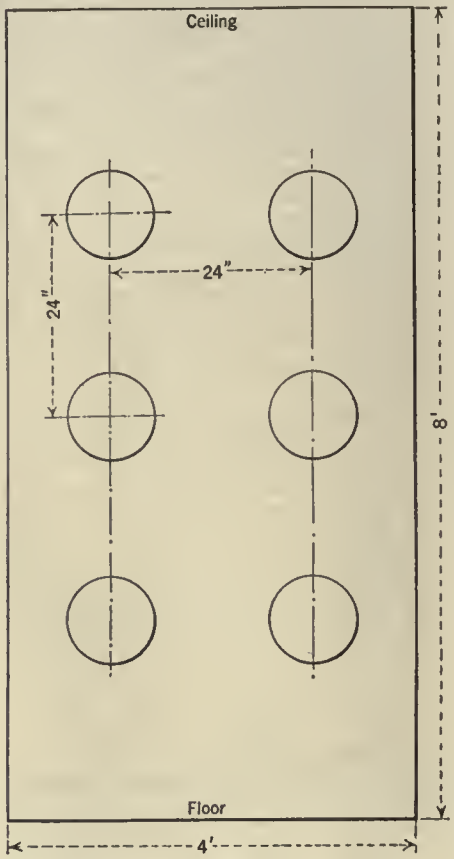


FIG. 7

Method of mounting six dynamic units on a large baffle

Many of the manufacturers issue complete specifications together with frequency-response curves, and much can be learned from these data. The reader is warned against believing that a loud speaker must be good because it is a dynamic loud speaker. It is also important to remind him that a loud speaker cannot be judged unless it is used in the proper manner, and with adequate associated apparatus. The larger the capacity of the amplifier, up to a reasonable limit, which feeds the loud speaker, the better will be the quality of the reproduction with a good loud speaker. If it is possible to use a well-designed amplifier with two 250-type tubes in push-pull in the last stage, an excellent result may be obtained. It is undoubtedly true that a sacrifice will be made if a smaller output is employed. This is particularly undesirable for the production of low tones which are so necessary for natural reproduction of speech and music.

MULTIPLE LOUD SPEAKERS

WHERE feasible, splendid results may be obtained by using two or more dynamic loud speakers in the same baffleboard. In one such design, built by the writer, six dynamic loud speakers of well-known make were placed in a single baffleboard as shown dimensionally in Fig. 7. These six loud speakers had their voice coils connected in series and were supplied by a special Amertran transformer feeding from two 250-type tubes in push-pull. At least four worthwhile advantages are obtained by the use of multiple loud speakers. First, the inequalities of the individual frequency-response curves are smoothed out. Second, for a given sound energy radiated, each loud speaker supplies less load and therefore distorts less. Third, the sound comes from a large area instead of from a small one. This last factor greatly improves the naturalness and the sense of three dimensionality. Fourth, the radiation of the low-frequency and the high-frequency tones are markedly improved and a better tonal balance is obtained.

Book Reviews

PRACTICAL RADIO. By James A. Moyer and John F. Wostrel, Third Edition, 1928, McGraw-Hill Book Co., New York, 378 pages, $2.50.

James A. Moyer, S. B., A. M., one of the authors of *Practical Radio*, bears after his name on the title page the following list of affiliations: *Director of University Extension, Massachusetts Department of Education, Fellow of the American Association for the Advancement of Science; Fellow of the Royal Society of Arts; Mitglied des Vereines Deutscher Ingenieure; Membre Titulaire Association Internationale du Froid; Member of the Franklin Institute; American Society of Mechanical Engineers; Society of Automotive Engineers; Institute of Electrical Engineers, etc.*

Nevertheless, the book is not without merit. *Practical Radio* was first issued in 1924 and has been kept abreast of developments in subsequent editions. It is one of those non-mathematical, copiously illustrated and charted expositions written for experimenters, service men, boy scientists in the more advanced grades, and other fauna produced in quantities by the spread of broadcasting. All the emphasis, as one would expect, is on broadcast technology, especially in reception. This bias the authors reveal on page 2 with the bald statement: "The most important use of radio is for broadcasting the human voice." I certainly do not wish Messrs. Moyer and Wostrel any hard luck, but if they are ever on a vessel which catches fire 1000 miles from land I shall seize the opportunity to debate this opinion with them at greater length.

After a preliminary discussion on "What is Radio?" the book contains chapters on antennas, "radio electricity," crystal receiving sets and telephone receivers, vacuum-tube receivers, power sources for tubes, audio- and radio-frequency amplification, the selection, operation, and care of receiving apparatus (Chapter X), and radio transmission by telegraph and telephone. The inclusion of material is often haphazard; in Chapter X, for example, there is a discussion of the vagaries of distribution of field strength in cities, fading, etc. Following Chapter XII, on construction and testing of receiving instruments, the trend of the discussions is highly practical; the reader is told about machinists' drill gauges, panel templets, the testing of neutrodynes, and the characteristics of various types of battery eliminators. Chapter XV is devoted to "Common Troubles and their Remedies."

Clarity is a prime requisite in books of this type and *Practical Radio* succeeds in explaining lucidly, to the degree required by semi-technical readers, the numerous points which the development of broadcasting has raised. There are some loose statements, as when we are told, on page 51, that "The operation of the vacuum tube as used in radio sets was discovered by Edison," without any mention of Fleming and de Forest, and on page 195 where it is categorically set forth that in the Heising system of modulation "the two vacuum tubes (oscillator and modulator) should be the same type and as nearly electrically identical as possible." On the contrary, the modulator should be larger and of lower impedance. In practice this is accomplished by using a higher-powered tube as the modulator, or paralleling a number of tubes of the type used for the oscillator. Other such deviations from accuracy can be found in *Practical Radio* without the use of a microscope, in spite of the senior author's international feats in joinery, but to the students for whom this book has been written such details are inconsequential and the knowledge they want is certainly to be found within its covers.

CARL DREHER.

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

WGY's Attack on the Allocation Plan

WHEN an irresponsible citizen of the broadcasting world sets his private interests above those of the listening public and takes legal measures threatening the security of our new broadcasting structure, the product of years of patient effort, we condemn the error of his ways and hope for his ignominious defeat at the hands of the courts. But, when so respected a citizen of the radio fraternity as WGY takes the first step which is likely to restore ether chaos, we lose hope that broadcasting will ever be sufficiently stabilized to get along without frequent reallocations, legal proceedings, and political pussyfooting.

WGY's cause is a just one. No station is better entitled to a clear channel because it serves a large audience and is the principal program reliance over an extended rural area. But it went about securing justice in a manner which was exactly 100 per cent. wrong, because it endangers the entire system of allocation based on engineering principles. WGY did not hesitate to enlist the aid of grotesque exaggeration of the facts, the ever-ready services of the halo-seeking politician, and even shamelessly sought to fix upon the Commission the obloquy of restricting service to the sick and injured in the hospitals. The consequences of its course portend such destruction that the propriety of WGY's claim to a cleared night and day channel has become a matter of minor importance.

At this writing, it is too early to determine whether the injunction will have as far-reaching and destructive an effect as that obtained by WJAZ two years ago, which brought chaos to broadcasting and stagnation to the radio industry. But it appears that only good fortune can prevent the complete upset of the allocation plan as a result of WGY's injunction, which converts a Fifth Zone cleared channel into one shared by the First and Fifth Zones, thereby upsetting the principle of cleared channels.

FACTS OF THE CASE

THE case is one of such importance that its history is worthy of repetition. The Federal Radio Commission, under the Davis Amendment, is compelled to divide the channels of each character equally among the five zones. It decided to clear forty channels for high-power, night operation, allowing eight per zone. It is further required by the Davis Amendment that the facilities be divided among the states in each zone in proportion to their population. The eight cleared channels of the First Zone were, therefore, divided among the ten states in the Zone according to their respective populations.

The New York stations selected for clear channels were WEAF, WJZ, WABC and WHAM. Thus, three of the channels were assigned to the key stations of the three eastern networks, while the fourth was properly assigned to the western part of the state. The Commission's judgment in deciding upon WEAF, WJZ and WABC, each the key station of a different network, for three of New York's four channels can hardly be questioned. WGY might have challenged WHAM, but that station has excellent claims to a cleared channel. It is in an area somewhat more remote from New York than Schenectady and, therefore, less easily served by the three key stations in that city. Furthermore, Rochester is a source of musical talent of the highest grade.

WGY was assigned for daytime operation to a clear channel belonging to the Fifth (Western) Zone, occupied by KGO, which is operated, like WGY, by the General Electric Company. The Commission further gave special permission to WGY to operate in the East at night during



MR. J. W. HORTON

After a twelve-year association with the Bell Telephone Laboratories, Mr. Horton has joined the General Radio staff in the capacity of Chief Engineer.

any silent period on KGO's schedule. Because of a three-hour time difference, the earliest WGY is required to sign off, if no time concessions are made by KGO, is 8:17 P.M. and the latest 10:32 P.M. If KGO relinquishes all broadcasting between sunset and 7 P.M., this permits WGY to operate until 10 P.M. nightly. During four months of the year, this involves no sacrifice of time on the part of KGO because the sun sets after 7 P.M. on the coast during the months of May, June, July and August. For three months of the year, KGO's sacrifice is one hour or less in the early evening, for two months between one and one and a half hours, and for three months between one and a half and two hours, a part of which are afternoon silent periods.

Operation until ten P.M. gives the maximum of service to the majority of WGY's listeners including hospital inmates and rural listeners. After ten P. M. also, late listeners may, except in midsummer, receive their programs from one or more of the 50,000- 30,000- and 15,000-watt stations within 150 miles of WGY, not to mention the numerous less powerful stations, some of which have chain affiliations. Furthermore, in summer, when local service is the only reliance of the listener, WGY could ultimately have obtained the permission of the Commission to continue still later operation simultaneously with KGO at night because, due to summer attenuation, heterodyning is unlikely at that season.

WGY has not been singled out as the only high-power station to operate on limited time. Three 50,000-watt stations, WFAA, WTIC and WBAP, are operating, or will operate, on half time only. WENR, the only 50,000-watt station in the Chicago area, is limited to two-sevenths time. These are assignments imposed by the limitations of the Davis Amendment and do not represent unfair discrimination by the Commission. Thirty-nine stations of 5000 watts power or more have been assigned part time.

IMPORTANCE OF WGY'S SERVICE

NO ONE can fairly deny the magnificent service which WGY has rendered and its importance as a broadcasting station. Certainly it was entitled to go before the Commission and request one of the clear channels assigned to New York State. It did not, however, elect to take the orderly course, but went after a channel assigned to another zone, thus striking at the very heart of the principle of allocation. Anyone, not closely acquainted with the technicalities of allocation, would have gained the impression from press reports that WGY had been shut down entirely. Certainly, the letters from hospital inmates, copiously distributed to the press by WGY's publicity department, gave the impression that these sufferers believed they would hear no more of WGY after November 11. In pleading for the injunction which converted a clear Fifth-Zone channel into one heterodyned by a First-Zone station, Attorney General Jeremy R. Waldron of New Hampshire asked the Court of Appeals to grant the injunction "so that WGY listeners in our state will not be deprived of service after November 11."

WGY declined to comply with the Commission's procedure of challenging another station assigned a New York State channel on the ground that it had no quarrel with such stations. What WGY should have done, if it did not elect this course, would have been to strengthen the allocation plan, rather than to aim at its fundamental principles, by demanding additional clear channel for each zone. For example, were there fifty clear channels, allowing ten per zone, as recommended by the engineers' plan, the Commission automatically would have recognized WGY. The weight of its evidence could have been thrown in support of clearing more channels and giving better service.

Whether additional applications for injunction by other stations will follow the precedent established by WGY cannot be determined at this writing, but certainly the way has been paved for such action. We hope that, ultimately, WGY will secure its clear channel and that, in the process, the principle of allocations based on engineering considerations will not be even temporarily destroyed.

Commissioner Robinson Stands Firm

COMMISSIONER Ira E. Robinson has been consistently out of sympathy with the other members of the Commission. He has firmly opposed the allocation plan, favoring a policy of delay in taking active steps to relieve the broadcasting situation. He inclines to the view that the listener is best served by

many, low-power stations and fails to appreciate the improved service obtained by a more powerful signal. He has frequently expressed the belief that Congress expected the Commission to take several years to investigate the problems of broadcasting, which indeed it has already done, before it begins to function.

The progressive members of the Commission, however, over-ruled Commissioner Robinson's obstructive tactics and put through the allocation plan, after some compromise, in spite of him. When hearings over the plan began, Robinson issued a statement: "Having opposed and voted against the plan and the allocations made thereunder, I deem it unethical and improper to take part in the hearings of complaints against the same or the hearings for the modification of the same." He did not have the strength of conviction to resign from the Commission, but is evidently relying upon Congress to support him.

ANOTHER ROW

ANOTHER row with Commissioner Robinson was precipitated over the ruling regarding television and still pictures. He stated, after the ruling restricting still picture and television broadcasting to one hour a day and prohibiting it between six and eleven P.M. was adopted, that "the forwardness of manufacturers could well be curbed for the present. One induced by the order of the Commission to buy a television receiving set is likely to be so disappointed that he will not only damn the Commission but, at the same time, junk his newfangled contrivance for which he has paid the advertised price."

The radio industry is indeed fortunate that Commissioner Robinson was not in power at the time that broadcasting began in 1921 because broadcast receivers of that day were certainly worthy of the same condemnation. As a matter of fact, the crude results obtained with present-day television are well known and it is entirely unlikely that anyone will damn the Commission for the pioneering character of the art. The Commission has taken into full consideration the importance of protecting the listener from intrusion during entertainment hours by prohibiting picture transmissions between six and eleven P.M.

Conservatism is considered a characteristic of the English people, particularly of the Government itself. The British Broadcasting Corporation, however, which collects its income through the Government and takes no important action without its approval, has been progressive enough to inaugurate regular picture broadcasting.

It is no wonder that rumors of Commissioner Robinson's impending resignation frequently are heard from Washington. We believe, however, that these rumors are rather an expression of the hope of progressively minded people.

It is always desirable to have conservative influences present in any regulatory board or commission but, when the cause of conservatism is lack of knowledge of the subject, it is not always a helpful influence. Commissioner Robinson is thoroughly sincere and has the courage of his convictions in the face of preponderant opposition. His unfortunate situation demonstrates the hampering result of appointing novices to a job requiring experts.

The Regenerative Decision

THE Supreme Court of the United States has ruled that Dr. Lee deForest, and not Edwin H. Armstrong, is the original inventor of the oscillating vacuum-tube circuit. Considering that the Armstrong and Fessenden patents were the foundation of the Westinghouse Electric and Manufacturing Company's membership in the five-power patent pool, it would appear that its present exalted position in the radio field is insecurely based. Anyone who examines the evidence placed before the Supreme Court, however, would discover a curious thing. They would find that Armstrong claimed to be the first to produce the device which we call the feed-back oscillator and was using it for receiving signals over thousands of miles as early as January, 1923. They would discover that deForest never claimed to have set up such a radio circuit until April, 1913, when he claimed he received signals over a distance of twenty miles. Nevertheless, by a technical legal process, he has been declared the inventor. The decision is based upon a strictly technical interpretation of the term "inventor" as the first to observe and record the invention or discovery. Apparently, Dr. de Forest stumbled accidentally upon the phenomenon of self-oscillations generated by the vacuum tube in the summer of 1912 while working on a wire telephone repeater. With the soft tube, with which he worked, it is indeed difficult to prevent the audio-frequency howling which he observed. Armstrong, at a later date, with the deliberate mental processes of a research engineer who knows what he is doing, evolved the theory and carried out the practice of building the first deliberately designed, radio-frequency oscillator. That he did his work later than deForest's accidental discovery is no discredit upon him and, despite the decision of the courts, he will always remain, in the minds of most engineers, the real contributor. For a technical legal reason, the court could not distinguish between audio-frequency and radio-frequency oscillation and, had this been possible, there seems little doubt that the decision would have proved favorable to Edwin H. Armstrong.

It must not be forgotten that this is only one of many discoveries which have been credited to Armstrong. Among these are the super-heterodyne circuit, the regenerative system, and the almost forgotten super-regenerative circuit. It is by no means proved that this latter will not ultimately be widely used in radio reception and we hope that Mr. Armstrong will devote himself again to his brilliant researches, rather than to fruitless patent litigation.

The decision in favor of deForest has no practical effect upon the licensing situation inasmuch as both deForest and Armstrong patents are covered by RCA licenses, although certain shop rights acquired by the Kolster Radio Corporation appear to be affirmed.



RADIO PICTURES TRANSMITTED IN THREE MINUTES

This picture of Kay Christiansen, chief engineer of the technical division of Danish Broadcasting, was transmitted in three minutes by a Danish radio picture transmitter.

With the Broadcasting Stations

THERE is considerable speculation as to the effect the election of Herbert Hoover will have upon the future status of radio regulation. According to the law, the Commission is automatically disbanded March 15 and thereafter becomes an appellate body with regulation residing directly in the hands of the Department of Commerce. Presumably, before that event takes place, the allocation plan will be fully established and the number of hearings will have fallen off. On the other hand, with Congress coming into session, such political pressure may be brought to bear upon the Commission that many of the stations will renew their protests and force the Commission back into its present routine of almost continuous sessions and hearings.

Mr. Hoover is thought to be sympathetic with Department of Commerce regulation, particularly after the work of the Commission has become effective, but there are so many political angles and aspects to the situation that anything may be expected. The terms of the Commissioners automatically end on March 15 and it may be hoped that thereafter the entire membership of the Commission will consist of radio men of the calibre of Caldwell and Lafount. Lawyers are necessary to the work of the Commission, but they are constituted by nature to bind themselves with the obstruction of red tape; energetic and effective tackling of problems in face of their inherent character is almost impossible. We owe whatever progress has been made by the Commission in its two-year tenure of office principally to the two members who are thoroughly acquainted with the radio phases of the problem and their ability to persuade the rest of the Commission to carry out allocations based on engineering rather than political considerations.

A CONFIDENTIAL survey of the effectiveness of commercial broadcasting has been prepared for the National Broadcasting Company. Most of the statistics released by stations show general census figures for the prosperity and business of their alleged service areas. Others, like the N. B. C. survey, go further and look into listener preferences as to the hours and frequency with which they use their radio receivers and the character of programs which they prefer. The great fundamental question, however, which interests the advertiser, is not the potential audience which he may have, but the actual sales or goodwill influence of his program. Surveys should consider the competitive situation which exists for the listener's attention. We are accustomed to thinking of audiences of millions for a particular program, but calculations, which take into account all the reasons why listeners may *not* be listening to a particular program, prove that audiences are considerably smaller than is generally estimated.

A further and more serious loss in the effectiveness of broadcasting is the remoteness of benefit to the sponsor who has presented an entertaining program. The art of capitalizing the broadcasting effort is the least developed phase of commercial broadcasting. As the ingenuity of the devices employed to bring actual consciousness of sponsorship relation to the program offered increases, it will place even greater valuations upon the possibilities of commercial broadcasting.

Another research of great interest has been prepared by the Dartnell Corporation of Chicago, entitled "The Use and Limitations of Radio Advertising." After quoting a number of authorities on the scope and suitability of broadcasting to various classes of business, it summarizes for the first time the actual appropriations expended by most leading commercial sponsors over a period of years and classifies them according to the character of each sponsor's business.

ONE of the principal test cases before the Commission at this time, which will determine its jurisdiction, is that pending in Chicago. WOK-WMBB has advertised its intention of going on the air in spite of the fact that the Commission has denied it a license. The moot question of property rights with a 20,000-watt transmitter, representing a considerable investment, is squarely the issue of the case. The District Court for the Northern District of Illinois denied an application for an injunction against the District Attorney who was seeking to enforce the Federal Radio Commission's assignment under the new allocation plan on WCRW. The Court held that WCRW had not exhausted the avenues provided in the Radio Act for a consideration of its case before applying for an injunction restraining the Commission. The Radio Act was held constitutional in this decision.

THE Federal Radio Commission issued regulations for synchronizing experiments which are helpful in that they lay a definite basis for such work in the future. They are rather stringent, requiring several months of test before the results can be applied under average broadcasting conditions. In fact, the safeguards which the Commission has placed on these experiments are so complex that they will discourage any but the most advanced laboratories from even undertaking such work. However, the public should be protected against experiments undertaken principally to secure publicity rather than scientific results and, if the regulations prove too burdensome to promote progress, the Commission will, doubtless, modify them slightly.

GENERAL Order No. 48, of the Commission permits stations, licensed to operate during daytime, only, on clear channels belonging to other zones, to take advantage of the silent evening hours of the major station. This is a wise regulation because many of the stations in the far west, assigned to cleared channels, begin operation at six or seven P. M. instead of directly at sunset, thereby leaving valuable hours available, under the new regulation, to the eastern stations assigned with them.

AN INTERESTING sidelight on the comparative values of broadcasting and newspaper advertising appeal, under very special conditions, is revealed in the remarks of Scott Howe Bowen at the National Association of Broadcasters convention in October. He stated: "The Democratic National Committee spent $35,000 in a series of newspaper advertisements and received in return less than $2000 in contributions. It later employed a network of National Broadcasting Company stations at a cost of $4000, which brought in $70,000 in contributions. Another experiment, through the Columbia network, involving an expenditure of $2000, brought in $50,000 in contributions."



A RADIO STATION IN THE WILDERNESS

This picture shows the forest camp at Red Lake, Ontario, Canada, which is one of the nine places in that district where short-wave radio stations have been installed to keep airplanes and forest rangers in the vicinity in touch with headquarters. The radio shack is in the building next to the tower, the latter being used to dry hose after a forest fire. The call letters of the station are VE9BD.

Commercial Radio Telegraphy and Telephony

THE latest addition to the international telephone service is the linking of the United States and Austria by the Bell System.

THE Mackay System is beginning the construction of radio-telegraph stations to inaugurate commercial and press service between San Francisco, Honolulu and Manila. This duplicates the existing network of the Radio Corporation of America and is another step in the intensive competition rapidly developing in American world-wide communication.

GENERAL Order No. 51 of the Commission requires discontinuance of the use of spark transmitters employing damped waves except in the case of ship stations. This is the formal embodiment of the final elimination of what was once a problem of great proportions, the interference created by commercial spark stations upon broadcast reception.

THE African Broadcasting Company, Ltd., which has practical control of broadcasting in the South African Union, appears at last to be established on a sound commercial basis, following its many vicissitudes of previous years. The company reports some three thousand new subscribers and a decrease in the number of listeners in Johannesburg who have, in the past, been evading the payment of license fees.

With the Radio Manufacturers

THE Kolster Radio Corporation announces successful experiments with a beam antenna, the angle of which may be changed to compensate fading effects.

Dr. Kolster also announces a small, direct-reading, radio compass for small vessels which can take bearings for distances up to approximately 25 miles. The over-all height of the instrument is only three and a half feet.

THE Radio Manufacturers' Association has apparently repudiated its agreement with the National Electrical Manufacturers' Association, which provided that R. M. A. would review NEMA standards and thus centralize standardization work in NEMA's hands. It has issued a 25-page leaflet of standards which differ in minor respects from the NEMA standards and are not as comprehensively or as satisfactorily compiled as the 150-page book which has heretofore been the sole standard authority of the industry. No explanation has been made by R. M. A. for its attempt to restore chaos in the standardization situation.

THE details of the new Radio-Albee Orpheum combination have been announced. A holding company, to be known as Radio-Keith-Orpheum with David Sarnoff as Chairman of the Board, has been formed and two classes of stock issued, 3,500,000 shares being Class A and 500,000 Class B, the latter being assigned to the Radio Corporation for a photofilm license. Dividends will be divided in the ratio of 1,100,000 shares to Keith-Orpheum, 500,000 to R. C. A. and 200,000 to F. B. O.

NEGOTIATIONS between Columbia Graphophone, Columbia Phonograph, Western Electric and Electric Research Products Corporation are said to be nearing completion. This makes a set-up quite similar to the R. C. A.'s association with Victor Talking Machine and requires only the addition of a film company to the Columbia group to round it out.

THE R. C. A. has incorporated two export subsidiaries, the R. C. A. of Argentina, Ltd. and the R. C. A. of Brazil.

THE bi-annual census of manufacturers shows a 32.3 per cent. gain in the value of radio B and C batteries manufactured in 1927 as compared with 1925. The figures for the two years were respectively approximately $25,000,000 and $33,000,000.

ATWATER KENT has broken ground for a new three-million-dollar factory which will double its output and make it the largest radio factory in the world.

—E. H. F.

A Few Radio Questions Answered

NEARLY everyone wants to know the answer to some one question about radio. Many want to know the answer to specific questions, such as "What is wrong with my set, the tubes don't light?" Others want to know the answers to general questions: answers which should be obvious but are not. In this page the Laboratory Staff has attemped to answer a few of the questions that are asked it many, many times, and in this paragraph expresses the hope that readers who have other similar questions will not hesitate to send them in.

—THE EDITOR

WHY is the volume control placed in the r.f. amplifier?

It need not be; it may be connected in the antenna-ground circuit, in the r.f. amplifier, in the detector, or in the a.f. amplifier. It preferably should be connected in a circuit ahead of the detector, so that the signals may always be kept below the point where detector overloading begins. This is particularly important when a leak-condenser detector is used—because it has a low overloading limit. It is our guess that 99 per cent. of the sets now in use have this kind of detector. If the volume control is placed on the audio amplifier, that is, after the detector, distortion is liable to result on strong signals, even though the volume from the loud speaker is low. This is due to too strong signals being placed on the detector input.

I HAVE a 171-type power tube. Is there any advantage in using a 171A-type tube?

The only advantage is in the improved economics of your radio system. The new tube will not deliver more volume, nor will it last longer, nor will it give better quality. It consumes half the A-battery current; hence, it is about twice as efficient, if you chose to call the efficiency of the tube the amount of audio-frequency output it will deliver per watt of power used up to heat the filament.

I DROPPED my audio transformer and now the quality seems "sour." What is wrong?

The chances are that your audio transformer had a high-permeability core made of one of the new alloys of iron, nickel, etc. It is a fact that the greatest care in manufacture is necessary not to lower the permeability of the core material by severe mechanical shocks. When the permeability is high, a relatively small core and relatively small amount of wire will produce a high-inductance winding. When a shock lowers the permeability, the inductance goes down, and the low frequencies fall out.

It is a standard physics class experiment to drop iron rods on a hard floor in such a direction that at the moment of contact the molecules can be oriented properly with respect to the earth's magnetic field. After a sufficient number of shocks, the iron bar will be found to be permanently magnetized. It is possible that your audio transformer has become permanently magnetized—which would have the same effect as sending too much d.c. current through it. It "saturates" easily.

HOW can I tell if my tubes need replacing?

According to certain publicity writers a new tube should be placed in each socket of a set least once a year—but don't you believe it. Just because you bought a tube a year ago to-day, is no reason why you should throw it in the wastebasket and invest in a new one provided, of course, a test proves it to be a good tube. Tubes do not run down in just that manner. The Laboratory has records of a number of Sylvania tubes which ran on a life test for 1500 hours without any change in their constants—except a minor improvement in some of the tubes—and were then taken off and used around the Laboratory for months afterwards. Some tubes last 1000 hours, others become anaemic at the end of a few hundred hours—for no reason that anyone can state. The tubes may have come from the same plant and exactly the same run—but something in their make-up gave them a short life.

If your set seems to have slowly given up its sensitiveness to weak signals, if it no longer gives out low notes, and if you can't get DX on a crisp cold December night when your next door neighbor gets PWX, you'd better have your tubes tested. When the quality seems bad, and the amplifier overloads easily, look to the 171-type power tube which is probably being run on a.c., and whose filament has been overloaded so that it no longer has sufficient electrons to handle low or loud notes. Any reputable dealer can test the tubes.

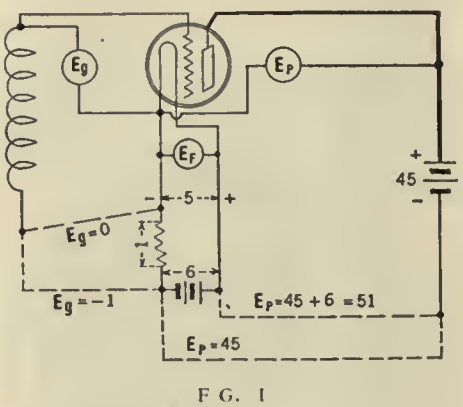


FIG. 1

WHERE should a filament rheostat be placed, in the positive or negative lead? Should the minus B wire be connected to minus or plus A wire?

Look at Fig. 1. Here th e resistor, which may be variable or not, is connected in the negative filament lead. The bottom end of the coil attached to the grid is connected on the battery side of this resistance. There is a voltage drop across this resistance, which makes the end nearer the battery one volt more negative than the end near the tube. Since all tube voltages are measured with respect to the negative end of the filament, this voltage drop is applied to the grid. We can say, then, that the grid is one volt negative, meaning that it is actually one volt more negative than the negative end of the filament ($E_g=-1$). If the coil were attached to the filament end of the resistor, the grid would be at the same potential as the filament, and would be at zero bias ($E_g=0$). It makes absolutely no difference in this case if the resistor is in the plus or minus lead.

When minus B is attached to minus A, the plate potential is the voltage of the B battery. When minus B is attached to plus A, the plate potential is the voltage of the B battery plus the voltage of the A battery, because plus A is above the voltage of minus A—which is connected to the negative filament lead—by the voltage of the A battery. Thus, if the B battery is 45 volts, and the A battery is 6 volts, and minus B is attached to plus A, the plate potential is 45 plus 6 or 51 volts. If the minus B is attached to minus A—and we prefer such a connection—the plate potential is the same as the B-battery voltage, namely, 45 volts. For years telephone circuits have connected minus B to plus A, but we don't see any good reason for it except tradition.

CAN a high-mu tube such as the 240 be used as an r.f. amplifier?

Yes, and it will make a good one too. The trouble is that the amplification will go up a bit faster than the selectivity, so that the circuit seems to tune broadly. If a transformer is used to couple a high-mu tube to another amplifier tube or to a detector, the turns ratio must be greater when using a high-mu tube than when using a 201A-type tube. An explanation of this turns ratio business may be found in "Strays from the Laboratory" September and December.

WHAT is a band-pass amplifier?

Strictly speaking it is an amplifier that admits, amplifies, and transmits only a certain band of frequencies, say from 50 to 60 kc., and refuses all other frequencies. Strictly speaking again, there is no such thing. All band-pass amplifiers admit a certain amount of currents of other frequencies, but this amount can be made quite small. A true band-pass amplifier characteristic would look like Fig. 2, and the amplifier would consist of a great many stages of filters, each composed of inductance and capacities.

A band-pass amplifier which does not have a sharp "cut-off" would look like Fig. 3, and a sharper one would look like Fig. 4. Both admit frequencies on either side of the desired 50–60 kc. band but in smaller amounts. Theoretically it is possible to build a band-pass amplifier with a flat top and steep sides. Whether or not an amplifier has such a characteristic in practice has not been determined in the Laboratory.

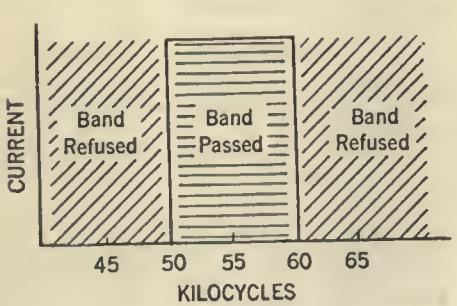


FIG. 2

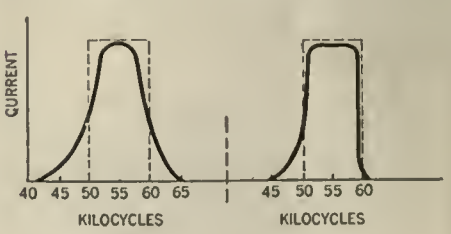
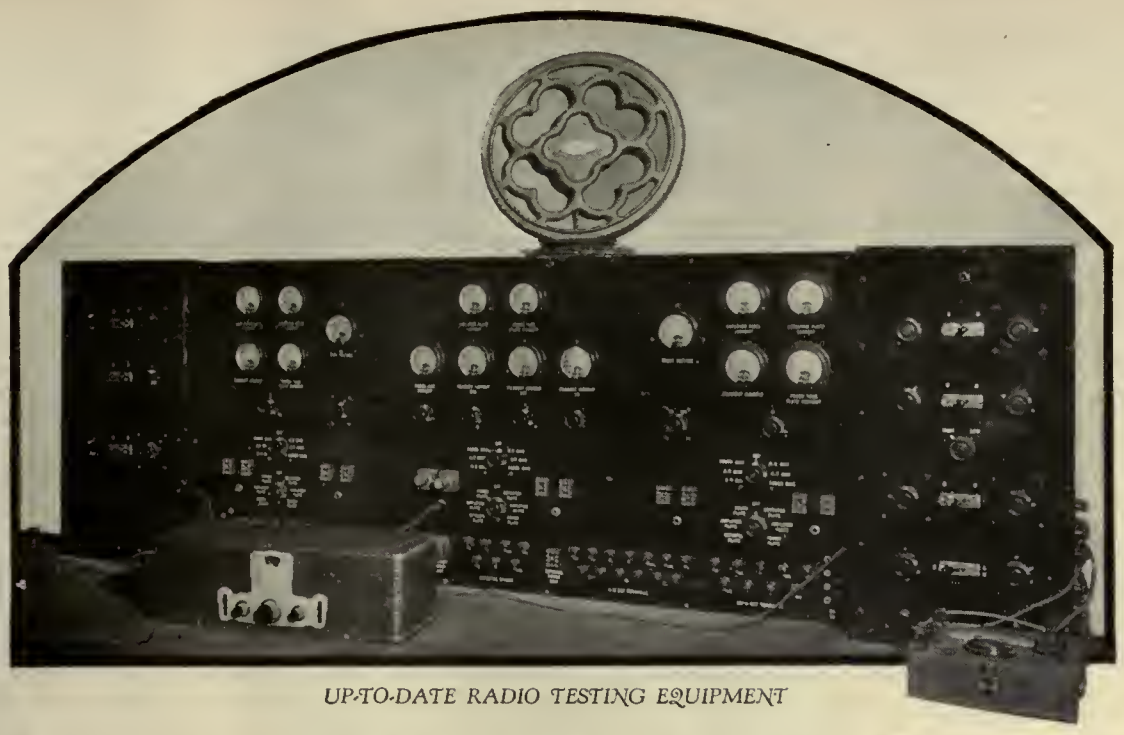


FIG. 3 FIG. 4



UP-TO-DATE RADIO TESTING EQUIPMENT

Measuring a Receiver's Performance

By KENNETH W. JARVIS

IN ALMOST any Sunday newspaper radio supplement you may find something like the following: "Buy Now—a Guaranteed Jumpidyne—Coast to Coast Reception—Wonderful Tone Quality—Hair-Splitting Selectivity—Loud-Speaker Volume"—and so on for about two columns of variegated adjectives. On the next page you may read about another make, also "The Finest Receiver on Earth" with remarkable distance-getting ability and marvelous reproduction.

These picturesque descriptions are undoubtedly works of genius on the part of hard-struggling advertising managers, but do they help persuade a wavering prospect that his only hope of radio blessedness is to buy a Jumpidyne? It is rather doubtful. At best these masterpieces of word structure do nothing more than attract attention. True, attention is the first step in making a sale, but it's a long way to the dotted line.

Are such statements logical and proper in merchandising a radio product? Must the technical rating of our receivers be measured by the ingeniousness of the copy writers in coining new superlatives? Any radio engineer will answer these questions with a most emphatic "No," and will gladly repeat his answer if occasion demands. While not easy, performance characteristics of our receivers can be obtained and definitely expressed in numbers. Curves will be shown later illustrating this point.

There are several good reasons why the "performance characteristics" of radio receivers have not been used much to date. Such measurements are hard to take. Engineers could not agree as to what measurements were necessary nor how to make them. And, if made and published, the radio buying public would not know what it was all about. All of these objections are rapidly being answered; this prophesies the end of the set with nothing but adjectives to sell it. Measuring equipment is available. The Standardization Committee of the Institute of Radio Engineers have practically completed their work in the specification of Standard Tests. And the public is being educated by such articles as this. All of which is sufficient reason why our radio receivers should be sold to the public on their own merits.

HOW to measure the performance of a radio receiver has always been a subject of primary interest. Those inexperienc d in the field have never been able to see why some simple standards for receiver performance could not be set up to give information as definite and useful as that to be had from makers of automobiles. Radio engineers themselves—who ought to know—have been slow to agree on what the measurements should be and how they should be made. The author of this article, Mr. Jarvis, who is a member of the engineering staff of the Crosley Radio Corporation, discusses the problems of receiver measurement and tells something about how they are being solved.

—THE EDITOR.

SENSITIVITY MEASUREMENTS

PROBABLY the most important characteristic of a radio receiver is its sensitivity. This is the "mysterious" element that is responsible for distant reception. It's the influence that has made radio what it is to-day. Even the old timers still experience a thrill when tuning in a faint signal from across the Atlantic or Pacific. The sensitivity of a receiver is sort of a magic Arabian rug that takes you, via ear at least, to wherever you want to go. There is only one difference. The magic rug could go anywhere—the radio receiver will take you to the distance determined by its sensitivity.

How is this sensitivity measured? Engineers have agreed that the sensitivity of a set shall be determined by the amount of signal necessary to produce a standard output. (This "standard output" is arbitrarily agreed upon as a power of 50 milliwatts, which corresponds roughly to fair loud-speaker volume.) It is about half the output that can be obtained from a 112-type tube without distortion. The set to be measured is, therefore, connected to its proper A, B, and C voltages and an r.f. signal of certain characteristics (400 cycles at 30 per cent. modulation) impressed in the antenna circuit. The input voltage is varied until the standard output is reached, and then the input voltage is measured. Obviously, the more sensitive a receiver is, the *less* will be the voltage input. Thus, a set having a sensitivity of 40 microvolts per meter would be twice as sensitive as one having a sensitivity rating of 80 microvolts per meter. In reading the curves this point *must be remembered*. The *highest* curve is the *least* sensitive.

In Fig. 1 are shown three curves taken on three different receivers. These are marked A, B and C. Notice that the horizontal scale (frequency in kilocycles) is uniform while the vertical scale (sensitivity in microvolts per meter) is logarithmic. [The term "microvolts per meter" is determined in this manner: If one has a vertical antenna with an effective height of 10 meters—a meter is a little over three feet—and a distant transmitting station impresses a voltage across this antenna of 100 microvolts, the "field strength" at this point is said to be 10 microvolts per meter.—*The Editor.*] Obviously C is the best receiver throughout the entire broadcast band, while the curves of A and B cross and recross, giving A more sensitivity in the middle of the range with B having greater sensitivity at the

extreme ends. With this data in front of you, which set would you buy? You should not decide until you know the value of the other factors, such as selectivity and fidelity. You must know the prices. And your judgment may be influenced by the appearance, ease of operation, dealer service facilities, etc. But to decide definitely, assume the prices for the various receivers are as follows: A-$95, B-$125, C-$100 (These are not the exact retail prices of these receivers, but are quite close. The exact figures are not given for obvious reasons. Neither does this price include fancy cabinets with which these receivers can be equipped.)

The sensitivity is roughly determined by the product of the radio-frequency amplification and the audio-frequency amplification.

DATA ON SELECTIVITY

THE selectivity of a radio receiver is the degree to which it rejects unwanted stations. It is measured by the strength of signal necessary to produce Interference Output. (This "Interference Output" is also arbitrarily agreed upon as a power of 50 microwatts, which corresponds roughly to a barely audible signal in the loud

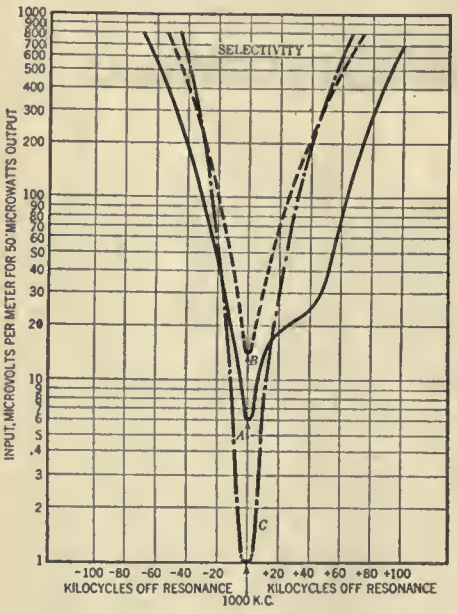


FIG. 2

speaker. It has one thousandth the power of the Standard output.) It is usually necessary to draw a complete curve to specify the selectivity. The selectivity curves for the three sets are shown in Fig. 2. All of the sets were tuned to resonance at 1000 kc. and the signal frequency was varied. Thus, in the case of set C, a station having a frequency of 1030 kilocycles would have to have a field strength of 80 microvolts to cause any noticeable interference to the listener. The shape of the curves in Fig. 2 is of more importance than their actual position. Their positions are determined by their relative sensitivities at this point. (Notice the order of sensitivity on Fig. 1 at 1000 kilocycles is C, A, B, just as is the order on Fig. 2.) The curve shapes of Fig. 2 are quite similar. The curve on receiver C is slightly sharper and this set, therefore, has the best selectivity. All of these sets are single-dial control. The queer shaped curve of A in Fig. 2 is due to the fact that one of the gang condensers did not track properly. Proper alignment of this condenser would have produced much better selectivity.

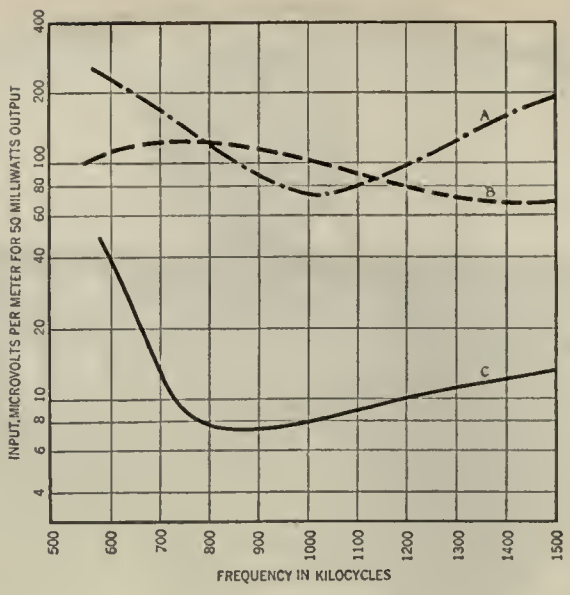


FIG. 1. SENSITIVITY

As sensitivity is the most important characteristic of a receiver, it was emphasized first. Then as more stations began crowding the ether, selectivity was the great cry. Low-loss coils and condensers had their day. As the army of listeners grew they became more critical, until to-day perhaps the biggest demand of a receiver is *fidelity* to the original. Quality and perfectly flat characteristics probably have been lied about so much that we are all rather skeptical. However, it is quite safe to say that the audio characteristics of a receiver (including the loud speakers —terrible sinners) are by far the weakest link in the chain of perfect reception. The selectivity of radio-frequency amplifiers "cuts the sidebands" and hurts the high-frequency reproduction. The detector arrangement is also the cause of considerable unwanted distortion.

In spite of many advertisements to the contrary, it is safe to say that an audio amplifier with a perfectly flat response curve from 30 to 10,000 cycles has never been built into a commercial set. Overloading in detector, amplifier or speaker is not only common, but customary. Quality and fidelity are sacrificed on the altar of volume. In self-defense some acoustic designing engineer may build such a set, and it probably will employ a 5-kilowatt tube!

REGARDING QUALITY OF REPRODUCTION

BUT before describing the fidelity of the receivers A, B and C, one point must be *emphasized*. The human ear is probably the least critical and least perceptive of all the sense organs. Certainly it will overlook an enormous amount of abuse camouflaged as music, and no receiver will sound half as bad, even to a trained ear, as the fidelity curve looks to the eye. In justice to the acoustic designing engineer, a fourth curve D, is added to the three of the receivers already discussed. Curve D is typical of radio sets constructed three years ago. These curves may be a little harder to understand. They are plotted in percentage response of that at 400 cycles. This means that if each receiver were adjusted to give the same sound output at 400 cycles, the other frequencies would sound as shown on the curves. A, B and C are all about alike at high frequencies. The decrease is due to the effects previously mentioned. At the low frequencies B gives the best fidelity (that's what the extra $25.00 pays for), with C and A following in order. The set producing D, in its day, was advertised as having "a marvelous audio system, having straight-line characteristics, and giving almost perfect quality." Obviously this amplifier would deliver an awful wallop at frequencies near 1000 cycles, but to term this "quality" was a sad (but still ethical) error.

CONCLUSIONS

WHAT does all this mean? It means that receiver performance (including many other factors not touched upon here) can be measured, it should be, and will be when the buying public demands accurate technical information regarding the product it is buying. In purchasing an automobile (radio) the buyer wants to know more than the number of cylinders (tubes). He wants to know its ease of handling (ease of operation), horse power (sensitivity), riding comfort (fidelity), safety (selectivity), oil and gas consumption (batteries or power supply). Those factors which his experience and judgment cannot evaluate (such as horsepower—"sensitivity") are rated by the manufacturer and given as part of the guarantee.

These measurements are difficult to make. The majority must be made at radio frequencies, where the slightest mistake means a big error. They must be made with small voltages and even smaller watts. (Millionths of a volt and thousand millionths of a watt). Receivers may vary in sensitivity, selectivity, fidelity and amplification enormously. There are sets run on a.c., d.c., generators, and batteries. There are super-heterodynes, neutrodynes, regenerators, stabilized receivers, and a host of other "dynes" and "flexes." Measuring apparatus must be sensitive, accurate, foolproof and rapid. Human equations must be eliminated, as prejudiced opinions should not be allowed to affect the results.

To what end is this being done by the larger manufacturers? That radio progress may not cease and that the customers may know exactly what they are buying some of the better-known manufacturers "engineer" their products, but many others merely build them out of coils, condensers, screws and cabinets.

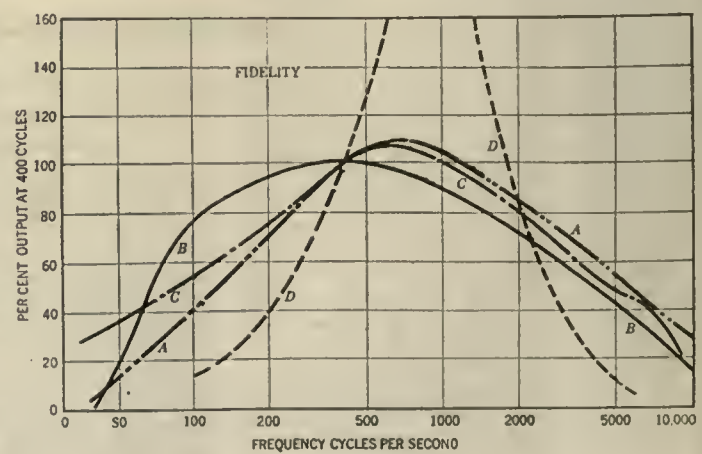
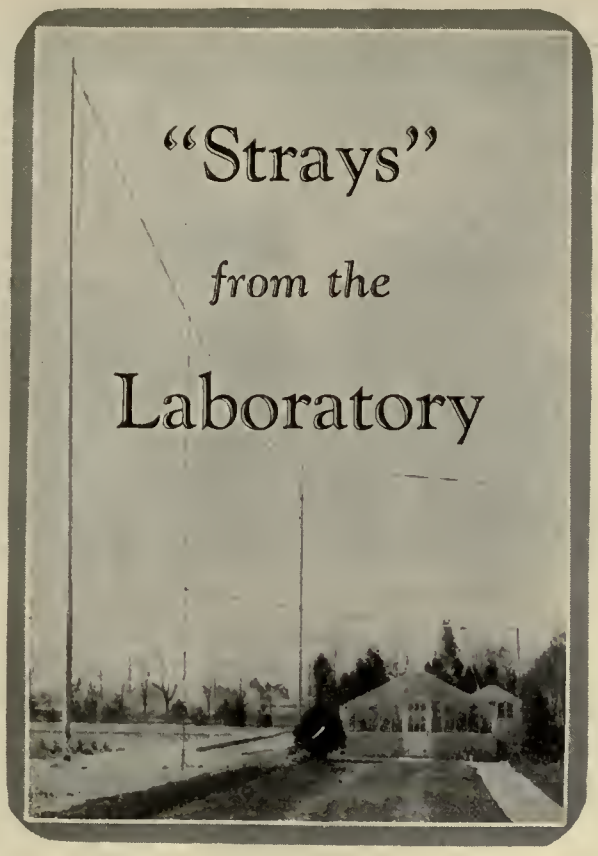


FIG. 3

"Strays" from the Laboratory



How Much Output Power is Needed

IN ATTEMPTING to state our point of view on the moving-coil loud speaker in November RADIO BROADCAST, we neglected one point of interest—it is brought to our attention by Zeh Bouck, who says. "There is one point in favor of the dynamic speaker which you failed to bring out, namely, its capability in the way of handling power.

"If volume in excess of that generally considered adequate for home reception is desired, a dynamic speaker is practically a necessity. It has been my experience that the best of cones suffer noticeably with even moderate usage and, after a few months of service, overload on relatively low volume—a fault that probably will never characterise a good moving-coil speaker."

Mr. Bouck is correct, of course. The ability to stand a lot of punishment in the form of power is one of the chief advantages of this type of loud speaker, of which the Jensen, Magnavox, Peerless, Rola, etc., are good examples. When using a 171A-type tube to provide the volume considered as necessary in most homes, the dynamic gives the impression of being able to handle this power without pin rattle or pole-pieces chattering on the low notes.

We are glad to note that Mr. Bouck recognizes there is a certain output of power beyond which it is not necessary to go for home reception. There are many people who refuse to recognize such a level; even if they use a 250-type power tube with full output, they want more. In the smallest apartments and in the midst of the most intimate conversation the radio is geared up to the limit. Many listeners seem to revel in a vast amount of sound, as others do in a riot of color. It is the amount of sound that attracts them, not the form or the sequence of the mixture of sounds. However, it is true that the complete benefit of a loud speaker which reproduces low notes is not secured unless the volume is rather high because it is only then that the low notes attain full perfection. But one cannot realise the full beauty of his automobile motor—if it is a good one—unless he goes about 75 miles per hour—but few of us find it necessary to extract the absolute limit of pleasure out of anything.

Many readers have asked what kind of amplifier we use. It is a single 171-type tube with something less than 180 volts on the plate and the reproducer is a standard moving-coil loud speaker in a three-foot baffleboard—and you never saw a more awkward object. We listen to symphony concerts, which we believe to be a good test of the volume range of present-day broadcasting, and manage to enjoy them without bothering the neighbors.

We understand Eveready (National Carbon Company) engineers made a series of tests a year or so ago in which many listeners, some of them musicians, voted on the volume level they desired while a receiver behind a screen was adjusted in output. The majority indicated a volume corresponding to the output of a 171A tube without knowing what the actual volume level was. There is also a feeling, we have heard, at the General Electric laboratories that a 171A is all that is needed for home reception.

Mr. Bouck states that cone speakers do not stand up under hard usage. We have never run into this difficulty, nor have we seen the similar trouble that some moving-coil speakers are said to have, namely, the disintegration of the paper cone or the leather or rubber circle that attaches it to the iron frame. Has any reader had an experience of this nature?

This Month the Following Subjects are Discussed in "Strays"

1. HOW MUCH POWER IS NEEDED
2. WHAT IS A DYNAMIC SPEAKER
3. OBTAINING C BIAS
4. THE TASK OF EDITING
5. EMPIRICAL RULES AND FORMULAS

What Is a Dynamic Speaker?

AFTER great deliberation the Aural Devices Committee of the Engineering Division of the R.M.A., of which Paul G. Andres is chairman, approves the following definition of a dynamic loud speaker.

"A Dynamic Speaker is one in which the portion of the conductor carrying the alternating signal current is a part of the moving system, the force producing the motion being due to the location of this conductor in a magnetic field."

This, in our estimation, is swell. And now the N.E.M.A. has a definition, and if the I.R.E. gets up a definition, and the Bureau of Standards gets up a definition, and they can all agree upon one which the National Better Business Bureau will not object to, we may be able to learn what a dynamic speaker is. By that time another craze in loud speakers will probably be on the horizon, and we can repeat the performance ad libitum.

Some Interesting Formulas

ANY one wanting a pleasant hour or two of calculation and speculation may substitute values into the expression below for the turns ratio between secondary (tuned) and primary in the radio-frequency transformer coupling two tubes in a conventional r.f. amplifier. The values of turns ratio and maximum gain for the tube and its transformer are functions of the inductance and resistance of the secondary, and the plate resistance of the tube. Some constants of German tubes, measured in the Laboratory at the request of the manufacturer, are given in the accompanying table, and some coil data will be found on page 260 of September RADIO BROADCAST.

$$(\text{Turns ratio})^2 = N^2 = \frac{L\omega}{R} \times \frac{L\omega}{R_p} = \frac{L^2\omega^2}{RR_p} \quad \text{or}$$

$$N = \frac{L\omega}{\sqrt{RR_p}}$$

and when this turns ratio is used, the maximum possible voltage gain is

$$K = \tfrac{1}{2}N\mu = \tfrac{1}{2}\frac{\mu L\omega}{\sqrt{RR_p}}$$

It is particularly interesting to substitute into these equations the constants of the German Seibt tube W-404 which has an amplification factor of 28.5 and a plate resistance of 41,000 ohms.

Obtaining C Bias for a.f. amplifiers

AUDIO amplifiers continue to absorb the attention of Howard Rhodes, Technical Editor of RADIO BROADCAST. In December, we described some data taken on a two-stage transformer-coupled amplifier made up from Sangamo type-A transformers which proved that a well-designed amplifier does not necessarily give a better response to low frequencies when operated out of a low impedance.

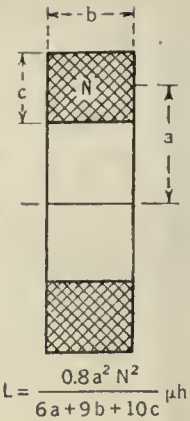
Now let us consider the business of getting a C bias for an amplifier tube, not the last stage, by using the voltage drop across a resistor. What is the effect on the frequency characteristic of the amplifier of bypassing this resistor? The results of Mr. Rhodes' measurements are shown in the following table. Clearly there is a definite gain in bypassing the resistor—and this gain comes at the

Table I

	Type	I_f	I_p	μ	R_p	G_m	E_p	E_g
Te Ka Da Tubes	4A15	.13	2.6	14.6	10,000	1,480	90	— 3.0
	4N08	.068	3.7	10.0	9,000	1,100	90	— 1.5
	4H08	.068	2.3	13.0	13,000	1,000	90	— 1.5
	4L15	.125	4.6	6.0	6,600	1,000	135	—12.0
Seibt Tubes	H407	.16	4.0	17.0	18,000	900	135	— 1.5
	U410	.095	2.4	11.0	13,000	810	90	— 4.5
	L418	.12	11.0	6.0	5,600	1,070	135	— 9.0
	L419	.32	8.0	6.0	7,300	1,100	135	—13.5
	W404	.16	1.4	28.5	41,000	690	157.5	— 1.5

high frequencies, although many experimenters have advocated the use of a condenser because of improved low-frequency response. What is the cause?

At high frequencies the transformer can be looked upon as in Fig. 2 in which L, the primary inductance, is shunted by all the distributed and stray capacities, C, of the circuit. L_1 is the leakage inductance, R_p is the tube's plate resistance and R is the C-bias resistor. Now the leakage inductance and the capacity form a series-resonant circuit. The effect of L shunted across C is negligible, since it is a high-impedance shunted across a lower impedance. When the resistor, R, is not bypassed a considerable voltage is developed across it, due to the resonant current flowing through the resistance in this circuit. This voltage is introduced into the amplifier so that it is out of phase with the voltage from the signals on the grid of the tube. In other words it detracts from the amplification at this frequency.



When the resistor is properly bypassed, the voltage drop here is greatly reduced, and, of course, the out-of-phase voltage introduced into the amplifier is reduced, so normal gain is experienced.

Whether or not the resistor should be bypassed depends upon conditions. For example, there is usually a tendency for an amplifier to sing at the point where the capacity resonates with the leakage inductance. The tendency for the amplifier to sing, due to this resonance condition, then, is decreased when an out-of-phase voltage is introduced, due the C-bias resistor. Some amplifiers which do not sing when the bias resistor is not shunted, do sing when it is bypassed. In the case of the amplifier measured in the Laboratory, there was a gain of 6TU at 6000 cycles—which went a long way toward making up the usual loss at this frequency, due to only ordinary side-band cutting in the r.f. amplifier.

Cycles	Without C TU	With C TU
60	-.5	+.5
100		0
2000	-1.0	0
4000	-2.5	0
6000	-6.0	-.7

The task of Editing Radio Copy

FEW writers for and readers of a magazine like RADIO BROADCAST realize the complexity of the tasks of its editorial and technical staff. Let us consider a how-to-make-it article, perhaps on a prominent kit from a well-known manufacturer. The kit comes to the Laboratory, is tested, accepted, or turned down. Then the article is looked over, diagrams are checked against lists of parts, the photographer is called in, and, after the result of his labor comes to the office, an "over-lay" is made, that is, the photograph is overlaid with a thin sheet of paper and the various condensers, resistance, coils, etc., are marked with letters and numbers which correspond with the list of parts and the circuit diagram. Here is where trouble begins. The set, the list of parts, the diagram, and the article which comes from the outside, from the kit manufacturer perhaps, seldom—may we say, never?—check. On the diagram a resistor may be marked as 50,000 ohms, in the list of parts it is 100,000 ohms, and in the article itself it may not be mentioned, or it may have a third value. Which is correct?

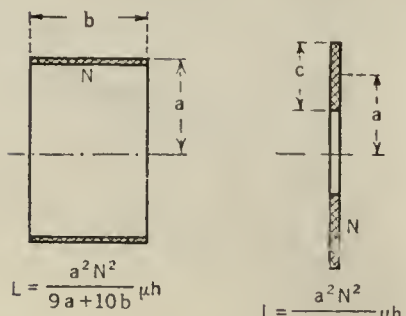


FIG. 1

A recent article came to the office—late as usual—and still later came the receiver. The list of parts did not check either the diagram, or the receiver, although the manufacturer claimed we would have no trouble because the material was "just as he sent to his would-be purchasers." After exchanging several telegrams and long-distance phone calls, a list of parts, a diagram, and a photograph were assembled which checked—but unfortunately this list will not check anything the manufacturer sends out. What is the reader to do? Why cannot the manufacturer check his material before it gets into print?

We have a bulletin sent out by a well-known manufacturer, this time describing a B-power system which makes it possible to "get away with" smaller filter condensers. The diagram sent out with the bulletin gives one value of condenser; the circuit diagram gives another. Which is correct? Who knows?

We have another yarn from a publicity writer of a nationally known organization—we are going to turn it down—in which the list of parts gives several items which do not appear on the circuit diagram, and the diagram gives two items which do not appear on the list of parts.

The Technical Staff feels that its responsibility is to the reader. It will get up a list of parts which will work properly as evidenced by a test in the Laboratory—and if the manufacturer is foolish enough to send out material which not only conflicts with what we print hut which contradicts his own printed matter, it is his own fault.

Incidentally, every receiver and power supply is tested in the Laboratory before it is described in the magazine—some of them several times, as well as many aggregations of apparatus whose descriptions never see the printed page of this magazine.

Empirical Rules and Formulas

THE CONFLICT between simplicity and accuracy rages in the soul of every technical man. Is there not some short cut to a mathematical or laboratory investigation that will give sufficient accuracy? What factor can we neglect in order to obtain the result sooner, and still not have the bridge we are designing fall down? It has been said that nearly any result may be obtained from a mathematical analysis of a given problem, providing the proper assumptions are made—and, as every physicist knows, many, many, problems cannot be solved completely at all. There are always some factors which must be neglected in favor of others.

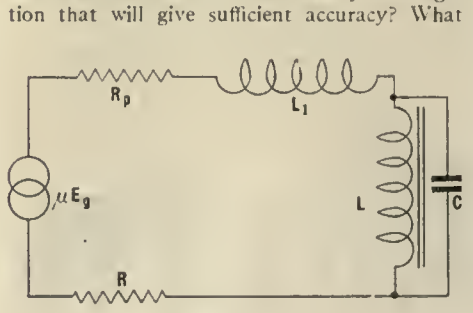


FIG. 2

In the hunt for simplified methods, certain empirical rules and formulas appear. Several have recently been published which are very interesting. One was in *Experimental Wireless* (England) September, 1928, and this was reprinted in *Lefax*, October, 1928. It related to a simple tube tester with which a service man could quickly determine the value of tubes. In the course of many measurements Marcus G. Scroggie, who developed the tube tester, discovered that the following expression would "work" with all modern tubes with a fair degree of accuracy.

$$R_p = \frac{0.6\ V}{I_p}$$

where R_p is the plate resistance of the tube
I_p is the plate current
V is the "lumped voltage" on the plate.

The lumped voltage is the effective voltage on the plate of the tube; that is, it is the sum of the voltages E_p (the voltage due to the plate battery) and E_g (the voltage due the grid). For example, if a tube has 90 volts on the plate, a C bias of 4.5 volts, and an amplification factor of 8, the lumped or effective voltage on the plate is

$$V = E_p + \mu E_g$$
$$= 90 + 8(-4.5) = 54$$

so that the effective voltage on the plate is 54 volts. Now, if the tube has a plate current of 2.5 milliamperes under these conditions, the plate resistance, R_p, can be obtained from Mr. Scroggie's formula. We have taken this formula and computed the figures below which give the measured and calculated R_p of several tubes and the discrepancy between them. The table follows:

Tube	R_p (meas)	R_p (calc)	%
199	15,500	14,500	—6.45
201A	11,000	12,900	+15.1
226	9,400	8,700	—7.45
112A	5,000	5,400	+8.0
171	2,000	1,750	—12.5
210	5,000	4,825	— 3.5
250	2,100	1,430	—32.0

Another set of empirical formulas appeared in October *Proceedings* I.R.E. and were developed in the Hazeltine Laboratories by Harold A. Wheeler. They relate to the inductance of three types of coils illustrated in Fig. 1. The inductance of the coils may be calculated with good accuracy by using the formulas on the diagrams.

For example, the formula for the multi-layer coil is accurate to within 1 per cent. if the three terms in the denominator are about equal, the formula for the solenoid inductance is accurate to 1.0 per cent. if the length of winding is greater than 0.8 times the diameter, and the formula for the single-layer spiral or helical coil is accurate to 1.0 per cent. if the dimension (c) is greater than 0.2 the dimension (a). All of the dimensions must be in inches to be used in these formulas. The inductance of such coils may he computed with one setting of this slide rule, and without consultation of complicated tables or correction factors.—KEITH HENNEY

A Simple A.C. Operated Tube Tester

By THE LABORATORY STAFF

THE following description of a simple tube tester will be interesting to service men and others who have occasion to doubt the efficiency of a tube. The tester determines the mutual conductance of the tube, that is, the amount of plate current variation with a given change in grid bias, but will not indicate whether the tube is microphonic, noisy, gassy or, suffering from other common ailments. The tester may be plugged into any a.c. socket, provided the voltage and frequency have the values for which the transformer is designed.

The circuit diagram shows a transformer which has all standard filament voltages, including 7.5 for power tubes. In the Laboratory it is seldom necessary to test tubes of this sort so a socket for them was not included in the set-up shown in Fig. 2. A resistor in the center-tap circuit (and the cathode of heater-type tube) provides a C bias for the tube. A switch short circuits part of this resistor in order to change the C bias and thus to change the plate current. The mutual conductance is the ratio between the corresponding plate current and grid voltage changes.

The circuit diagram and the picture show clearly how the parts of the tester are connected together. The list of apparatus includes only standard material, but any other similar units may be used, of course.

In operation, the tube is placed in the socket and the tester is plugged into a lamp socket. This lights the filament and puts a voltage on the plate. Current flowing in the plate circuit is read on the meter, M, and in returning to the center of the filament—or the heater—passes through the biasing resistors, R_1 and R_2, which are connected in series. The values of these resistors are known; in this case the total resistance is 4000 ohms. Then the resistor R_1 is shorted and the plate current increases because the bias on the tube is reduced. The difference between the two plate currents as read by the meter, divided by the difference between the two grid-bias potentials gives an estimate of the mutual conductance. The bias on the tube is calculated by multiplying the plate current by the biasing resistance in the circuit. As an example let us give the values obtained in the Laboratory when a 201A-type tube was tested. With a C-bias resistance of 4000 ohms (3500 plus 500) the plate current was 1 milliampere. When the 3500-ohm resistor was shorted the plate current increased to 3.1 milliamperes. The two biases were, then, $4000 \times 0.001 = 4$ volt and 500×0.0031 or 1.55 volts. The mutual conductance is

$$G_m = \frac{I_{p1} - I_{p2}}{E_{g2} - E_{g1}} = \frac{.0031 - .001}{4 - 1.55} = \frac{.0021}{2.45}$$

$$= 860 \text{ micromhos}$$

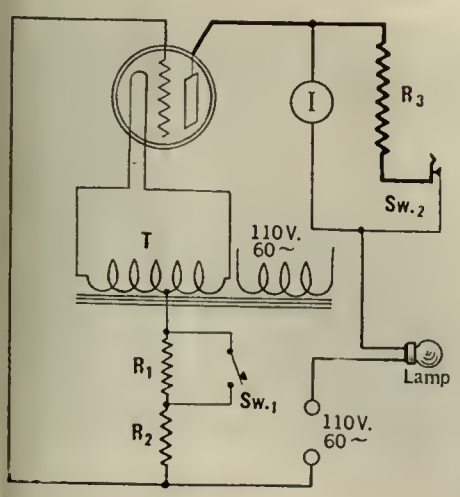
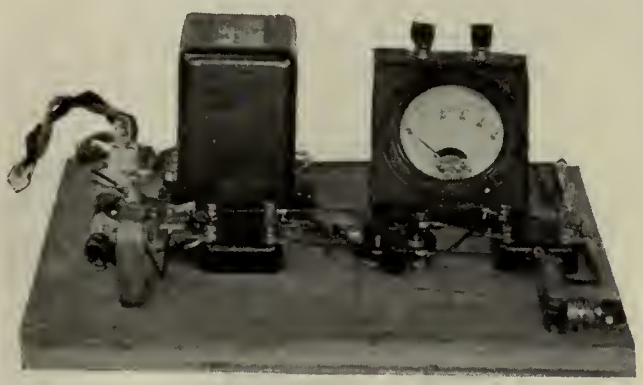


FIG. 1



VIEW OF A.C. TUBE TESTER

THE tube tester described on this page may be used for checking the mutual conductance of any standard a.c. or d.c. tube. The tester is plugged into a 110-volt light socket and no batteries of any kind are required. Incidentally, the mutual conductance is the only important characteristic of a tube which it is necessary for a service man to check.

—THE EDITOR

ACCURACY OF TESTER

THE value of mutual conductance obtained by this tester is not very accurate because each change in grid-bias resistance changes the plate voltage as well as the plate current and the definition of G_m involves holding the plate voltage constant. In the Laboratory, however, several tubes were tested and the values of mutual conductances compared with values obtained on a bridge when the tube was operated at standard values of bias and plate voltage. The results outlined below show that the accuracy is all that is desired for practical purposes.

Tube type	No. tested	% accurate
226	4	93%
201A	5	78%
112A	3	90%
171A	3	89.5%

The meter used was a Model 301 Weston, 0-5 milliamperes. A shunt, R_3, is provided to reduce the sensitivity of the meter by a factor of three, so that its full-scale reading is 15 milliamperes. A switch removes this shunt when desired so that lower currents may be read more accurately. The switch has a spring in it so that the meter is always shunted until the operator deliberately removes the resistor, R_3. The value of the resistor varies with the meter, of course, but a rheostat may be placed across it and adjusted until any desired multiplying factor is secured. Then the wire of the rheostat used may be cut off and fixed in position. Between 3 and 4 ohms were required with the Weston meter.

A small flash lamp is connected as a fuse in series with the a.c. line to the plate of the tube to prevent an accident in case of a short circuit. Incidentally, the meter is in a very dangerous position in the circuit and it might be wise to place a short-circuiting strip of wire across its terminals. Of course, after the tester has been connected properly the strip should be removed. However, such a complication was not considered necessary in the Laboratory and the mortality of meters has been nil.

The operator will learn very quickly from experience the proper value of G_m for all standard types of tubes. Then, when tubes fall below this value they should be rejected or rejuvenated. He might, as an example, take a new tube, a very bad tube, and an old tube which still gives good signal strength. He can test them on this device and record their mutual conductances. Any tube which approaches the very bad tube should be rejuvenated or thrown away.

LIST OF PARTS

THE parts actually used in the construction of the tester are as follows:

T_1 One Silver-Marshall filament transformer, type 325;
R_1 One Ward-Leonard fixed resistor, 3500-ohm, type 507-56;
R_2 One Ward-Leonard fixed resistor, 500-ohm, type 507-17;
R_3 One Frost resistor, 4-ohm;
R_4 One General Radio center-tapped resistor; type 439;
Sw_1 One Frost filament switch;
Sw_2 One jack switch, S.P.D.T.;
One dial light and socket;
Two Frost sockets, UX-type;
One Benjamin socket, UY-type;
One wooden baseboard.

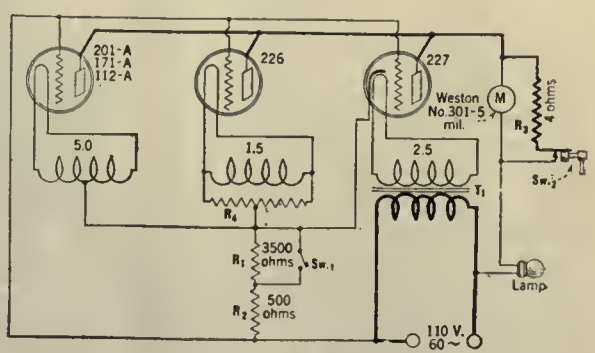


FIG. 2

The Isotone Screen-Grid "Super"

By DUDLEY WALFORD



THE ISOTONE IN A PHONOGRAPH-RADIO CABINET

This receiver was designed for use either as a radio set or a phonograph amplifier, and, when installed in a cabinet of the type illustrated, full advantage is taken of its dual entertainment value

ESSENTIALLY, there are very few different types of radio receivers, and of these the super-heterodyne is unique in that it is the only one in which the number of circuits which must be tuned to the frequency of the received signal is not made greater with an increase of amplification. In an ordinary tuned radio-frequency receiver, if we wish to obtain more gain, we have to provide additional tubes and tuned circuits, and in operating the receiver it is necessary that these circuits always be adjusted to resonance with the wavelength of the particular station we desire to receive. In a super-heterodyne most of the amplification takes place in the intermediate-frequency amplifier which always operates at the same frequency and therefore, does not have to be adjusted when receiving signals of different frequencies. This is one of the major advantages of the super-heterodyne receiver, and one of the most important parts in such a receiver is the intermediate-frequency amplifier, for upon its characteristics depend the sensitivity and selectivity of the set.

Accurate matching during manufacture of the transformers in an intermediate-frequency amplifier is not very difficult if the intermediate-frequency is low, say 30 to 60 kc. On the other hand, the disadvantage of using a low intermediate frequency in an ordinary super-heterodyne is due to the phenomenon of so-called "repeat points" by which it becomes possible to tune in most local stations at many points on the dial. A super-heterodyne can be made essentially "one spot" by the use of a high intermediate frequency, but at such frequencies the effect of tube capacities, etc., becomes important and accurate matching of the intermediate-frequency transformers during manufacture is not always possible. When using a high intermediate frequency it is of advantage, therefore, to so arrange the transformers that they may be manually adjusted to the point of maximum sensitivity after the receiver has been completely constructed. Such transformers are used in the H. F. L. Isotone receiver described in this article. The following paragraphs will discuss in more detail the technical characteristics of this set.

Fundamentally, the Isotone is a standard screen-grid super-heterodyne utilizing nine tubes. There is an additional tube which is used when the instrument is employed for phonograph reproduction. The ten tubes of the set are distributed in the following manner: one 201A-type first-detector tube, one 201A-type oscillator tube, three 222-type intermediate-frequency tubes, one 112A-type second-detector tube, one 112A-type phonograph-amplifier tube, one 112A-type first-stage a.f. tube, and two 171A-type push-pull a.f. tubes.

The set itself is composed of four main units, namely, the front tuning unit, the screen-grid intermediate-frequency amplifier, the audio-frequency amplifier, and the control box. The wiring and testing of these four units is done at the factory; each piece of each individual unit undergoes several tests and then the entire unit is tested.

One of the main features of the receiver which is not apparent from the schematic diagram is the operating frequency of the intermediate-frequency amplifier which is 475 kilocycles. Most set-constructors are by this time aware of the fact that such a frequency allows the receiver to be tuned as a "one-spot" instrument and does away with many of the annoying repeat points on the dial. When such a high frequency is used, it is absolutely necessary, as mentioned previously, that the intermediate-frequency transformers be furnished with a means of compensating the various tube capacities and the capacities of the wiring in the receiver.

The tuning of each transformer in this set is accomplished by two condensers—one of these, a small mica condenser, C_1, having a fixed value of 0.0001 mfd., is connected permanently across the secondary of each intermediate-transformer, T_1, T_2, T_3 and T_4, and the other, a small variable condenser, C_2, having a variable capacity of 0.000025 mfd., is connected in shunt with the fixed condenser, C_1. This system of manually tuning the four transformers allows one to adjust the intermediate-frequency amplifier easily to the point of maximum sensitivity and selectivity.

In the shield compartments of the intermediate-frequency amplifier are the four transformers, their associate tubes, sockets, resistors, tuning condensers and twelve 0.5-mfd. by-pass condensers. The twelve by-pass condensers are of extreme importance in the proper operation of the amplifier. While their use increases the cost, the results seem to justify the expenditure, for the operation of the amplifier is perfectly stable, and oscillations cannot be produced under any normal operating condition.

Immediately to the right of the screen-grid amplifier we see the completely shielded audio section of the Isotone. This consists of four transformers, four sockets, a by-pass condenser, a series resistor and the necessary input and output tip jacks. The first transformer, T_5, in the ampli-

THE H. F. L. Isotone described in this article is very different from the standard design of super-heterodyne kit. Whereas the usual set of this type requires many long tedious hours for its construction, the ten-tube Isotone may be completely assembled and placed in operation in less than one hour! This is made possible by the use of wired units which the set-builder fastens to the chassis and wires into the circuit. The design of the set is such that it is almost impossible to make a mistake, and the necessary circuit adjustments are easily accomplished. The Isotone is also efficient when used as a phonograph amplifier.

—THE EDITOR.

fier section is in the output circuit of the phonograph pick-up unit; it has a turns ratio of 1 to 1. When the set is being used as a radio receiver, this transformer and its associate tube is switched entirely out of the circuit by the automatic control switch, S.

By referring to the schematic diagram, it will be seen that the plate voltage to the phonograph tube, and also to the second-detector tube, is supplied through the resistor, R_1, connected between B-plus terminal of the first audio-frequency transformer and the 135-volt supply lead. This resistor is bypassed by a 1-mfd. condenser. The audio-frequency transformer, T_6, has a ratio of 5 to 1, and the input transformer, T_7, to the push-pull circuit has a ratio of 2 to 1. The schematic diagram shows that the output of the loud speaker is taken from opposite ends of the high-impedance choke, L_1.



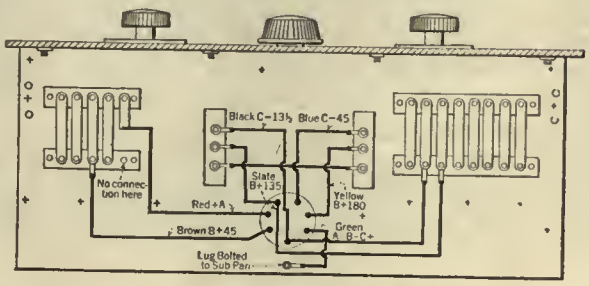
VIEW OF COMPLETED RECEIVER

This picture of the Isotone shows the set with shields in place. It may be noted that the receiver consists of five units which are mounted on a steel chassis

THE TUNING UNIT

THE long unit immediately in front of the two amplifiers contains the tuning circuits. This unit consists of the antenna-tuning stage at the left, the oscillator at the right, and in the center are located the control resistors and the automatic ballasting switch. The antenna-tuning circuit is equipped with detachable leads to the coil, L_2—a highly desirable feature inasmuch as it permits the operation of the set on either a loop or an outside antenna. Ordinarily the instrument is set up for loop operation, but the operator may employ an outside antenna by simply plugging the three flexible connections from the coil into three tip jacks in the antenna compartment. The antenna may then be connected directly to the antenna binding post. This circuit is tuned by the condenser, C_3, having a capacity of 0.000475 mfd., and the inductance of the coil L_2 is such that the dial reading of C_3 will coincide with those of the oscillator tuning dial, C_4, when the two dials are properly matched by means of a small midget condenser, C_5, in the oscillator circuit. These two dials may then be operated with readings almost exactly the same over 85 per cent. of the dial. The oscillator circuit is tuned by a condenser, C_4, having a capacity of 0.00025 mfd. The r.f. heterodyne voltage is transferred from this circuit to that of the antenna circuit through the pick-up coil, L_3, which is connected to the center-tap terminal of the loop antenna (or L_2 if an antenna is used).

The controlling devices for the receiver are located in the small metal compartment situated between the two drum dials in the center of the front tuning unit. This metal compartment houses a special wire-wound potentiometer, R_2, having a value of 25,000 ohms and serving as a voltage divider in the screen-grid circuits. This control allows any potential from 0 to 67½ volts to be placed upon the screen grids of the tubes. The other variable control is a 500,000-ohm volume-control potentiometer, R_3, which is connected across the secondary of the first audio-frequency transformer.



PICTURE WIRING DIAGRAM

The design of the Isotone is such that its construction may be accomplished in less than one hour. The simplicity of wiring is indicated in this diagram which shows all connections which it is necessary for the set-builder to make in order to complete the circuits of the five individually wired units

The switch, S, in the center handles several operations. In one position it automatically connects all of the circuits required to make the Isotone operate as a radio receiver. With this adjustment, the phonograph-amplifier tube is disconnected from the circuit. In the reverse position the Isotone operates as a phonograph amplifier; the switch connects only the last four tubes of the instrument, or the audio amplifier, and at the same time disconnects the remaining six tubes in the radio section of the set.

One of the interesting features of the controlling system is the 6.6-ohm resistor, R_4, which is automatically connected across the filament-supply circuit when the audio amplifier is being used for phonograph work. The extreme desirability of this arrangement is appreciated when it is realized that this ballast resistor has a load characteristic which corresponds with that of the six tubes which are disconnected when the set is being used for phonograph reproduction. This permits the use of an A-power unit and the voltage supplied to the tube remains steady at all times, regardless of the position of the control switch. If it were not for this ballast resistor, the filament voltage would jump suddenly upward when the six tubes were disconnected, and the remaining four tubes in the audio amplifier would be subjected to a filament potential considerably above their rating.



VIEW OF SET WITH SHIELDS REMOVED

The arrangement of apparatus on the chassis of this receiver is shown clearly in the above picture. The symbols used for the purpose of identifying parts correspond with those used in the text, list of parts, and schematic diagram

ASSEMBLY AND WIRING

THE assembly of an Isotone receiver is such a simple procedure that even a novice set-builder would not experience difficulty with the task. The main steel base plate is supplied with all necessary holes punched in the proper positions. The assembly operation is started by simply placing the three main units down on the base plate and securing them in position by means of a few nuts and bolts. Slots have been cut in the base plate and the terminal strips of the individual units protrude down through the slots.

The positions of the terminal strips are such that when the three units are mounted in their respective positions, practically all of the connections can be made by means of metal connecting strips which are furnished with the kit. Therefore, it is only necessary for the constructor to slip the thirteen metal connecting strips down over their respective bolts and tighten them on by means of nuts. The wiring is then completed by running the power connections from the cable receptacle to the proper points on the terminal strips. There are ten wires to be connected in all. The above describes all of the connections which it is necessary for the assembly of the receiver. There is ½" of space between the bottoms of the individual unit base pans and the top of the

main foundation base plate. All of the wiring in the receiver (with the exception of the external power leads), is placed within this $\frac{1}{2}$" of space.

Originally the H. F. L. Isotone was designed as a battery-operated receiver. The engineers realized that, while electric operation was highly desirable, a satisfactory receiver would have to be built around direct current tubes. Tubes of the a.c. type, and particularly those of the a.c. screen-grid type, are not considered by the writer to be conductive to the best possible results.

Therefore, in designing the Isotone particular attention was paid to stability, ease of operation, and economy in operation. When a receiver was realized on a direct-current basis which furnished these desirable factors, it was decided that the practical way of electrifying such a set would be by a dry power-supply unit furnishing all A, B and C voltages.



THE POWER UNIT

This power unit, which was designed especially for use with the Isotone receiver, supplies all necessary grid, filament, and plate potentials. The A current is obtained from a dry rectifier unit, and a 280-type tube is employed to provide the B voltages

POWER SUPPLY UNIT

THE Model 5 ABC power supply was designed as a special current-supply device for the H. F. L. Isotone. The A voltage is furnished by an Elkon dry rectifier unit operating in conjunction with large filter chokes. The power supply also furnished plate potentials of 50, 135 and 180 volts for the plate circuits of the various tubes. In addition to these voltages there is also a connection marked "90 volts" which has an individual variable resistor as its controlling device. From this terminal any voltage from 0 to 180 volts may be obtained. Thus, the unit will deliver a set of voltages which will operate practically any receiver in existence to-day.

Regarding the performance of the receiver. In an actual test in the City of Chicago on October 22nd, 1928, the Isotone brought in station PWX, Havana, Cuba, with full loudspeaker volume for a period of one hour starting at nine p. m. Central Standard Daylight-Saving Time. The temperature at this time was around fifty degrees, and it is estimated that at this same hour over twenty seven local stations were operating.

LIST OF PARTS

THE Isotone receiver is sold only in semi-completed form as described in this article; that is the various units are supplied completely assembled and wired. However, it may be well to list the actual parts of the H. F. L. kit just as they come to the set-builder:

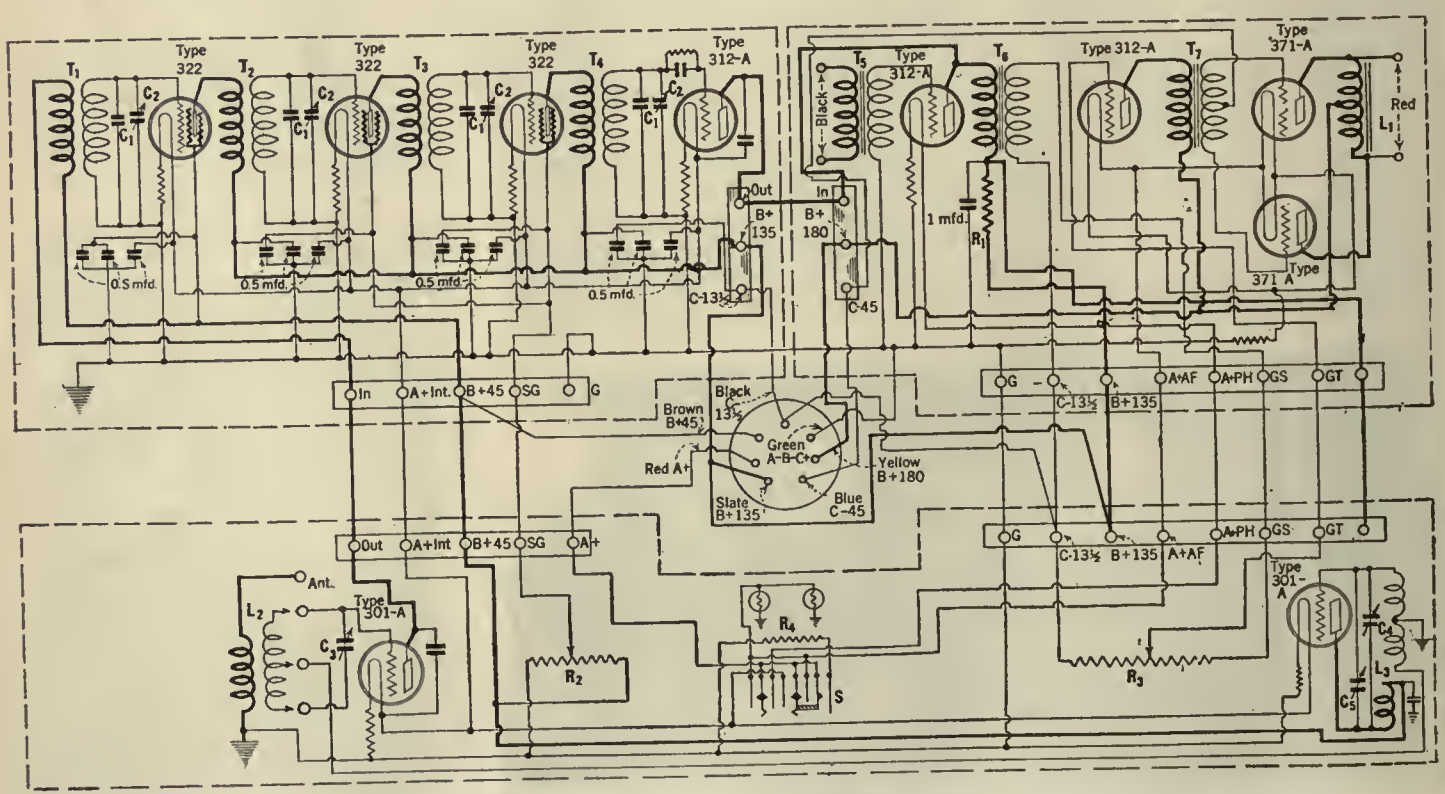
One assembled and wired tuning unit;
One assembled and wired screen-grid amplifier;
One assembled and wired audio amplifier;
Eight shield cans with tops;
One base assembly plate;
One drilled and engraved front panel;
One seven-wire cable and socket;
Two gold escutcheons with knobs (attached);
Two dial lights (inside of drums);
Two large walnut switch knobs;
One small walnut switch knob;
Two steel panel supporting brackets;
Twelve plated connecting strips;
Fifty-five 6–32 hexagon brass nuts;
Fourteen $\frac{3}{8}$-inch hexagon spacer studs;
Fourteen $\frac{3}{4}$ by 6–32 inch R.H. machine screws;
Six $\frac{1}{4}$ by 6–32 inch F.H. black machine screws;
Four $\frac{3}{8}$ by 6–32 inch R.H. machine screws;
Eleven tinned copper lugs;
Six feet push-back wire.

Assuming A.C. operation, the constructor will require the following accessories;

Three 222-type tubes;
Three 112A-type tubes;
Two 171A-type tubes;
Two 201A-type tubes;
One Model 5 ABC power supply;
One 280-type tube (for the power supply);
One Pacent phonograph pick-up unit (optional);
One loop antenna.

For D.C. operation the following batteries will be required:

One 6-volt storage battery (120-ampere hour);
Two 22½-volt C batteries;
Four 45-volt heavy-duty B batteries.



COMPLETE SCHEMATIC DIAGRAM OF RECEIVER

Although the five basic units of the Isotone receiver are supplied completely wired by the manufacturer, this diagram shows the circuit of the entire set. The peculiar arrangement of the diagram will be found a great aid to the set-builder when constructing the set, as it follows closely the mechanical arrangement of the parts. The dotted lines of the diagram enclose the shielded circuits

No. 15. January, 1929.

Radio Broadcast's Service Data Sheets

The Bremer-Tully 8-20 Radio Receiver

THE Bremer-Tully model 8-20 receiver consists of four stages of radio-frequency amplification followed by a detector and a two-stage audio amplifier.



TECHNICAL DISCUSSION

1. Tuning System

There are four main tuned circuits in the receiver, consisting of L_1C_1, L_2C_2, L_3C_3 and L_4C_4. The fifth tuned circuit, L_5C_5, is in a sense a wave trap; it is not connected between the grid and filament of the first r. f. tube as the first tuned circuit generally is, but instead is coupled to the small primary coil L_5 which is connected between the grid and filament of the first r.f. tube. It should be noted that the leads from the neutralizing condensers to the grid circuits are not connected directly to the grid of the tube, but instead are connected to a tap on the secondary coils at a point a few turns from the grid end of the coil, the designers of the receiver having determined that with such a connection the receiver is neutralized more easily over the entire broadcast band. Type 226 tubes are used in all the r. f. stages, with about 100 volts of plate potential.

2. Detector and audio system.

A leak-condenser-type detector is used, the grid leak resistor, R_1, having a resistance of 3 megohms and the grid condenser, C_{11}, having a capacity of 0.00025 mfd. The detector tube is a 227-type with about 45 volts on the plate, and its output contains a 0.006-mfd. condenser, C_{12}, to bypass the r. f. currents directly to the cathode. The r. f. choke, L_7, also helps to keep the r. f. currents out of the a. f. amplifier where they might cause distortion. The choke coil, L_7, connects, through the phonograph jack, J, to the first audio transformer, T_1.

3. Volume control.

The resistor R_4 is the volume control, and it will be noted that it is actually connected across the grid-filament circuit of the first r. f. tube and also in series with the plate circuit of the second r.f. tube. When the movable contact on the volume control is at the position of maximum volume (2) all the resistance is connected between the grid and filament of the first tube and there is zero resistance in the plate circuit. As the arm is moved toward the other end (1), the resistance connected between the grid and filament of the first tube is gradually reduced and at the same time the resistance in the plate circuit is proportionally increased.

4. Filament circuits.

Filament current for the various tubes in the receiver is supplied by several filament windings on the power transformer located in the power-supply device, the 226s being supplied with 1.5 volts, the 227s with 2.5 volts and the power tubes with 7.5 volts. Across secondaries S_1 and S_2 are placed center-tapped 8-ohm resistors, it being necessary to connect all the grid and plate returns to a center point of the filament circuit to prevent hum. Similarly a 15-ohm resistance is connected across the 2.5-volt filament winding, S_4, supplying the 227-type tubes and a 40-ohm resistance across the 7.5-volt filament winding, S_6, which supplies the 210-type tubes.

5. Plate circuits.

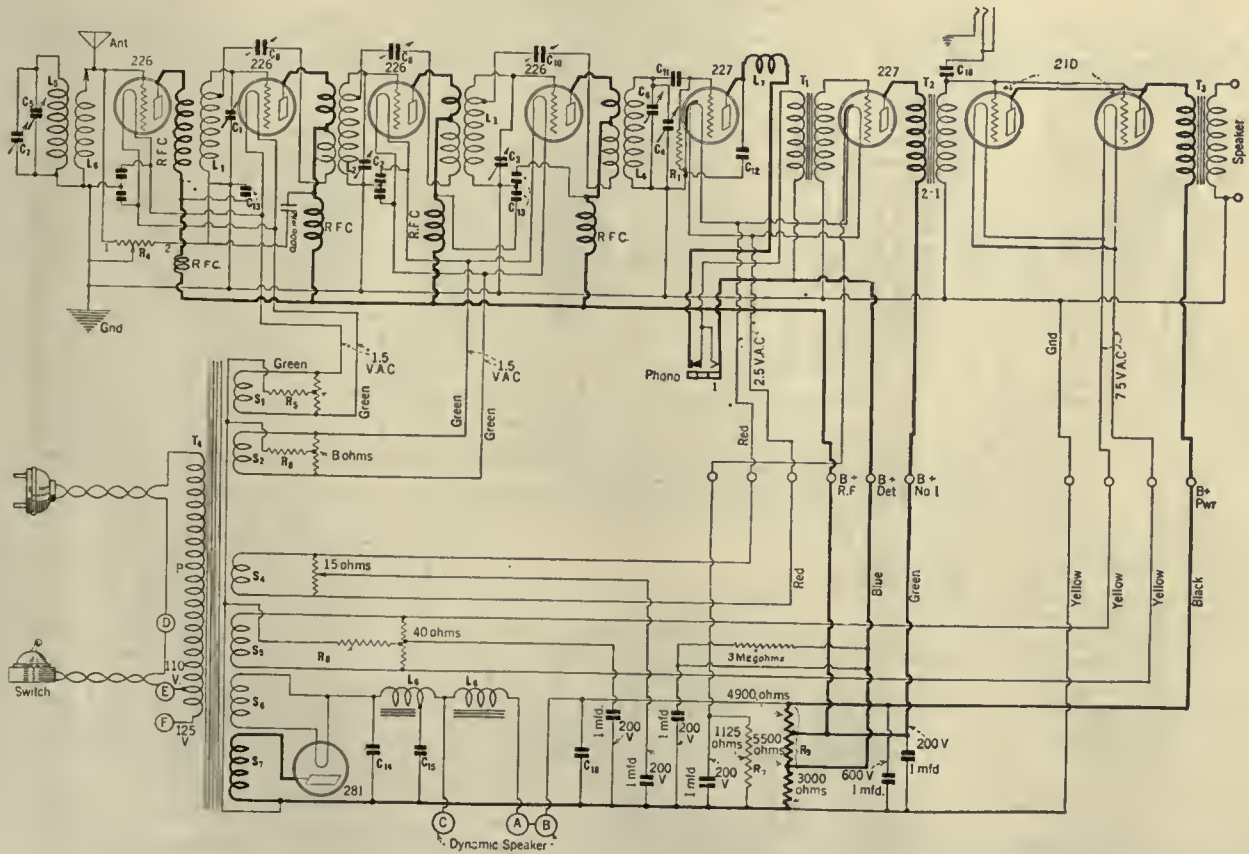
The plate circuit of each r. f. tube contains an r. f. choke, marked R.F.C. on the diagram, to prevent any of the r. f. currents passing into the plate-supply device. The by-pass condensers, C_{13}, are connected from each r. f. choke to ground. All of the r. f. tubes are supplied with the same plate potential, and the other plate leads connected between the receiver and the power supply furnish voltage to the detector and audio amplifier tubes.

6. Grid Circuits.

All tubes in the receiver are biased by connecting resistors of the correct value between the center points of the filament circuits and negative B. Grid bias for the first two r. f. tubes is obtained by the voltage drop across a 770-ohm resistor, R_6. The drop across this resistance is about 6 volts. A similar resistance, R_5, supplies grid bias to the third and fourth r. f. tubes. Grid bias for the first audio tube is furnished by the 1125-ohm resistance, R_7, and grid bias to the power tube is obtained from the resistance, R_8, which has a value of 770 ohms.

7. Power supply.

The power-supply transformer, T_4, contains a primary winding, P, tapped for line voltages of 110 and 125, and six secondary windings. A 281-type half-wave rectifier is used. The filter system consists of the two choke coils, L_8 and L_9, and the 2-mfd. filter condensers, C_{14}, C_{15}, and C_{16}. C_{14} has a voltage rating of 800 volts, and C_{15}, and C_{16} each have a rating of 600 volts. The filter circuit is ordinarily closed by terminals A and B in the power supply. If, however, a dynamic loud speaker is to be used, and the field of this speaker is to act as one of the filter choke coils, then the connecting link between A and B is removed and the terminals from the field winding of the loud speaker are connected to terminals B and C. The output of the filter system is fed directly to the plate of the 210-type tube. After reduction by the resistor, R_9, the voltage is correct for application to the plates of the r. f. detector and first audio tubes. One-mfd., 200-volt, by-pass condensers are connected as indicated on the diagram between negative B wire and various points in the circuit. They prevent coupling which might cause distortion. The power to the receiver is completely controlled by the switch connected in the primary of the power transformer.



CIRCUIT DIAGRAM OF RECEIVER AND POWER UNIT

No. 16. January, 1929.

Radio Broadcast's Service Data Sheets

The Freshman Model Q Receiver

THE model Q Freshman receiver is unusual in that it employs a 222-type screen-grid tube in the r.f. amplifier. The 222-type tube used is one designed for d.c. operation, but in this receiver it is operated on alternating current. The single screen-grid stage of radio-frequency amplication is followed by the usual 227 heater-type a.c. detector, the first audio stage with a 226-type tube, and a 171A-type power tube.



MODEL Q

TECHNICAL DISCUSSION

1. Tuning system.

This receiver contains only two tuned circuits, L_1C_1 and L_2C_2, and both of the tuning condensers are ganged to a single control. A small midget condenser, C_3, with a maximum capacity of 50 mmfd., is connected in series with the antenna. The two tuning controls, i.e., the main dial controlling C_1 and C_2, and the vernier adjuster controlling C_3, are interdependent and a slight change in one necessitates a change in the other. It should be noted that the plate of the detector tube connects through a fixed condenser, C_4, to the lower end of the inductance, L_2. The r.f. currents in the plate circuit must, therefore, pass through C_4 to the lower end of L_2 and hence through C_8, with a capacity of 0.02 mfd., to ground. These currents in the plate circuit of the detector which flowing through the condenser C_6, connected in the grid circuit of the detector, thereby impress on the grid circuit of this tube a small voltage and causes regeneration which increases the gain of the receiver.

2. Detector and audio system.

The grid-rectification detector in this receiver, using a grid leak, R_1, with a value of 2 or 3 megohms, and a grid condenser, C_4, with a value of 0.00025 mfd., is followed by a two-stage transformer-coupled amplifier with a 226-type tube in the first a.f. stage and a 171A-type tube in the power stage. C_8 with a capacity of 0.02 mfd. is part of the regenerative system mentioned in the preceding section.

3. Volume control.

The volume control consists of a variable resistance, R_2, connected between antenna and ground, and in this position it serves to regulate the amount of energy supplied to the first r.f. amplifier.

4. Filament circuits.

Since four different types of tubes are used in this receiver it is necessary that the power-supply transformer contain four separate filament windings. A 3.1-volt winding, S_1, supplies the 222-type r.f. amplifier, a 2.25-volt winding, S_2, supplies the 227-type detector tube, a 1.4-volt windings, S_3, supplies the 226-type audio amplifier and a 4.8-volt winding, S_4, supplies the 171A-type power tube. It is interesting to note that all of these voltages are somewhat lower than the rated filament voltages of the tubes they supply. These low voltages are used because it has been found that the various tubes will give satisfactory emission with these potentials and that their life will be greatly increased.

5. Plate circuits.

The plate of the 222-type tube is supplied with 170 volts, the detector with 50 volts, and the first audio and second audio tubes with 170 volts. The screen-grid of the r.f. tube is supplied with 50 volts. It will be noted that the 170 volts with which the plates of the r.f. tube and first audio tube are supplied is considerably above the maximum value specified by the standard tube manufacturers. The reason for the use of these high voltages is probably that the hum in the output of the receiver is less than with rated voltages, due to the fact that with high plate voltages high values of grid bias can be used and as a result the modulating effect on the grid circuits of any a.c. hum voltages is proportionately less. All the plate circuits are bypassed to ground with fixed condensers.

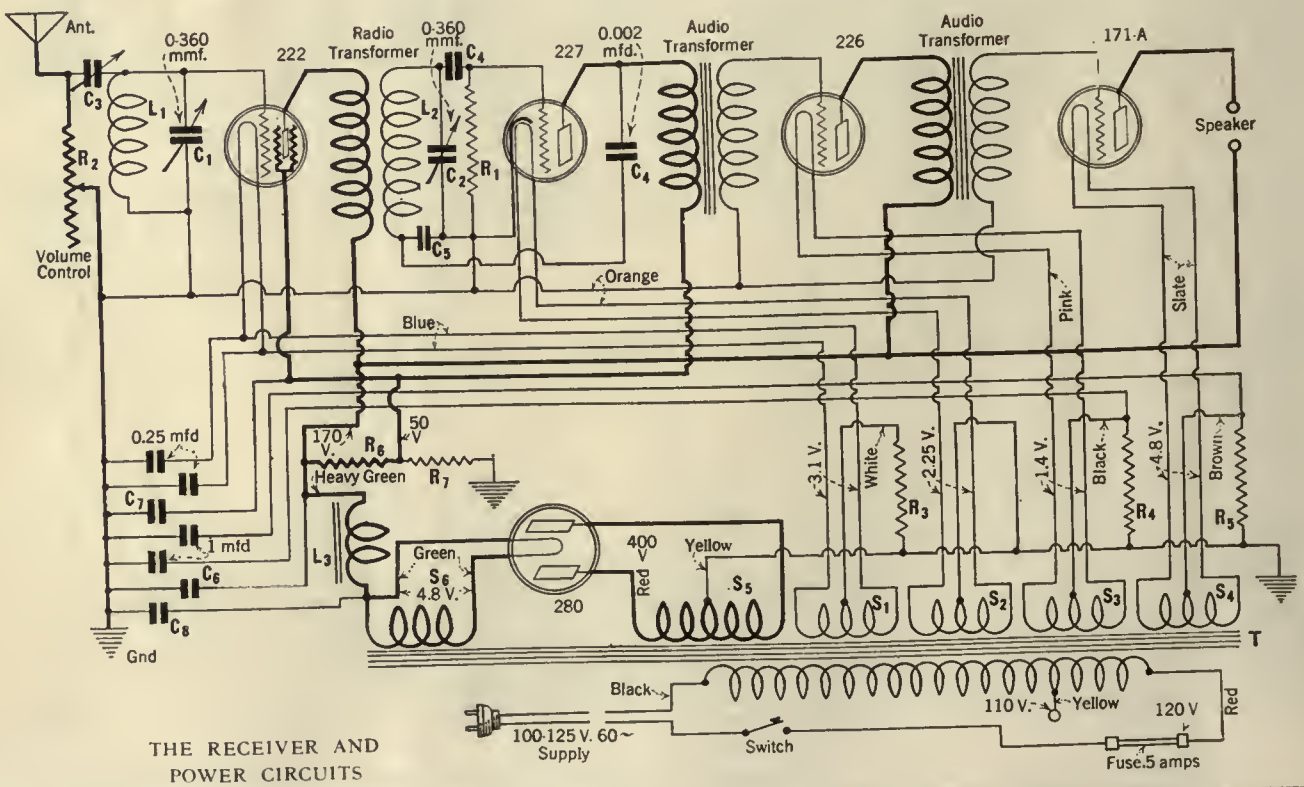
6. Grid circuits.

Grid bias for the various tubes is obtained from resistors connected in series with the center taps of the various filament windings on the power transformer. The 3.1-volt winding supplying the 222-type tube has in series with its center tap a fixed resistance, R_3, which supplies a negative potential of approximately 2.5. volts to the control grid of the r.f. tube, There is no bias on the grid of the detector tube except that due to grid current flowing through the grid leak, R_1. The 226-type audio amplifier tube obtains grid bias from the 1800-ohm resistor, R_4; the voltage drop across this resistance places a negative bias of about 10 volts on the grid of this tube. Negative bias on the grid of the power tube is approximately 35 volts and is obtained from the voltage drop across the resistance, R_5.

7. Power supply.

A 280-type full-wave rectifier is used in the power supply, this tube being supplied with 400 volts from the secondary winding, S_6, and 4.8 volts on the filament from S_6. The output of the tube feeds into the filter system consisting of a single choke coil, L_3, and the two condensers, C_8 with a capacity of 2 mfd., and C_9 with a capacity of 4 mfd. C_8 has a rating of 2000 volts and C_9 has a rating of 1000 volts. It should be noted that condensers of a far higher voltage rating than is actually applied to them are used in order to insure long life without danger of break down. The output of the filter circuit supplies the plates of all of the tubes except the detector, and by use of the voltage dividing resistors, R_6 and R_7, the maximum output potential is reduced to 50 volts for the plate of the detector tube and the screen grid of the 222-type tube. R_6 has a value of 12,500 ohms and R_7 is a 10,000-ohm resistor.

Note: As this issue goes to press we are informed that the Freshman Model Q receiver has been superseded by the model 3Q. The new receiver employs an additional tuned circuit—THE EDITOR.



THE RECEIVER AND POWER CIRCUITS



SERVICING A RADIO RECEIVER

Servicing Home-Made Radio Receivers

By B. B. ALCORN

IN THE repair of radio receivers the service man is confronted with two different types of problems; one manner of trouble is to be expected in the modern factory-built set, but it is impossible to anticipate the sort of defect which may be discovered in a home-assembled outfit. Fortunately, however, the man who "rolls his own" is not easily discouraged—he does not surrender to the extent of requesting the aid of a service man until he has exhausted his ideas as well as those of his friends.

In the October article of this series there were listed, in the order of their importance, the causes of trouble experienced in the servicing of factory-made receivers. These disorders as well as others are encountered in home-made sets. However, very frequently when called upon to service sets of this type the poor results will be found to be caused by (1) the use of an incorrect, inefficient, or tricky circuit, (2) carelessness in wiring or assembling of parts, (3) the use of poorly selected apparatus, (4) improper arrangement of apparatus and wiring, and (5) all sorts of peculiar conditions which are the result of lack of knowledge on the part of the novice set-builder.

From the remarks given in the above paragraph it may be appreciated that in some cases, in order to make the set operate properly, it is only possible to salvage the apparatus and rebuild. However, the usual radio fan is not supercritical when regarding his own work; as a result a simple repair which will cause the set to operate—even if the performance is poor—is often considered entirely satisfactory. I might add that the inexpensive repair almost invariably is preferred, as the set-builder objects when it is necessary for him to pay for work he should be able to do himself.

[The third installment of a series of articles discussing the problems of a radio service man]

Home-made sets may be divided into three distinct classes, namely, the completely home-made set, the home-assembled kit set, and the home-modernized factory-built receiver. The first type usually presents the greatest problem to the service man, the kit sets often can be repaired without too much difficulty, and those which fall in the last class may or may not be reconditioned, depending upon their design, but frequently they should have been junked years ago.

AN UNUSUAL SHORT CIRCUIT

WHILE on the subject of home-constructed radio receivers, a few experiences with sets of this type may be of interest. A set which recently was given to us for repair typifies the unusual conditions which frequently are found. This particular set was made by a very careful workman; every connection was carefully soldered, the circuit was correctly wired, the best available parts were used throughout, and the construction was beyond criticism, except for one detail. An examination of the receiver showed that each by-pass condenser—they were of the moulded-bakelite type—was mounted to the base panel with a machine screw passing through a hole drilled in the center of the condenser. Of course, drilling the holes through the condensers caused a short circuit in each case, thus making the receiver entirely inoperative. The builder of the receiver, admitting that his knowledge of radio was limited, explained that in constructing the set he tried to improve the mechanical design which was described in a newspaper radio supplement.

Another interesting experience with a home-constructed set proved very baffling for some time. The builder of this set had had considerable experience in building receivers for himself and his friends, and he had been very successful in most cases. However, the set in question proved to be his Waterloo. On the surface the construction of this set appeared to be perfect, but an electrical test showed many shorts throughout the circuit, The wiring was checked from beginning to end and it was found to be correct in every particular; nevertheless, shorts were existant in all parts of the circuit. Finally it was discovered that the front and base panels of the set were made of "self-shielding" material (these panels present the appearance of bakelite, but are imbedded with a wire mesh) which was as effective in short circuiting the various parts as an uninsulated metal chassis would have been. After insulating the apparatus and wiring from the wire mesh in the panels the set performed perfectly.

A third experience concerns a home-constructed "Hi-Q 28" kit set which was wired for operation with a.c. tubes. The set was carefully

constructed by a man who had had considerable radio experience, but it refused to function. No error was found in the wiring diagram which was studied carefully, and an electrical test failed to disclose the trouble. However, it was discovered that with the antenna connected to the grid of the detector tube, the set would pick-up signals, but with the shields in place and the antenna connected with the antenna post the set was "dead." After considerable checking it was found that a 0.00025-mfd. by-pass condenser had accidentally been connected in shunt with the secondary of the detector r.f. transformer, thus causing the detector circuit to tune to a much higher wavelength than the preceeding r.f. stage which was tuned by a condenser on the same shaft as the detector condenser. As soon as this condenser was removed from the circuit the receiver provided excellent results.

The troubles located in home-reconstructed commercial receivers usually are as foolish as those found in other home-made sets. We were recently called upon to repair an old four-tube Garod reflex receiver, this set having performed satisfactorily until the owner decided to improve the quality of reproduction by substituting new a.f. transformers. However, after the new transformers had been installed the volume was much lower than it had been originally. An examination of wiring disclosed the fact that the first transformer was connected backwards, i.e., the secondary winding was connected in the plate circuit.

The next incident, which concerns a Radiola 17, is more amusing than instructive. The set had an open grid suppressor and it was brought to the shop for repair, but when the cabinet was opened it was found that around each tube was a piece of friction tape which held in place a large square of tin foil. After the grid suppressor had been replaced the set, minus the tin foil decorations, was returned to the owner, and out of curiosity we asked his reason for placing the tin foil on the tubes. He explained that when the set started to lose volume he thought that the tubes were at fault. After noting that the "silver plating" on the inside of some tubes was heavier than on others, he decided to repair the "weak" tubes with tin foil.

The novice experimenter who builds receivers is not the only radio fan who causes trouble for the service man. On the other hand there is the ambitious radio fan who adds accessories and other "gadgets" to his factory-built receiver, as in many cases this is also the cause of poor results. This fact calls to mind a short of a peculiar nature occurring in an Atwater Kent model 20 receiver, and in this particular instance the trouble was very difficult to locate.

The owner of the receiver purchased a Philco B-supply unit and for several days he was very much pleased with the results. Then, one evening he returned the power unit to the dealer and stated that it would not deliver current, and, as no amount of argument would convince him that the power unit was in perfect condition, he was given a Bosch power pack in exchange. The next morning the Bosch unit was returned and the customer requested that a service man examine his receiver. The man who tackled the job found a very unusual condition; both power units would work satisfactorily if, when changing the connections from the batteries to the power unit, the tubes were not turned off, but if the tubes were turned off and on the power unit would not operate the receiver. Further examination disclosed a short circuit in the B + 135-volt lead of the set, and it was discovered that a by-pass condenser had blown out. When new condenser was installed in the set perfect results were obtained.

The Atwater Kent model 20 receiver is not the only set in which by-pass condensers are apt to become shorted upon the addition of a B-power unit, as the trouble is experienced frequently with many old-type receivers. In this connection the writer would suggest replacing the by-pass condensers of old sets with new condensers, which are capable of withstanding a higher voltage, before installing a B-supply device.

While on the subject of B-supply devices a short of a peculiar nature which was encountered in the power circuit of a Freshman Equaphase a.c. receiver might be of interest. In this particular case the receiver behaved in a very strange manner; in the middle of a musical selection the volume would increase to terrific proportions and then die away to a whisper the next moment. After considerable checking it was found that the trouble was caused by an uninsulated wire which short circuited the detector resistance of the voltage-divider strip. However, it was discovered that, as a result of the short circuit, considerable current passed through the wire, thus producing sufficient heat to cause the wire to expand and open the shorted resistor. Of course, when the wire cooled it contracted again and shorted the resistor, and then the cycle was repeated. This short circuit proved very difficult to locate as the wire in question was fastened to the cover of the power unit and nothing out of the ordinary could be noted when the apparatus was examined. However, the set tester described last month proved its values as it detected the variations in plate voltage.

NO SERVICE man—and his number is legion—can hope to succeed completely unless he has the best of radio backgrounds. He must know, almost instinctively why things go wrong and where to look for the trouble. The service man can learn only little if he attempts to remember—merely—how a certain trouble was cured; he must go back to fundamentals. These articles by Mr. Alcorn, himself a practising service man, are designed not so much to tell service men how to cure specific troubles, but more to discuss common troubles and their remedies. This, we hope, will help to show those who are eager to learn something about what that knowledge must be and how they must apply it. —THE EDITOR.

MANIFESTATIONS OF SHORTS

IN B-supply devices and the power packs of receivers shorted filter condensers and choke coils make their presence noted by an increased a.c. hum in the loud speaker. Incidentally the only remedy for such trouble is to replace the defective parts. Also, the writer wishes to state that all radio service men would appreciate it if less insulating material were used in the manufacture of these units, as the time employed in digging out the defective parts certainly could be employed more profitably.

Another shorted condenser which develops quite frequently in Radiola models 17 and 18 receivers occurs in a part of the circuit where one would not be apt to look for trouble. The circuit diagram of Radiola 17—it was incorrectly labelled as the 18—was given in the first article of this series (Page 26 November RADIO BROADCAST). The small condensers designated by the letters G are the ones which have been found defective in a number of instances, G_3 being the unit which generally is found at fault. This short is very difficult to locate the first time it is encountered, as the set seems to be operating properly except that signals cannot be picked up. In the repair of the receiver the condenser may be omitted from the circuit if another is not available, as little or no difference will be noted in the results.

Short circuits in accessories, such as loud speakers, lightning arrestors, extension cords, etc., should receive some mention at this time as devices of this type are the cause of considerable trouble and it seldom occurs to the service man to look for shorts in these parts of the circuit. This is especially true of the loud speaker, and for this reason it is advisable to connect a pair of phones to the output of the set before making further tests. Often it will be found that the windings of the loud speaker have become shorted or burnt out, or the cords have become defective.

TWO INTERESTING OPEN CIRCUITS

THERE recently have come to our attention two open-circuit troubles which are considered of particular interest, because in each case the set-checking device failed to detect the defect. The first instance concerns a Radiola 17 receiver, and when the complaint was received the cause was diagnosed as an opened grid suppressor. However, an electrical test showed the circuit to be in good condition, even though the set lacked volume on all stations, including powerful local broadcasters. In this case the problem was solved by the old method of attaching the antenna to the grid of each of the various r.f. tubes. As soon as the antenna wire was touched to the grid of the second tube signals were received with greatly improved volume, thus indicating that the trouble must be located in the first r.f. circuit. Finally it was discovered that an open circuit existed in the volume control which is in the antenna circuit of the receiver.

The second open-circuit difficulty was experienced with a Crosley Bandbox receiver, and it was suspected that the trouble would be found in the external power-supply unit. The set did not provide sufficient volume, but the set-checking device indicated that the receiving circuit was satisfactory, and the output voltages of the power-supply unit were found to be correct with a d.c. voltmeter. As a last resort the battery-voltmeter continuity test was given the set and an open was found in one of the r.f. choke coils. We have never been able to determine why this defect did not show up in the test with the set-checking device, but it did not and we were forced to spend more time in looking for the trouble than was profitable. In addition, it was necessary to rewind the choke coil as none of this type was available at the time.

Another thing which should be remembered in connection with Crosley Bandbox receivers is that the external power unit is not of the dry type; it employs a Merschon filter condenser which is of electrolytic construction. Because of this fact the power unit should never be installed on its side, as the electrolyte is apt to seep through the cork and cause corrosion. The writer knows of several cases where this mistake has been made and in one instance a beautiful mahogany bookcase was badly discolored. Incidentally, it is never good policy to install power units on their side when a filament-type tube is used as a rectifier. In the instructions which are supplied with each tube the manufacturer recommends that the tube be operated in a vertical position if maximum life is desired. When the tubes are operated in a horizontal position the filament is apt to sag and cause trouble.

The Service Man's Corner

THE many practising radio service men who see RADIO BROADCAST regularly have praised highly the articles for and by service men which are now a regular feature of this magazine. Those of our readers working in this field seem to like "The Service Man's Corner" especially. "Although I feel confident to face almost any kind of service problem," writes one reader, "I enjoyed reading the first 'Service Man's Corner' and am looking forward to future issues. All of us need to keep in touch with what other workers are doing and I feel I can always learn something from reports of other's experiences."

Even though some of the suggestions appearing in these pages may seem self-apparent and too simple to deserve mention, it is possible that the point covered is so obvious that many readers have never thought of it.

A.C. Hum: Some service men tell us that where they have replaced a.c. tubes in an "electric" set an unusual amount of hum developed. The answer is apparently in the fact that some a.c. tubes or circuits vary slightly in some characteristic and adjusting the resistor responsible for balancing out the hum will cure the trouble. In other words, the resistor in question should have the tap adjusted in the exact center, but in the case of some tubes, the lowest resulting hum in operation results when the resistor is adjusted slightly off-center, the exact point being a matter of experiment. Many commercial receivers now are equipped with variable "center-tapped" resistors, which makes the solution of this trouble simple. In servicing less modern sets, it may be wise where possible to replace the fixed center-tapped resistor with a variable unit.

Getting the "lows": It is curious how a condenser across the loud-speaker leads helps to bring out these lower notes that everybody is yelping for. Try different values until the customer yelps out loud. [This stunt will be effective on low frequencies, but will cut off most of the highs.—*Editor.*] There is another suggestion I wish to make at this time: have a routine in checking a receiver and don't vary from it. I spent several days learning that a voltage-divider system was "open" in the detector supply before I relearned the value of an invariable routine. The groping was unproductive, but the trouble was almost at once apparent when the set was checked systematically. We never seem to learn: I blew three tubes a few days ago, and repeated that performance the next day. And yet it's so easy to remove tubes while working on a set!



[What test routine do readers prefer? The best contributions will be printed.—*Editor.*]

H. J. GODDARD, Ellendale, N. D.

R.T.F. Set Trouble: In servicing an Atwater Kent, the following trouble presented itself. The set worked on local stations but the signal strength was weak. Having eliminated the batteries, tubes, antenna, and loud speaker for faults, the set itself was inspected. It was a one-dial, three-condenser set. The puzzling thing was that all continuity tests showed the set to be ok. By placing my finger on the stator plates of the first condenser the signals faded out completely; the same result was found in touching the third condenser. On the center condenser the signals remained the same. Moving the second condenser caused little change.

Grasping the center or second r.f. coil, and forcing it slightly from side to side, the set worked ok at times. The continuity test showed no open circuits. By moving each wire connected to this coil a bad connection was located where the lead was soldered to the coil. The connection was slightly corroded. The condition was this: even though this connection passed 22 volts in the continuity test, the corroded joint would not pass r.f. current because of its high resistance. After the connection was cleaned and resoldered the set worked satisfactorily. Such a condition might not occur in a new set, but this possibility is well to remember when working on receivers which have been in use for some time.

—THOMAS GLOSE, Allentown, Pa.

Filament voltage on the CX-350: A service man writes us that he "is having trouble with a new CX350 tube arcing across between the elements and wonders if the trouble is general with others." He continues, "I am using the drop across a 1500-ohm resistor for grid bias and the tube draws 50 mils. On loud signals, there is an arc inside the tube and the milliammeter in the plate circuit deflects toward the high end of the scale. I have had three tubes and they all do the same thing."

Roger M. Wise, chief engineer of E. T. Cunningham, has cast some light on the probable cause of the trouble. He says: "In using the CX-350 we find that the important precaution of operating the filament at approximately the rated voltage is often overlooked. We investigated recently a complaint of flash-over in an amplifier in which two of these tubes were being used. When tested in our laboratory, the tubes in question operated normally at rated maximum plate voltage, but when placed in the amplifier giving the trouble, one of the tubes arced. A check on the operating conditions showed that while the plate voltage in this amplifier was only 375 volts, the filament voltage was 6.0. As soon as the filament potential was raised to the rated figure, 7.5 volts, the tube operated satisfactorily."

THIS page marks the second appearance of our department exclusively for the practising service man. It is unique, we feel, because for the most part it is written by the service man himself. These pages will be a forum where the service man can discuss his problems, get his pet idea into print, and see now and then a hint which will be useful in his daily work. Contributions which should preferably be short, to the point, and typewritten are solicited and will be paid for if used. Address your articles to the editor, "Service Man's Corner."

—THE EDITOR.

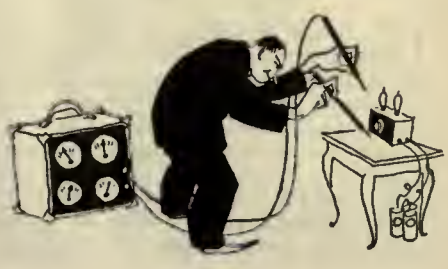
Items of Interest

SOME manufacturers tell us that the demand for power amplifiers for public address work in its various possible applications is one of the year's most astounding developments in radio accessories. The service man and professional set-builder who is interested in this work ought to have—in addition to the catalogs of the various makers—the *General Radio Experimenter* vol. 3 no. 4 for September, 1928, for the article "Notes on Group Address System," by C. T. Burke. Silver-Marshall's *The Radiobuilder*, vol. 1, no. 6, dated October 9, 1928, describes in interesting detail the new S-M rack-and-panel "P. A." amplifiers. Jenkins & Adair, of Chicago have just issued Bulletin No 7 on a microphone mixing panel which should be useful in more pretentious public address systems.

¶ The Weston Electrical Instrument Corporation have just released descriptions and prices on testing apparatus for the service man. Their publications describe Model 537 a.c.-d.c. set tester, Model 533 Counter Tube Checker (which is a.c.-operated) and circulars Y and X describing portable a.c. and d.c. testing instruments respectively.

¶ What list of equipment do service men feel is the minimum for field work? Most service men feel rather strongly on this point and we should like to have lists submitted. The results will be tabulated and be published in this department.

¶ Practising service men, especially those who are working out of a radio store, will find the excellent loose-leaf tube data book issued by E. T. Cunningham, 370 Seventh Avenue, New York, of constant value. These sheets, supplied in a binder give the following data: name of receiver, manufacturer's name, model number, a chart showing location of tubes, socket number and what part in the circuit each tube plays. Space is provided on each sheet for notes, and remarks containing useful data on the set in question. We are advised that Cunningham will supply service men with the book, on request.



Volume Control in the "Talkies"

SOME years ago an eminent progressive, being asked in a locality noted for repeated industrial warfare what he thought of law and order, answered to the effect that he thought it would be all right, but he had never seen any. Exaggeration often points the way to truth. The truth about volume control in the sound-movie field is that in most theatres there isn't any. This is probably the most serious defect in the technique of audible photoplay reproduction at the present time. The theatres, in this matter of gain adjustment, are now at the stage in which broadcasting was in 1923, but the effect is worse, because the combination of sound reproduction with pictorial action presents more difficult problems than sound reproduction alone.

The principal faults may be summarized as follows:

(1) General level of speech reproduction too high.

(2) Failure of volume to follow the action or to maintain a natural proportionality.

(3) Abrupt jumps from one musical selection to another as scenes change.

(4) Inability to adapt sound reproduction to audience reaction in special cases.

Under the first count of the indictment, I may say that I attend a good many sound-picture showings in various cities and different sizes of theatres, and very rarely encounter inadequate volume of either speech or musical accompaniment. Excessive loudness of synchronized musical accompaniment I hear sometimes, but not often enough to write an article about it. Unnaturally loud speech reproduction, however, is rampant. This generally excessive level of speech reproduction is caused by failure on the part of the recording experts, projectionists, theatre managers, and other functionaries to appreciate the simple fact that speech is usually not as loud as music. So, in changing from orchestral accompaniment to speech, during a picture, they ought to drop the level, perhaps 10 TU. But in most pictures which have talking portions alternating with music nobody does anything about this. The result is that even in the top gallery the speech is absurdly loud. The setting should be such that in this location conversational speech from the sound movie machine is loud enough to be comfortably understandable. In a house with good acoustics this will not be much louder than speech of the same sort from an actor on the stage. Even when this rule is followed the speech may be too loud in the front of the orchestra, but it will not be as bad as when the level is excessive up above.

TOO MUCH VOLUME

THIS chronic tendency to oversupply volume leads to a number of corollary defects. One is a distortional change in voices. An actor playing a love scene, for example, and talking to a girl at close range, naturally speaks in a low voice. His low voice is not the same, in distribution of overtones, fundamental pitch, and other characteristics as if he were talking loudly. The recording operator, perhaps, brings up the gain control to get above the noise level of his equipment. Then in the theatre some more amplification is piled on, and the voice issues from the projectors a few million times louder than at the beginning. The ear recognizes the fact that

THIS is the first of a series of articles dealing with sound motion pictures. RADIO BROADCAST *was first and alone in its field to provide intelligent and authoritative articles on the engineering aspects of broadcasting and we are happy to be first now with authoritative articles on sound movies. The latter field is so close to broadcast engineering that it is proving of absorbing interest to almost everyone in radio. Pages in this magazine will regularly be devoted to this subject.* —THE EDITOR.

something adventitious has happened to the man's voice. Quiet speech sounds natural only when it is reproduced at a relatively low intensity. Furthermore, dramatic contrast is lost when even moderately loud sounds are reproduced heavily. If you deafen the audience with the amorous murmuring of the lovers, what more can you do when they begin to shout at each other, or when the hero pulls a machine gun out of his trousers and shoots one of his fellow gangsters? If you are working at plus 10 for sounds of low volume, and you emit 100 times as much energy for a louder sound, the effect on the ear goes up to plus 30, an increase of 200 per cent. as far as the ear is concerned. But if you are already working at plus 40 the same ratio of increase only brings you up to plus 60, an increase of 50 per cent. to the ear. The audiences, even though they don't know much about logarithms, have ears which act logarithmically.

Part of what has been said also has a bearing on the second point listed above. Fundamentally, the failure to correlate volume with the action of the play is a fault in recording. Skillful gain variation in the theatre can make up for defects in recording, but what we frequently get is mediocre recording to begin with, aggravated by bungling in reproduction. One of the faults frequently mentioned by critics of talking pictures is that when characters go backstage after a close-up there is no corresponding diminution in the level of their speech. This is something which should be taken care of in recording, but usually isn't. The close-up is one shot and the movement backstage very likely another. By the time the recording engineers are taking the latter they have forgotten the initial volume, but the audience, getting the two close together, notices the incongruity. The remedy lies in recognition of such defects, more utilization of instruments, and standardization of technique. Similarly when an actor turns away from the audience there is not the change in his voice which one would expect. The reason usually is that a second microphone was used to pick him up when he turned away, and the recording expert neglected to bring down the gain control somewhat on his transmitter to take care of its direction with respect to the future audience.

Some of the troubles discussed above involve refinements in technique and training of skilled personnel, which cannot be accomplished overnight, but such scandalous defects as abrupt changes in musical selections are inexcusable. As long as audiences tolerate such barbarities it seems there will be producers and exhibitors foolish enough to perpetrate them. In the meantime other producers will refine their technique and sell the product to the more far-sighted theatre proprietors, and when the public becomes critical the latter will get the business and the former will be left wondering why their seats are empty. As yet, unfortunately, the public has not become discriminating, and one sees audiences sitting through synchronized pictures in which, as the scenes change, one musical selection is abruptly broken off and another starts with full volume in the middle of a bar. These are the subtle operations of the cutting rooms on sound film. As originally scored, the picture has appropriate musical selections fitted to the various scenes, with suitable transitions and pauses as scenes change. Further changes being decided on, pieces are chopped out of the reel. This may improve the picture (sometimes the more that is cut out the better the picture becomes) but unfortunately the sound track goes with the picture, and with it the artistic transitions arranged by the musical director. Of course these portions might be re-orchestrated, but the productions have to appear on schedule, and some of the producers are willing to send the stuff out as long as they think there is a chance that the audiences will not get up, throw the chairs at the screen, and lynch the house manager

AUDIENCE REACTIONS

ANOTHER difficulty, for which the producers cannot be held responsible, lies in the uncertainty of audience reactions. In one instance which I witnessed the victim was the illustrious Martinelli, singing *Va Prononcer Ma Mort*, from *La Juive*, one of Vitaphone's operatic shorts. The tenor appeared in street clothes on the screen after being divested of his costume and Hittite nose. A small audience on a warm Sunday afternoon applauded only moderately and when the shade of Martinelli implacably offered two or three bows and synchronized smirks after they were silent, naturally they laughed. In this case the projectionist was caught flat-footed. He should have doused the grateful artist as soon as the audience indicated that it could bear to let him go back to the rewinder. Too few bows are always better than too many. A much harder problem is encountered in connection with loud laughter from audiences during comedies. In a stage comedy when the audience laughs loud enough to drown out the succeeding dialogue the actors pause and wait for the roars to die down. In vaudeville they can laugh with the audience.

(*Concluded on Page 200*)

No. 131 **Radio Broadcast's Home Study Sheets** January, 1929

Calibrating a Radio Wavemeter

A RADIO laboratory, regardless of how small it may be, cannot get along without a wavemeter or frequency meter. Such a meter generally consists of a coil, a condenser, and a dial. If it is part of an oscillating tube circuit, so much the better. It can, then, be used as a source of signals from which a receiver may be adjusted to a desired frequency. A good frequency meter can be made from coils such as the General Radio Company Series 277 which have the dimensions shown in Table 1. When attached to a tube, as shown in Fig. 1, with or without a grid current meter, a very useful frequency standard may be had. The problem is to calibrate it. Calibrating such a meter is a very interesting and instructive experiment.

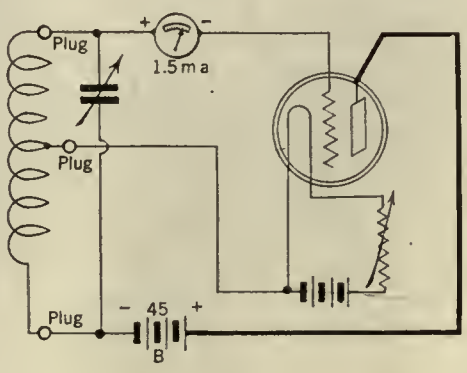


FIG. 1

LIST OF APPARATUS

1. An oscillating wavemeter as in Fig. 1.
2. An oscillating detector tube, tuned to some known frequency in the broadcast band. (See Fig. 2.)
3. An audio amplifier connected to the output of the oscillating detector.
4. A pair of headphones connected to the output of the amplifier.

TABLE I

Coil	Turns	Size Wire	Diam.	Length of Winding	Inductance
277–A	15	21	2 11/16"	1 5/8"	0.014 mh
277–B	30	21	2 11/16"	1 1/2"	0.055 mh
277–C	60	21	2 11/16"	1 5/8"	0.217 mh
277–E	90	27	2 11/16"	1 3/8"	0.495 mh

PROCEDURE

Connect up the wavemeter and the oscillating detector and place within a foot or two of each other (See Figs. 1 and 2). Connect the detector loosely to an antenna and pick up a known broadcast station. By means of a vernier condenser, or a fine adjustment on the tuning condenser, tune the detector to "zero beat" with the broadcasting station. Move away the antenna coupling coil slowly and see if the beat note—which should be as near zero as is possible to hear in a quiet room with one stage of audio—changes. If so, adjust the tuning again until no sound is heard. The broadcasting station and the local generating receiver are tuned to the same frequency. In the Laboratory a 610 kc. station was used.

Now use the broadcast-band coil for the wavemeter, and make its tube oscillate. Couple the wavemeter and the detector inductances fairly closely together, perhaps by winding a turn of wire about each and connecting the turns together. Turn the wavemeter dial slowly, and mark down on a piece of paper when beat notes are heard in the telephones. A very loud note will be heard when the two circuits are in exact resonance (it may be necessary to decrease the coupling to get the exact dial setting), and another loud note will be heard when the wavemeter is tuned to the double frequency—or half the wavelength—in our case at 610 and 1220 kc. Between these points several other much weaker "squeaks" may be heard. Put them down but mark the strong ones with an asterisk. Then use a smaller wavemeter coil and repeat. Put down the squeaks again marking the loudest. At least two loud notes should be heard, the second and the fourth harmonic, in our case, the 1220 and 2440 kc. points. Repeat for as many coils as are to be calibrated.

If the coils are wound so that each smaller coil has half as many turns as the preceding one, the beats will occur at the same place on the dial. That is, if we pick-up 610 kc. at 85 degrees on one coil, we ought to look for 1220 kc. at about 85 degrees on the next smaller coil, and so on.

Now prepare a table like that in Table 2, in which the numbers along the top are secured by multiplying the detector frequency by whole numbers, say from 1 to 5, and in which the vertical columns represent the upper figures divided by whole numbers. Thus in our table, the detector frequency is 610 kc. Twice this gives 1220 kc., three times 1830 kc., etc. Reading down, one half gives 305, one third gives 205, etc. Then from this table make a list of the various frequencies that may be looked for in our calibration, viz., 610, 763, 813, 915, 1016, etc.

TABLE 2

	1	2	3	4	5	6
1	610	1220	1830	2440	3050	3660
2	305	610	915	1220	1525	1830
3	202.5	406	610	813	1016	1220
4	152.5	305	457	610	763	915

What actually happens as we tune the wavemeter is as follows. We are listening in the oscillating detector circuit. It is generating not only a 610 kc. current but multiples of this frequency as well, harmonics they are called. These additional frequencies are much weaker than the fundamental, 610 kc. When we tune the wavemeter to 1220 kc., its fundamental (1220 kc.) beats with the second harmonic of the detector (1220 kc.) and so we get a squeak. It is also possible for the second harmonic of some frequency to beat with the third of another, producing a beat frequency of 610 kc. For example, a beat occurs when the wavemeter is tuned to 763 kc., that is because 763 kc. is the fifth harmonic of 152.5 kc., and 610 kc. is the fourth harmonic of 152.5 kc. (see Table 2).

We now have data showing points on the wavemeter dial where we heard beat notes, and a list of frequencies at which beat notes should occur. How can we identify and properly label the points?

Let us consider the broadcast-band coil, which in the Laboratory is tuned by placing the condenser across only half the coil so only a small part of the band is covered. We set down the figures as in Table 3, and subtract the dial settings as in Column 2. We heard strong beats at 10.2 and 85 degrees on the dial. We guess that these are respectively the 1220 kc. and the 610 kc. points. Now we note that from 10.2 to the next point is 24 degrees, and that from this point to the next at 47 is a difference of 13 degrees. If we consider 13 degrees as a unit, we see that there are 6 units between 1220 kc. and 610 kc. that is about 100 kc. per unit. So we put down 1220 kc. as the 10.2 degree point, subtract 200 kc. for the next and get 1020, (which is two units distant), subtract one unit or 100 kc. for the next and get 920 kc., and so on. Now we look at our table of expected beat notes and find that 1220, 1016, 915, 813 and 610 are to be expected. We can then attach these frequencies to the above points. We can get the frequencies of the other coil points in exactly the same way.

If we wish we may use another method of computing roughly what the beat frequencies are, and then check them against our table of expected beats as before. We note that between 10.2 and 85 degrees—a difference of 75 degrees approximately—a difference of 610 kc. exists, or a difference of about 8 kc. per degree. Then the difference between 10.2 and 34 should give 23.8 × 8 kc. or about 190 kc., that is from 1220 to 1220 - 190 or 1030 kc. Actually our table shows the frequency to be 1016 kc.

TABLE 3

Dial degrees	Diff.	Units Diff.	f Approx.	f Exact
10.2*			1220	1220
34.0	23.8	2	1020	1016
47.0	13.0	1	920	915
60.0	13.0	1	820	813
85.0*	25.0	2	610	610

*Indicates points on dial where loudest beat notes are received.

PROCEDURE

Either set up the apparatus and calibrate it as suggested, or complete the data in Table 2. Plot the frequencies against dial setting. Transfer these frequencies to meters and make a calibration of wavelengths in meters against dial setting. Make a table similar to Table 2 but calculate the beats in terms of wavelength in meters. Calculate the inductance of the coil (Home Study Sheet No. 2 July 1928) and from it calculate the condenser capacities at various settings and plot. As a check on the above data, pick up another broadcast station whose frequency is known and repeat the calibration. See how nearly the calculated points and calibration curve check each other.

PROBLEMS

1. Do you know why an oscillating vacuum tube produces harmonics?
2. If the nearest approach to the actual "zero beat" you can attain is 100 cycles at 1000 kc. what percentage accurate is your calibration? Why cannot frequencies below about 100 cycles be heard in the receivers?
3. Remembering that wavelength in meters is proportional to the square root of L times C, what is the ratio of capacity when the wavemeter is set at the second and then the third harmonic? That is, suppose the capacity setting of the wavemeter for the second harmonic is C degrees. What will it be for the third? Do you see a way to check your calibration by this method?

Note: Readers may send the answers to these questions to the Editor to be checked.

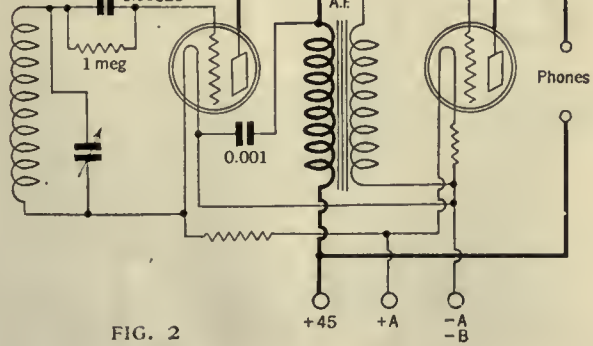


FIG. 2

No. 14 **Radio Broadcast's Home Study Sheets** January, 1929

Plotting Power Tube Characteristics

EVERY radio experimenter knows the value of the characteristic curves of a vacuum tube. Home Study Sheets Nos. 5 and 6 (September RADIO BROADCAST) tell how these characteristic curves may be made and how one can obtain from them the important tube constants. This Sheet tells us more about the power tube in one's audio amplifier.

No electrical apparatus is really necessary for this experiment. Some plotting paper, a rule, and perhaps a French curve will suffice. All of the data may be obtained from a single set of figures which show the plate current of a tube as the plate voltage is changed, the grid being maintained at zero bias. If, however, the experimenter desires to take data on one of his tubes and to carry out the result of the experiment, it is much better. All that is necessary is the E_p-I_p curve for a single value of grid bias (0).

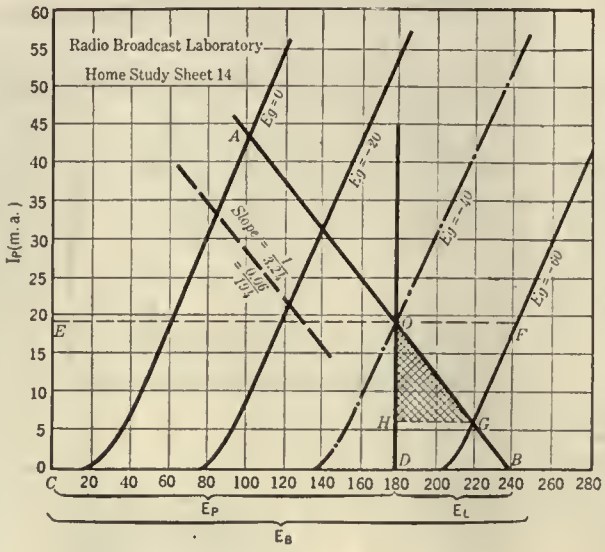


FIG. 1

DISCUSSION

The effective voltage, E, on the plate of a tube which does not have high-resistance load in its plate circuit is given by $E = E_p + \mu E_g$ which states in mathematical language that the voltage on the plate of the tube is equal to the sum of the voltage due the plate battery and whatever grid voltage there is multiplied by the mu of the tube. When the grid bias (E_g) is negative the effective plate voltage is less than E_p. That is, the plate current which flows when a 100-volt plate battery and a negative C bias of 20 volts are employed is less than the plate current which flows when the C bias is zero. How much less is it? We could tell if we had available the single curve mentioned above and shown in Fig. 1 ($E_g = 0$).

For example, let us take the $E_g = 0$ curve of Fig. I which represents the plate current of a tube, similar to the 171, at zero grid bias. Now suppose we want to plot the curve for $E_g = -20$. We assume various voltages and substitute in the formula for the effective voltage (This is called the "lumped voltage" in England). The mu of the tube is 2.8, and suppose we assume $E_p = 100$,

$$E = E_p + 2.8(-20)$$
$$= 100 - 56 = 44$$

and looking at our curve we note that when $E_p = 44$, $E_g = 0$. and the plate current is 8 mA. Therefore when $E_p = 100$ and $E_g = -20$, $I_p = 8$. This is one point for the new curve. Now assuming $E_p = 120$, $E = 120 - 56 = 64$ and the plate current is 20 mA. This system is continued until sufficient points are marked down to enable us to draw a line through them. This line will be parallel to the zero-grid voltage line. Then assume another grid bias, of say, —40 volts and plot that curve. Finally we have a family of curves like that in Fig. 1.

Now the slope of this line represents the reciprocal of the plate resistance of the tube, that is, the slope $= 1/R_p$, and a little calculation will show that R_p for this particular tube = 1620 ohms.

Engineers have shown that the maximum undistorted power output from a tube will be attained when the load resistance, into which the tube works is twice the plate resistance of the tube, in this case 3240 ohms. Under these conditions the plate current, goes up and down in accordance with the input a.c. grid voltages. How much does it vary, what is the a.c. power lost on the tube, what is the a.c. power in the load resistance, etc? We can find these various values in the following manner.

1. We draw the line AOB which goes through the intersection of the 180-volt line with the E_g = —40-volt line and has a slope equal to the reciprocal of the load resistance in ohms.

$$\text{That is, the slope of AOB} = \frac{\text{I (amperes)}}{\text{E (volts)}} = \frac{1}{3240} \text{ or } \frac{\text{I (milliamperes)}}{\text{E (volts)}} = \frac{1}{3.24}$$

and if we take 60 mA. as the vertical side of a triangle ,we get the horizontal side from $\frac{I}{3.24} = \frac{60}{E}$

whence E = 194 and connecting the 60 mA. point on the vertical axis with the 194 volt point on the horizontal axis we draw a line. Then the line through 0 is to be drawn parallel to this line.

Now with such a "family" of curves and the "load line," AOB, we can tell many things about what happens when the grid is excited with an a.c. voltage. Suppose the input grid voltage has a maximum value of 20 volts. The grid bias is minus 40, the plate current is 19 mA., the voltage actually on the plate is 180, and the voltage lost across the load resistance is 60 (240 — 180). In other words E_p = CD and E_l = DB. If the tube is so biased that no plate current flows, the entire battery voltage is applied to the tube, that is 180 + 60 or 240 volts. To apply 180 volts to the tube through a load resistance of 3240 ohms when 19 mA. flows, the plate battery must be 240 volts or CB.

Now when the grid swings from minus 60 (— 40 from the C bias and — 20 from the maximum negative input a.c. voltage) the current drops to 6 mA., and when the grid becomes minus 20 (— 40 from the bias battery and plus 20 from the a.c. input) the plate current increases to 31.5 mA. The voltage variations across the load under these grid-voltage variations are from 20 to 100 volts or a total voltage swing of 80 volts and the voltage variations across the tube are from 220 to 140 volts.

In other words, the plate current swings up and down this load line about its average value of 19.0 mA. and has a maximum value 31.5 mA. and a minimum value of 6mA.

The d.c. power used up in the plate of the tube is $E_p \times I_p$ or the area of the rectangle EODC and is equal numerically to 180 × .019 = 3.42 watts. Similarly the power used up in the load is $I_p \times E_L$ or the area of the rectangle OFBD and numerically is equal to 60 × .019 = 1.14 watts. These powers are being used in heating the plate and the load resistance, regardless of whether there is any a.c. voltage on the grid or not. Their sum, 4.56 watts must come from the B battery.

When an a.c. voltage is applied to the grid, a.c. power appears in the load resistance. The product of the r.m.s. values of current through and voltage across the load will give the power in the load. The maximum value of the a.c. voltage, e, across the load is H_g or 40 volts and the maximum value of current, i, is OH or 1.3 mA. Since the r.m.s. value may be obtained by dividing the maximum value by $\sqrt{2}$ we may get the power in the load as

$$\frac{e \times i}{\sqrt{2} \times \sqrt{2}} = \frac{e \times i}{2} = \frac{H_g \times OH}{2} = \frac{40 \times .013}{2} = 260 \text{ m.w.}$$

This represents the area of the triangle OGH.

Since the d.c. power supplied from the plate battery is constant, the a.c. power in the load must be added to the d.c. power used up there, and must be subtracted from the power wasted on the plate of the tube. When the grid is excited by an incoming signal, less power is used up in the tube, and the plate of a large power tube will actually run cooler when signals are applied to it.

PROCEDURE

Using the data in Table I, plot the "family" of E_p-I_p curves. Assume mu = 8, calculate (1) the plate resistance, R_p, (2) the proper load resistance, R_o, for maximum undistorted power output, (3) the load line, AOB, assuming a plate voltage actually on the tube of 135 and a grid bias of minus 9 volts. Calculate the d.c. power lost in the tube, and in the load, and the a.c. power in the load when the grid swings a maximum of 6.5 volts, that is from the E_g = −2.5-volt line to the E_g = −15.5-volt line. Draw in the rectangles representing the d.c. powers, and the triangle representing the a.c. power in the load. Calculate the total power supplied from the B battery, and, assuming the efficiency of the tube and circuit is the ratio between a.c. power in the load and the total d.c. power supplied from the battery, calculate the efficiency of the system. (Efficiency = $\frac{\text{a.c. power in load}}{\text{d.c. power from battery}} \times 100\%$)

TABLE I

E_p	$E_g = 0$	2.5	5.0	7.5	9.0	11.5
40	3					
60	6	3				
80	11	6	3			
100	16	11	6			
120		16	11			
140			16			

I_p (m.a.)

PROBLEMS

1. The power output of a tube is equal to

$$\text{power output} = \left(\frac{\mu E_g}{R_p + R_o}\right)^2 \times R_o$$

where E_g is the input r.m.s. voltage. Calculate the power output of the tube whose characteristics you have plotted. Compare this value with the value secured from the graphical method.

2. Do you know why the area of the triangle is the a.c. power in the load?

3. Using the above formula calculate the power output if $R_o = R_p$ and the efficiency of the system using the values of E_p, mu, etc., used in the experiment.

4. Using the above formula, plot a curve showing the power output from a 171 tube as the input a.c. r.m.s voltage is increased from zero to 37 volts.

5. Does more power come from the B battery when the grid of the tube is excited?

6. Does the output voltage of a B power unit change when the tube is supply a.c. power—or is the output voltage constant regardless of whether the tube is amplifying signals or not?

Note: Readers may send the answers to these questions to the Editor to be checked.

AS THE BROADCASTER SEES IT

BY CARL DREHER

Photographic Data For Broadcasters

H. B. MARVIN, during the discussion on his paper, "A System of Motion Pictures with Sound,"* said, "The latter (variable area type of sound record on film) requires a sound track which has a high degree of contrast and that is all. We aim at an exposure which will give us a density of 1.3 and develop to a gamma of 1, but these are not critical. The variable density system requires fairly close control of exposure and development in order to eliminate distortion. . . ."

It is as necessary for broadcast engineers who are transferring their allegiance to sound motion pictures to learn something about the photographic end of the business as it is for the movie people to acquire some familiarity with audio-frequency technique. While almost everyone knows something about photographic contrast, development, etc., a more scientific understanding of such terms is required by the professional. A useful work in this field is *Photography as a Scientific Implement*, written collectively by a group of authors, published by Blackie and Son, Ltd., in England, and distributed in the United States by the D. Van Nostrand Company. Chapter IV, on "The Theory of Photographic Processes and Methods," by S. E. Sheppard, is referred to in the present discussion of photographic exposure and development, which is not intended as more than an introduction and basis for further study.

We may begin with a few definitions. The *opacity* of a photographic image is defined as the ratio of the incident normal light to the emergent light. The *transparency* is the reciprocal of the opacity. It follows that opacity may theoretically be anything from one to infinity while transparency varies between zero and unity, the latter corresponding to perfect transparency. The Briggs logarithm of the opacity is called the *density*. The electrical engineer will note the analogy to transmission of energy along telephone lines. The ratio of the electrical energy impressed on a line to the energy received at the other terminal is analogous to the opacity of a photographic image in the field of optics, and the TU method of reckoning transmission loss and gain corresponds to photographic density, which is likewise a logarithmic function (See RADIO BROADCAST for September and October, 1926, pages 405 to 408 and 506 to 509, respectively, for a discussion of telephonic gain and the standard transmission unit).

Transactions, Society of Motion Picture Engineers, XII, No. 33, p. 86, 1928.

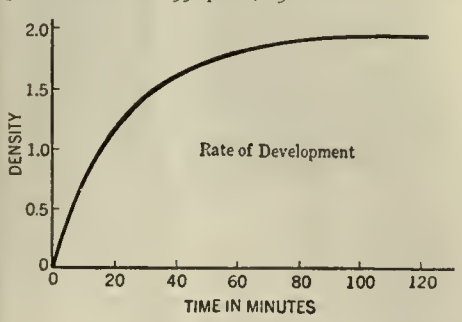


FIG. 3

It may be shown experimentally that, approximately,

$$D = pM$$

where D is the density, p is a constant, and M is the mass of metallic silver per unit area on a negative. The photographic process is essentially the transformation of silver from the ionic to the metallic state. The above terminology and relationship were worked out by the photometric physicists Hurter and Driffield, and they also introduced the characteristic curve of a plate or film shown below as Fig. 1, in which densities are plotted as ordinates against $\log_{10}E$, E being the *exposure*, which is the intensity of the light to which the plate was exposed multiplied by the time of exposure.

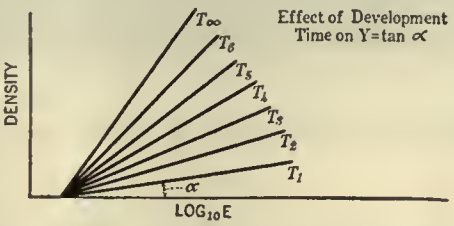


FIG. 2

This photographic characteristic curve which, it will be noted, is similar in shape to the static plate current-grid voltage graph of a vacuum tube, shows the relationship between two logarithmic functions: that of the opacity of a negative and the degree of exposure to light which produced the opacity. The region convex to the X-axis at the left is known as the *region of under-exposure*; the middle part, which is sensibly a straight line, is called the *region of correct exposure*; the portion to the right where the curve bends and becomes concave to the X-axis is the *region of over-exposure*. In the middle, where the curve is straight, the slope or tangent of the angle which the straight line makes with the X-axis is called the *development factor* (*gamma*). It is a convenient measure of the photometric contrast of the negative in question, and is also known as the *contrast factor*. Mathematically the straight line portion of the curve is represented by the equation

$$D = \gamma (\log_{10}E - \log_{10}i)$$

where D is the density, γ (gamma) the development factor of the negative, E the exposure (intensity of light x time) and i is a constant corresponding to the value of the exposure where the extended straight line cuts the X-axis. If E is held constant, therefore, it follows that $D = k\gamma$, that is, the density equals a constant times gamma.

However, there is more to the idea of gamma than the relation of density to exposure. The chemical development also plays a part, and in general the value of gamma increases with the time of development up to a limit of extreme contrast, called gamma infinity (γ_∞). Fig. 2 shows a family of curves illustrating the variation of gamma with the time of development T, up to the maximum T_∞. For each time of development there is a definite value of gamma corresponding to the slope of the line, and a definite linear variation of density with degree of exposure. All the curves intersect at the point $\log_{10}i$ on the horizontal axis.

The value of gamma, while it increases with time of development, does so at a decreasing rate (since less and less silver remains to be acted on) and ultimately reaches a limit which is largely fixed by the constitution of the plate in question. If plates which have been given a series of exposures increasing in geometrical proportion are subjected to different development times and the resulting densities are measured, a graph of density against time of development has the saturation form shown in Fig. 3. The decreasing slope is what would be expected. It is the same picture as that of a temperature-time variation in a heat run on a transformer, or many other chemical and electrical processes.

The meaning of Marvin's statement as cited above should now be clear. It indicates that in the process of sound recording by the variable area method the exposure is regulated so that the density, as plotted in Fig. 1, would be about 1.3 (corresponding to an opacity of almost 20) and subsequent development is timed so that, in Fig. 2, the appropriate curve would be one making an angle of 45 degrees with the horizontal axis and therefore having a tangent of 1.0. Of course, as far as regulation of exposure goes, the time is fixed by the constant movement of the film at the rate of 90 feet per minute, but the result desired may be secured by properly setting the intensity of the recording light, which is constant in the variable area system of recording. In the variable density system, since the recording is accomplished by audio-frequency variations in the intensity of the light source, it is difficult to avoid wave form distortion caused by movement above or below the straight portion of the characteristic of Fig. 1.

To some of the boys who are more given to reading *Liberty* than poring over technical treatises, the above discussion may seem unduly theoretical. If it seems so, it is merely because they are not at home in the field of photography, which, being older than radio, has a more extensive literature and at least as involved a technique. The discussion, as a matter of fact, is most elementary and less technical, probably, than much of the broadcast material which has appeared in this department in past years. The trouble is that it involves penetration of a new field to those of us who come from the radio side of the business. An understanding of it is indispensable to anyone who wants to approach such

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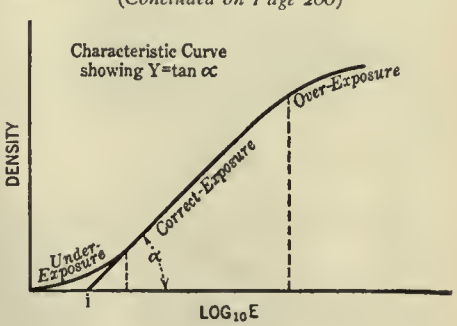
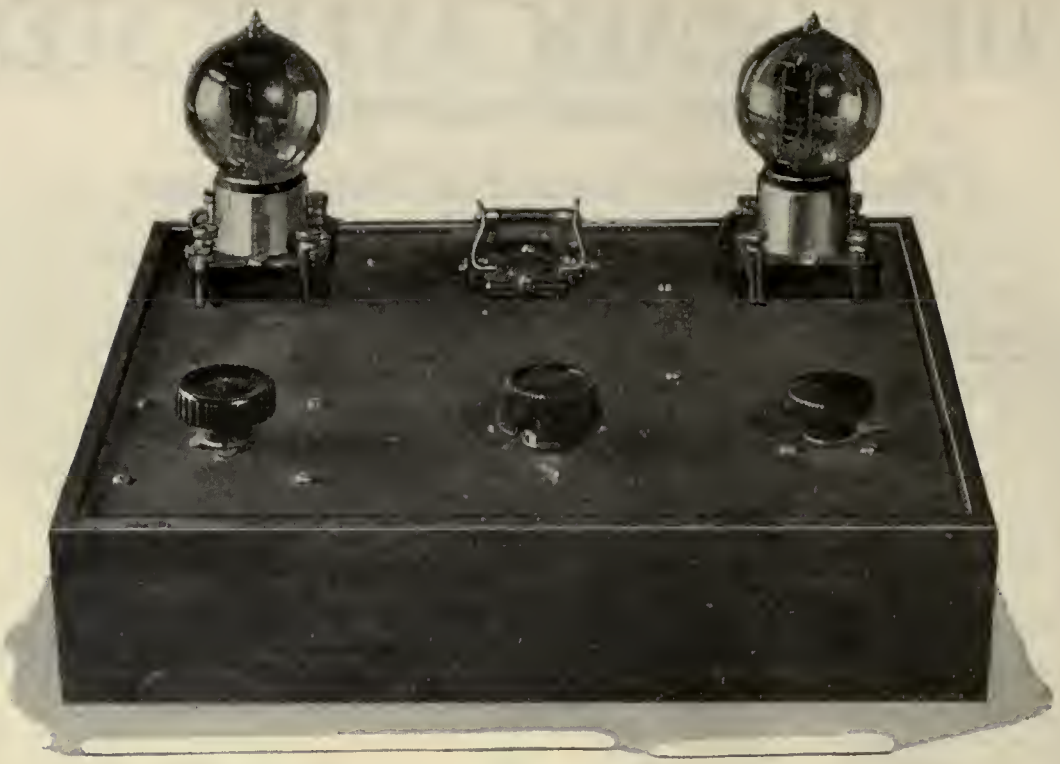


FIG. 1



GENERAL VIEW OF HOME-MADE AUDIO OSCILLATOR

An Inexpensive Audio Oscillator

By EDWARD STANKO

ONE of the greatest problems that confronts the average experimenter is the lack of adequate apparatus for conducting the tests that are so vitally important to the final outcome of the experiment. In nearly all cases the cost of the apparatus involved in making an experiment which leads to an authoritative answer places it beyond the reach of the individual. It was with the idea of solving this problem that the writer spent considerable time in designing the inexpensive audio-frequency oscillator presented in this article.

The various experiments and measurements to which an oscillator of this type may be put to use are not only quite varied, but at the same time quite useful. In connection with measuring the frequency characteristics of audio-frequency amplifiers, this oscillator has proved itself indispensable. Amateur or commercial radio stations may use it in place of the usual buzzer to modulate the carrier. In the broadcasting field, the oscillator may be used for lining up telephone circuits which connect the broadcasting station with remote apparatus. Many other uses may suggest themselves to the experimenter, such as determining the frequency characteristic of an audio-frequency transformer, filter coil, loud speaker, etc.

THE CONSTRUCTION OF THE UNIT

THE oscillator which is described here is made up of two component parts, the oscillator proper and the one-stage amplifier. For practical purposes it is desirable to have this stage of amplification built in the same housing, and combined with the oscillator to make one complete unit.

In constructing this oscillator, it is first necessary to obtain a Ford ignition coil (or some similar spark coil), such as used on the model T car. A photograph of this unit is shown at the left in Fig. 1. The wooden housing, which the ignition unit is molded in, is carefully removed with a screwdriver. While the process of dismantling the unit is in progress, an electric soldering iron should be kept handy for unsoldering all of the connections on the inside of the housing. When the entire housing has been removed, place the ignition unit in a moderately warm oven. After it has been given a thorough warming, remove the unit from the oven and cut off with a knife all of the surplus insulating compound in which the coils and condenser are imbedded. Remove the paper condenser and lay aside. It will be used later. Dig around in the insulating compound until the primary winding of the coil is located. The primary winding can be easily distinguished from the secondary by noting the size of the wire. The primary is larger in diameter than the secondary. When this winding is found, the wire is pulled out endwise until all of the wire is removed from the iron core. Care should be taken not to damage the secondary winding while the primary is being removed.

When the ignition unit is completely dismantled, as shown in the center in Fig. 1, it will be necessary to locate the secondary leads. The two outside leads will not be hard to find as they are at the extreme ends of the two secondary coils. The difficult problem is to locate the connection that connects the two secondary coils in series. This connection is usually found between the secondary coils imbedded in the insulating compound. Progress at this stage must be very slow, as considerable pains should be taken not to damage any of the windings or leads. When this connection is located, cut the connection at the center. Flexible wires are now soldered to all of the leads that extend from the two coils.

The unit is now ready for reassembly. The simplest and easiest way of assembling these parts is to get a tin can that will accommodate the two secondary coils and the iron core. Place the coils in the can, one on top of another, slip in the iron core and center it with respect to the secondaries with small wooden wedges. Pour the can full of hot paraffin and let it cool. When the paraffin has hardened, warm the can over a gas flame or immerse it in a bucket of hot water. After

THE oscillator which Mr. Stanko describes uses apparatus that nearly every experimenter has, or can obtain. It will generate audio frequencies from about 60 to 5000 cycles, which is sufficient range to conduct any and all tests on present-day audio apparatus. In the Laboratory, a similar oscillator has been in use for several years; we used a push-pull output transformer instead of a Ford coil, but the results are the same. The values of capacity indicated as C_1 in the circuit diagram must be determined experimentally. The larger the capacity the lower the generated frequency. The Laboratory Staff will be glad to learn of other apparatus of similar nature that experimenters have developed.

—THE EDITOR.

warming the can for a few minutes, turn it upside down and the unit will slide out in the shape of the mold. A simple and effective mounting can be made by getting a copper or brass strip, one inch wide and six inches long, and bend to shape as shown in Fig. 3. Twenty or twenty-two gauge strip will do nicely. As a safeguard it might be well to mention that if the copper strip is wrapped with rubber or friction tape the chances of short-circuiting any of the oscillator connections will be greatly reduced. The assembly should look like the right-hand view in Fig. 1. at this stage of the construction.

When using the oscillator for making certain measurements, the input to the system under test must be maintained at some constant value. As the output of the oscillator varies with the frequency generated, it is obvious that there must be some means for controlling the power output of the oscillator. Not only must we have some means of controlling the gain of the oscillator, but the gain control must be of a type that will permit the output of the oscillator to be varied without changing its frequency.

After experimenting with several types of gain controls, the constant-impedance type was chosen. This control, R_2 in Fig. 4, is composed of two 600-ohm Federal potentiometers mounted back to back on a piece of thin bakelite. The method of mounting them is shown on Fig. 2 A single shaft is used to rotate both of the potentiometers. If the wiring diagram of the constant-impedance control is traced out, it will be found that as the resistance is increased in one of the potentiometers, the resistance is decreased in the other, thereby keeping the impedance, which is the sum of these resistances, at the same

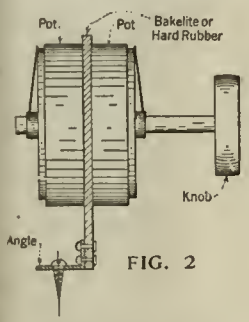


FIG. 2

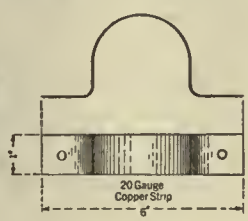


FIG. 3

value at any position of the control. Two grid condensers, C_2, are employed in this circuit, a 0.005-mfd. capacity for frequencies below 500 cycles per second, and a 0.00025-mfd. capacity for frequencies above 500 cycles. A grid leak of two megohms seems to be about right. The paper condenser from the Ford coil, C_3, is used in the primary circuit of the audio transformer to keep d.c. out of it.

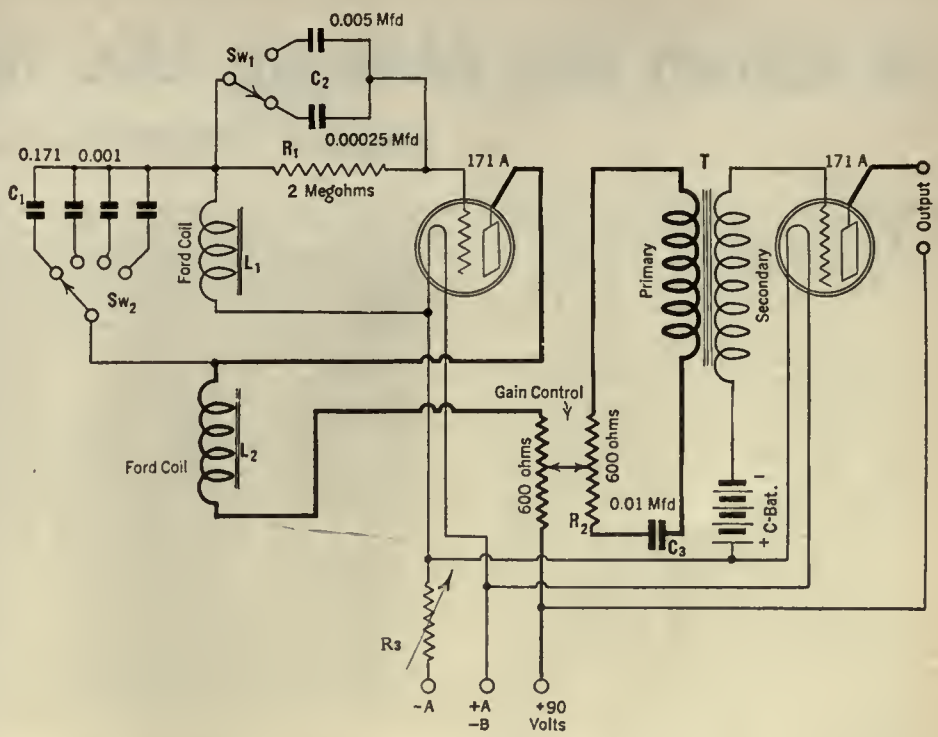


FIG. 4

This is the complete circuit diagram of the home-made audio oscillator described in this article. Note that the two 600-ohm potentiometers, R_2, are mounted on the same shaft

PRELIMINARY TESTS

WHEN the oscillator and amplifier have been wired up as shown in Fig. 4, the unit should be given a preliminary test. Connect batteries, light tubes, place a loud speaker or pair of headphones across the output, then move, switch, Sw_1, so that the 0.00025-mfd. condenser is connected in the grid circuit. Set switch Sw_2 on an open point, that is, so there is no capacity across L_1. The oscillator should immediately go into oscillation, generating a frequency around five- or six-thousand cycles per second. If the oscillator fails to work, check up on the wiring, particularly at the coil connections. If one of the coils is reversed, the oscillator will refuse to work and one or the other of the coils must have its connection reversed. When the oscillator is working properly a frequency of about 1000 cycles can be tried. To do this leave the grid condenser on the 0.00025-mfd. tap. Move switch Sw_2 so that the 0.0001-mfd. fixed condenser is shunted across L_1. If everything is working properly with this arrangement, a frequency around 1000 cycles should now be heard. Throw switch Sw_1 so the 0.005-mfd. condenser is connected in the grid circuit. Move switch Sw_2 so that the 0.171-mfd. condenser is across L_1. The oscillator should be now generating a low-pitched frequency around 100 cycles. If the oscillator refuses to work at this low frequency, use a larger grid condenser. However, it has been found that if the grid condenser was kept at the smallest possible capacity that would keep the circuit oscillating, the harmonics were considerably reduced. No attempt is made to give the exact numerical figures for the fixed condensers used across L_1, as the condensers manufactured by some concerns vary to such a degree that it would be entirely out of the question to attempt to build an oscillator from directions given that would be accurate enough for calibration purposes without first comparing the generated frequency with some known standard. However, capacities for several frequencies are mentioned.

The oscillator will generate audio frequencies from 60 cycles up to six-or seven-thousand cycles per second, depending upon the capacity of the

(*Concluded on page 200*)



FIG. 1. METHOD OF REBUILDING FORD SPARK COIL FOR USE IN AN AUDIO OSCILLATOR

The picture on the left shows the spark coil in its original case, the picture in the center shows the secondary coils and core which have been removed from the spark coil, and the illustration on the right shows the secondary coils and core mounted for use in the oscillator

A Chart for Making DX Measurements

By JAMES B. FRIAUF, Ph. D.

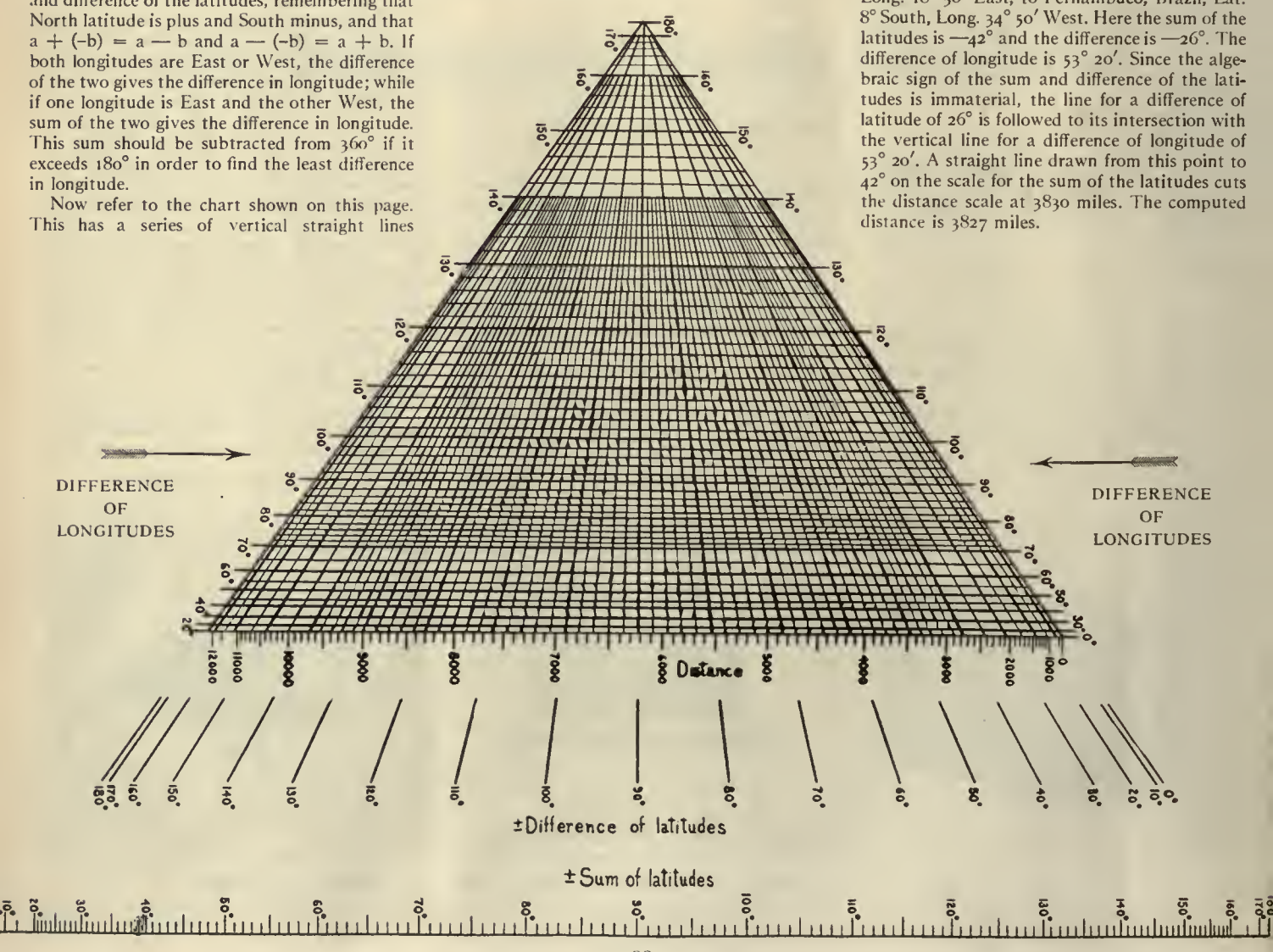
DUE to the use of short waves for broadcasting purposes it is possible for the broadcast listener to hear stations from distant continents as well as from the far corners of his own continent. In many such cases the DX enthusiast wishes to know the distance to the station which he has heard. This distance cannot be obtained directly from a map when the sending and receiving stations are widely separated, but can be computed by one of the formulas of spherical trigonometry when the latitudes and longitudes of the two stations are known. The computation is somewhat long and tedious, however, and the result obtained may be seriously in error unless the work is carefully done. For this reason the chart which accompanies this article has been prepared for the purpose of making the computation graphically. The use of this chart requires no knowledge of trigonometry, and the result is obtained in very much less time than is required to compute the distance.

The chart is for determining the distance between any two stations of known latitude and longitude. Hence, the first step in the use of the chart is to find the latitude and longitude of each station. This may be taken from a map with sufficient accuracy. Then find the algebraic sum and difference of the latitudes, remembering that North latitude is plus and South minus, and that $a + (-b) = a - b$ and $a - (-b) = a + b$. If both longitudes are East or West, the difference of the two gives the difference in longitude; while if one longitude is East and the other West, the sum of the two gives the difference in longitude. This sum should be subtracted from 360° if it exceeds 180° in order to find the least difference in longitude.

Now refer to the chart shown on this page. This has a series of vertical straight lines for the difference in longitude, and a series of straight lines radiating from a point at the left of the chart for the difference of the latitudes of the two stations. Find the line corresponding to the difference of the latitudes. These lines are marked at 10° intervals on their extensions into the space between the distance scale and the scale for the sum of the latitudes, and are marked "$\pm$ Difference of latitudes". The same line is to be used whether the algebraic sign of the difference of latitude is plus or minus. Follow this line to its intersection with the vertical line corresponding to the difference of longitude. From the intersection of these two lines, pass a straight line to the sum of the latitudes on the scale marked "$\pm$ Sum of latitudes," and here again the algebraic sign is immaterial. This straight line intersects the scale marked "Distance" at the distance, in land miles, between the two stations. It is advisable not to draw the straight line with a pencil since this would confuse the chart for future use, but to use a stretched thread or a piece of transparent celluloid with a straight line scratched on it.

A few examples will help to make this clear. Suppose that it is desired to find the distance from New York, Lat. 40° 40′ North, Long. 74° West, to Melbourne, Australia, Lat. 37° 50′ South, Long. 145° East. The sum of the latitudes is 40° 40′ + (−37° 50′) = 2° 50′; the difference of the latitudes is 40° 40′ — (−37° 50′) = 78° 30′. Since one longitude is East and the other West, the sum of the two should be taken, and since this sum, 219°, exceeds 180° it should be subtracted from 360° to give 141°. This is the difference in longitude between New York and Melbourne measured the short way around. The line for a difference of latitude of 78° 30′ is not drawn on the chart but would be one quarter of the way from the 78° line to the 80° line. Follow this to its intersection with the line for a difference of longitude of 141° which would be half way between the lines for 140° and 142°. From this point pass a straight line to the sum of the latitudes, 2° 50′, which is close to the lower end of the scale for the sum of the latitudes. This line cuts the distance scale at 10,350 miles which is the distance from New York to Melbourne. The distance computed from the formula is 10,360 miles.

A second example is furnished by the distance from Cape Town, South Africa, Lat. 34° South, Long. 18° 30′ East, to Pernambuco, Brazil, Lat. 8° South, Long. 34° 50′ West. Here the sum of the latitudes is —42° and the difference is —26°. The difference of longitude is 53° 20′. Since the algebraic sign of the sum and difference of the latitudes is immaterial, the line for a difference of latitude of 26° is followed to its intersection with the vertical line for a difference of longitude of 53° 20′. A straight line drawn from this point to 42° on the scale for the sum of the latitudes cuts the distance scale at 3830 miles. The computed distance is 3827 miles.



Armchair Chats on Short-Wave Subjects

By ROBERT S. KRUSE

THE writer now understands perfectly the feelings of an actor who is pushed suddenly on the stage and told to "fill" until some delay back stage can he "unscrambled." Luck is certainly with him if he has practiced something that is not included in the regular performance of the show.

This is a complicated way of explaining that the article describing a short-wave receiver, which had been scheduled tentatively for this issue, has been held over because of some changes on the part of a manufacturer who suddenly made it impossible to obtain certain apparatus which had been selected for use in the final version of the set. Of course, it would have been possible to substitute other parts but the time available prior to publication was insufficient to permit checking thoroughly the sensitivity and selectivity of the revised receiver. Therefore, as a matter of policy the receiver will not be presented, as it is considered unwise to describe a set before it has been tested, even if one feels sure of the results. As a result it is a case of "Better late than—early," and the receiver will retire for the present in favor of the assorted comments on short-wave subjects which form the basis of this month's article.

> This month's subjects include "Push-Pull Vs. Back-to-Back Circuits" and "Short-Wave Reception Troubles"

Push-Pull Vs. Back-to-Back

SEVERAL correspondents simultaneously have requested a brief and simple explanation of the differences between "back-to-back" and "push-pull" circuits. Unfortunately this is not a subject which lends itself to brief treatment, but in the following paragraphs an endeavor will be made to cover the more important aspects of the two transmitting systems.

Although the term usually is applied to audio-frequency amplifiers, the "push-pull" system is also used in many radio-frequency amplifiers and oscillators. On the other hand, because it is employed only in oscillators, the "back-to-back" system belongs exclusively to the transmitting fraternity. Both circuits always require the use of at least two tubes, but there are several important differences in the ways the tubes are connected. In order to appreciate fully the features of the two systems it is necessary to study carefully the circuit diagram of each. For the purpose of this comparison four versions of the old standby oscillator circuit devised by R. V. L. Hartley have been selected (see Fig. 1).

In diagram A of Fig. 1 we have a standard shunt-feed one-tube Hartley oscillator with a dotted line separating the tuned circuit, L_1C_1, from the tube and its plate supply, stopping condenser, and grid leak. The terminology employed is standard, R. F. C. being the r.f. choke coil, C_p the stopping condenser, and C_g and R_g the grid condenser and leak, respectively. Of course, it is understood that C_p and C_g both have capacities larger than the capacities of the tube; therefore, they do not affect the tuning, but serve only to keep the d.c. plate supply out of the r.f. tuning system to the left of the dotted line.

In diagram B of Fig. 1 is the schematic circuit of a shunt-feed Hartley oscillator with two tubes connected in parallel. It should be noted that in this diagram there is no fundamental difference in the circuit; in fact, the apparatus to the left of the dotted line has not been changed, nor have any additional feed chokes been added. It would even be possible to connect the grids of the two tubes directly together and use a single grid leak and condenser. However, smoother operation usually is obtained with the arrangement shown.

THE BACK-TO-BACK SYSTEM

THE diagram of a Hartley oscillator with two tubes connected "back-to-back" is given in diagram C of Fig. 1. This circuit appears very similar to diagram B but its operation differs in an important manner, even though the tuning system to the left of the dotted line has not been changed. Whereas in diagram B the two tubes operate simultaneously, an analysis shows that in diagram C they operate alternately, due to the fact that each tube operates only when its plate is positive. A comparison of the two circuits will quickly show the difference between them; in circuit B the plates of both tubes are supplied with current which flows through the choke coil, R. F. C., but in circuit C the currents for tubes Nos. 1 and 2 pass through separate choke coils, R. F. C_1 and R. F. C_2, which are connected to the two high-voltage terminals, M and N, of the power transformer, T_r, the center-tap terminal of which is connected to the filaments of the two tubes. Therefore, when M is positive tube No. 1 operates, but at this instant N is negative and tube No. 2 is inoperative.

THE PUSH-PULL ARRANGEMENT

THE circuit arrangement in diagram D of Fig. 1 shows an oscillator with two tubes connected in "push-pull". This arrangement has features which are similar to both B and C, but the operation of the system is quite different from either of the former circuits. Neglecting the dotted lines of the diagram and tracing the connections, it will be noted that the plate power, which is supplied to the center-tap connection of the coil L_1, flows in both directions through the coil to the plates of the two tubes. Therefore, the two plates are at the same potential as far as the power supply is concerned, but the r.f. voltage between them is obviously the entire voltage across the tuned circuit L_1C_1. Accordingly, we may say that in diagram C (back-to-back)the plates are at opposite sides of the *plate-supply cycle*, while in diagram D (push-pull) the plates are on opposite sides of the *radio-frequency cycle*. Conversely, the plates of the tubes in the back-to-back system are connected together through two large condensers and, therefore, have no *r.f. voltage* between then, while the plates of the tubes in the push-pull system are connected together by wire and have no *low-frequency voltage* between them.

In the above paragraph, we believe, the important differences between "back-to-back" and "push-pull" oscillator circuits have been clearly explained. However, some readers may be interested in the relative merits of the two systems. We shall, therefore, devote some space to this subject.

An important feature of the back-to-back system is that by careful adjustment of the various condensers, choke coils, etc., it is possible to obtain a r.f. output with a low modulation, i.e., a good tone. From the viewpoint of the reader this may prove a very unexpected conclusion, but let us study the action of the tubes. Inasmuch as the tubes are supplied with pure a.c. one would expect that tube No. 1 would oscillate briefly for 60 periods each second —if 60-cycle current is used—and that tube No. 2 would go through the same performance while No. 1 is resting, i.e., each tube would operate for $\frac{1}{120}$ of a second, or during one half of each cycle (see diagram A of Fig. 2). If this were true the r.f. output of the transmitter would be similar to the curve in diagram B of Fig. 2. In practice, however, this is not exactly what takes place in the tuned circuit, L_1C_1, of Fig. 1C. On the other hand, by careful adjustment it is possible to make each tube oscillate for more than one-half cycle, and, since this is true, it is evident that the r.f. output may be much smoother than indicated in diagram B of Fig. 2, as the train of oscillations of one tube

The Japanese Schoolboy's "Q" Signals

AT THE late International Radio Conference at Washington, D. C., many curious things were said and done, but a special height of foolish sublimity was attained in the new list of "Q" signals and their definitions.

It is not known just why anyone felt that it was necessary to tinker with the old list, but one can say with some certainty just who was retained to write the definitions of the abbreviations. It was positively *Hashimura Togo, Wallace Irwin's Japanese schoolboy. The inspired ability to choose the wrong word, the faultless gift for reversed word order, the special genius for associating ideas that have no connection —all are present.*

Hashimura has exceeded his Saturday Evening Post *performances in some ways, perhaps because the opportunity was so good. The "Q" Signals are so called because they all begin with that uncommon letter, and since the meaning of each is purely arbitrary Hashimura had free rein. Thus, he was able to use the abbreviation "QSF?" to mean "Is my automatic transmission good?" and to make the corresponding statement read "QSF" "Your automatic transmission fades out," Of course, only God and Hashimura know what conceivable connection there may be between fading and quality of keying.*

Again he was able to go through the list of questions, carefully removing the word "Shall" from each and replacing it by "Must" to secure the desired Asiatic flavor.

Again he was able—but why go further? Who let this silly set of definitions escape without proof reading of a capable sort?

—R. S. K.

overlaps that of the other tube. Diagram c of Fig. 2 is an oscillogram of one tube operating for a period of more than one-half cycle.

PUSH–PULL FEATURES

THE outstanding feature of the push-pull radio-frequency arrangement is less manifest than that of the back-to-back device. European writers consistently inform us that they are able to produce oscillations of a higher frequency and better stability with such circuits than with single tubes. I am quite unable to find similar results in either regard, nor do I see any theoretical basis for the belief. It is, of course, quite possible that the use of series feed via a center-tap connection may result in smoother tuning over a range of frequencies, because one avoids the troublesome natural frequencies and varying reactance of the feed choke. However, this is beside the case since the push-pull (or balanced) circuits have no monopoly over this method of feeding. The push-pull circuits can be shunt fed as suggested by the dotted lines in diagram d of Fig. 1, and, on the other hand, single-tube circuits can be fed without chokes by using a neutral connection of the tuning system as the feed point. For example, in Fig. 3 we have the one-tube Hoffman version of the Colpitts circuit in which one avoids both plate chokes and grid-leak losses. Incidentally, this circuit escapes the tiresome tendency of the push-pull systems to generate two frequencies near each other but unfortunately not quite the same.

Short-wave Tuner and Adapter Troubles

THERE appears to be considerable confusion and uncertainty among the purchasers of short-wave tuners and "adapters" for short-wave reception. On the one hand perfectly excellent apparatus is being accused unfairly, while on the other hand good results are vainly being sought with equipment that is quite incapable of decent work and which is unfairly giving the short waves a bad name. Perhaps it will be well to go over the possibilities and difficulties.

First of all, what has one a right to expect?

Assuming that one has a well-made set in good order, there is still no certainty as to the results which will be obtained. While the reception between 200 and 550 meters changes greatly between day and night this change is as nothing compared to the corresponding change on some of the short waves. Very roughly, wavelengths between 13 and 55 meters may be thought of as the "daylight waves" which work better by day than by night, but always over rather long distances. At shorter ranges they are rather unreliable and often very weak. The waves above 55 meters have the more normal ability to go further by night than by day, although between 30 and 60 meters lie waves which not infrequently do good daytime work. On dark days even 80-meter waves come through rather well. The summertime shifts the best working wavelengths toward the shorter end of the spectrum, simply because there is more daylight. In all cases one may expect rather rapid changes during sunset or sunrise at either transmitter or receiver.

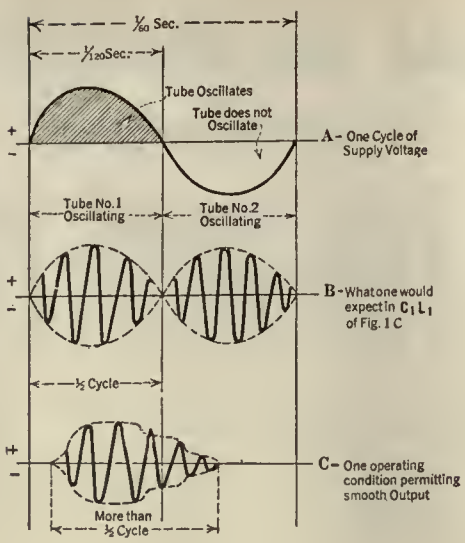


FIG. 2

With this rough set of rules as a guide one may begin to listen. However, at this point a very distressing difficulty may develop, namely, a "soupy" or "growly" audio quality that is entirely worthless as entertainment and often quite unintelligible. Such things happen in the 200–550 meter region at times, but not often or on all stations. But on short wavelengths every available station may be affected for an hour, a day, or a week, and in some locations the effect seems permanent! If the latter is the case, and one is sure that the tuner is not at fault, the short-wave idea had best be dropped. Usually, however, the effect is present only a portion of the time, and even then is seldom as prohibitive as the strong static which often mars reception on standard wavelengths.

Assuming now that we have managed to find signals and that they are decently free from the "audio-frequency fading" just mentioned, we may next proceed to determine the usefulness of the various available signals. On short waves it will be found that the strength of a signal has even less relation to the station's distance and power than is the case between 200 and 550 meters. Thus, at my own location the English station 5SW is somewhat stronger than WGY's various short-wave transmitters, though the latter are but 100 miles away and materially more powerful. Also, the English station fades far less. Usually it is the fading which determines the usefulness of a short-wave signal; if it is very bad one is subjected to such extreme changes of volume that all the pleasure is eliminated, especially as the effect usually carries with it the so-called "selective fading" which produces weird and unpleasant shifts of quality.

All this sounds as if the short-wave game were a most unreliable one and of no real value. This is by no means the case. If one will but accept its vagaries, and avoid them intelligently, when that is possible, one may hear quite an array of things with a short-wave receiver that would otherwise not "come in" at all. No inconsiderable part of this matter will arrive in good order and with steadiness as is shown by the occasional rebroadcasting of material received from another continent on a short-wave channel. Such work is usually done with a powerful initial signal. While it is true that a weak transmitter does occasionally put a strong signal into a remote region one still must not take seriously the claims of a broadcasting station which "broadcasts to the entire civilized world" with a 50- or 250-watt set.

Having agreed that the short-wave game is more of a sport and less of a utility than the standard waves, we arrive near the truth. Silver-Marshall's phrase, "The thrill bands" is correct. There is no thrill in the routine reception of a reliable station—but there is a possibility of a

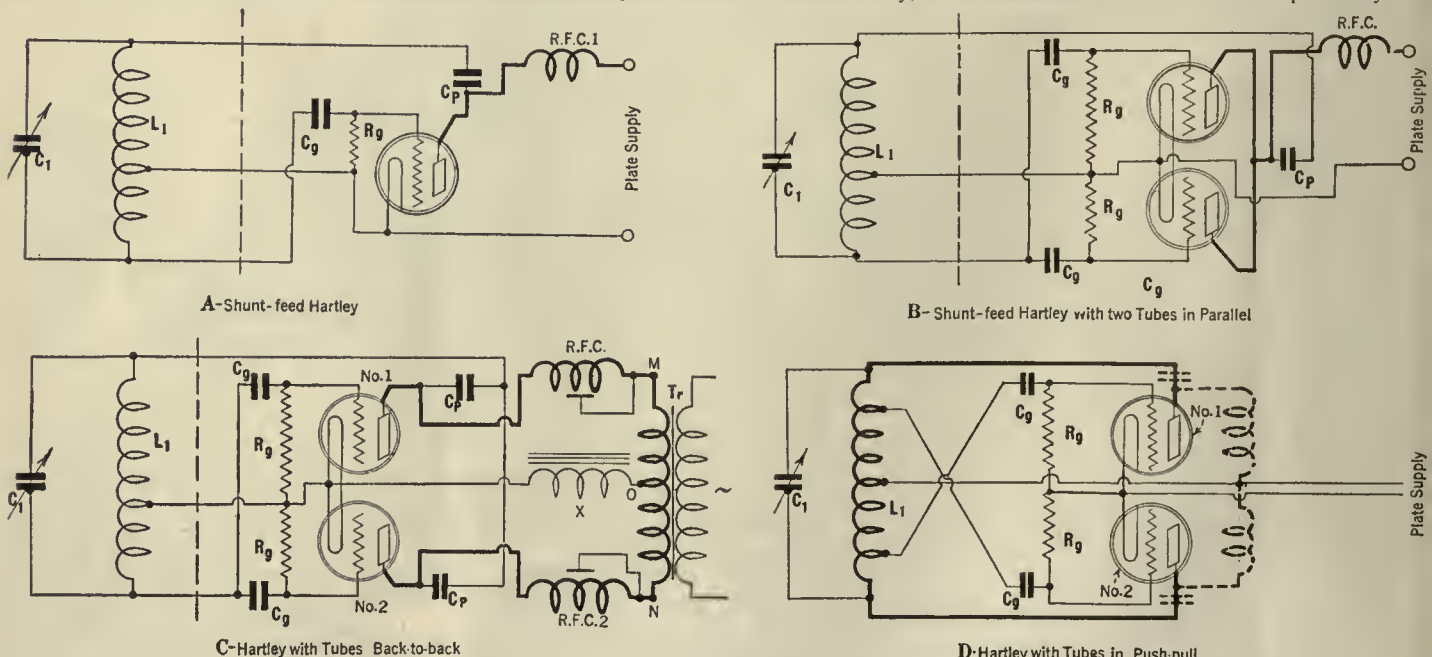


FIG. 1. FOUR POPULAR OSCILLATOR CIRCUITS FOR SHORT-WAVE TRANSMITTERS

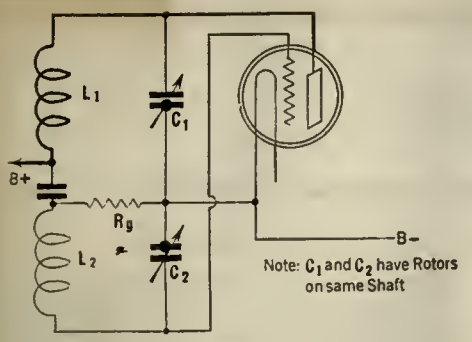


FIG. 3

thrill in fishing about among the short waves, uncertain of what one may land.

TROUBLESHOOTING—IN ADVANCE

IT MUST be repeated that there exists excellent short-wave equipment. Roughly it divides into three classes which can be thought of as (A) complete receivers, (B) short-wave tuners designed for use in connection with the audio amplifier of a broadcast receiver, and (C) short-wave adapters designed to autodyne or heterodyne the short-wave into an existing r.f. or i.f. amplifier, which may then handle it in the usual way. Since good and bad examples of each exist, one arrives at rather bewildering conclusions, making it hard to choose correctly, especially as the price does not seem to have a direct relation to the efficiency of the device. Fortunately, it is possible to lay down some rules that will be of help.

In types A and B we usually have a detector with a regeneration control. The coils may be of the plug-in type or a single coil may be used in the set. Before purchasing the set see if the regeneration control will cause the detector to oscillate over the entire tuning range of *each* coil. It is not serious if the oscillations fail below 15 meters or at the extreme ends (5 scale division or so) of other coils, provided there is enough overlap between coils so that this does not leave "blank" waves. Perhaps the best rule is to object if the set will not oscillate over the entire wavelength range without howling. The usual means of obtaining correct action should, of course, be tried. These include the use of a somewhat higher detector plate voltage and the use of several values of grid leaks between 1.5 and 8 megohms. If a means of loosening the antenna coupling is provided that also may be tried, and, if the tube is under suspicion, it may be changed. A reversed A battery will also cause trouble. If the set oscillates try the various coils in their sockets to make sure that a dependable contact exists. Finally, the tuning control and regeneration knob must operate smoothly, for, if there is any slipping or binding whatever, the tuner will be a constant aggravation. When the tuner is connected up it should be possible to operate both tuning and regeneration controls without a noticeable noise in the headset or loud speaker. One expects this from a standard-wave receiver as a matter of course, yet little attention seems to be paid to it by the makers of some of our short-wave jobs.

Type C may be simply a detector oscillating feebly and tuned to shift the beat-frequency wave into some existing broadcast amplifying system of a normal receiver. It is somewhat harder to locate faulty action in such devices, since one cannot detect the action as easily by listening. Close observation will make it possible, however, since one can hear the usual "rushing" sound whenever the oscillator or autodyne is working properly into the broadcast receiver. The most frequent failure of these devices seems to be a tendency to squeal, occasioned by the overanxiety of the designer to insure oscillation on all wavelengths. Generally this can be cured by reducing the plate voltage of the oscillator or autodyne tube. Where it is not convenient to use a lower battery voltage one may connect into the lead from the battery a high-resistance rheostat (500,000-ohm) shunted by a 0.1-mfd paper condenser.

TROUBLESHOOTING—AFTERWARD

SUPPOSING that one already owns the set, and finds that it must be made to work, several dodges are useful. First let us assume that there is difficulty in securing even oscillation—which means that one is also unable to secure smooth regeneration. If the coils are wound like Fig. 4A the difficulty probably lies right there, and rewinding the tickler with small wire, and bunching it as in 4B, will probably help materially. The number of turns can be determined by trial. Too many turns causes squealing, too few turns results in silence or feeble action. A fair rule is to start with $\frac{2}{3}$ as many turns on the tickler as on the secondary. After a rough adjustment has been made try changing the grid leak and plate voltage in an attempt to secure smoother action, always making sure that each coil of the set continues to work. Generally it is the smallest coil that causes trouble. Having obtained fairly smooth action one may find that, when a signal is tuned in, the regeneration control cannot be adjusted without having to retune; this is often true in circuits of the type shown in diagrams C and D of Fig. 4. However, this tuning effect of the regeneration-control condenser, C_2, can be reduced by moving the tickler coil, T, to the filament end of the grid coil, S, as in Fig. 4E, or if that is not convenient the control can be changed to the resistance type shown in Fig. 4F. In diagram F the condenser C_2 can be set for approximately the correct action and thereafter R is used with little or no tuning effect. Unless one wishes to lose the calibration ("logging") C_2 must then be left alone. R must be noiseless in operation, and, so far as I have been able to determine, the Frost resistor is the only one which meets this requirement for any length of time. Wire-wound or step-by-step devices are hopeless, as are the compression types.

The drive for C_2 (if used) may be through a plain dial, and in no case should a high-ratio "vernier" dial be used. The drive for C_1 should be the smoothest available. I have never found anything as beautiful in operation as the old-type National dial. Lest it be thought that undue emphasis is given the subject of dials one must consider that most short-wave tuners attempt to go from about 15 to 200 meters with perhaps 4 coils. In effect this means that one must cover about 20,000 kc. in going across the scale 4 times, as against some 1000 kc. for the scale of the usual broadcast receiver. With 5 times as cramped a scale, smooth operation is imperative.

As regards the type C devices which heterodyne the signal into an existing i.f. system, the combinations here become so numerous that one can hardly lay down general rules. However, a hint may be of value. If the short-wave heterodyne oscillator seems unwilling to work smoothly try converting the system into the circuit of 4F by connecting the primary of the first i.f. transformer to the points marked "output." The antenna may be connected to the grid end of the coil S (not to the grid but to the tuning condenser stator) through a small capacity of about 15 mmfd. (.000015 mfd.). A still better method might be to wind a single-turn primary around the lower end of the form on which S is wound. In either case there may be "dead spots, and" this always suggests overclose antenna coupling or a bad choke coil. The former is remedied by reducing down the capacity of a "vernier" condenser in the antenna — even where the primary is used! The latter is a matter of cut and try.

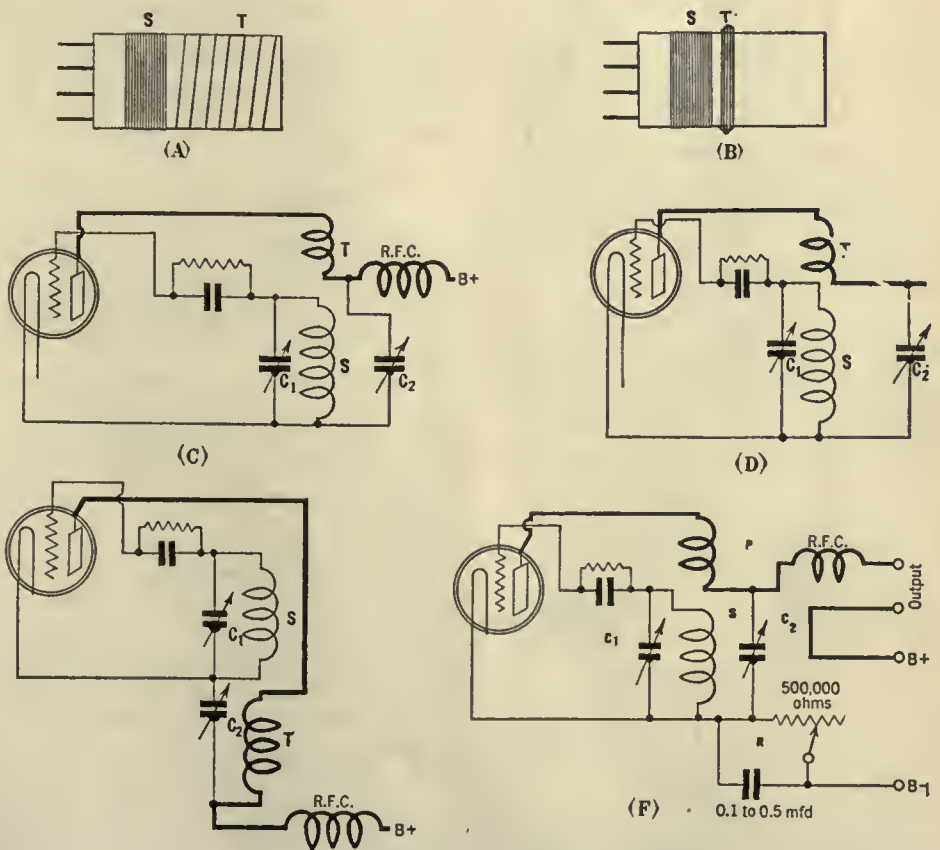


FIG. 4. SHORT-WAVE RECEIVING CIRCUITS

"Our Readers Suggest—"

THIS department of RADIO BROADCAST *is utilized each month for the presentation of miscellaneous short radio articles which are received from readers. These abbreviated manuscripts describe "kinks," radio short cuts and economies that the experimenter runs across from time to time and that can be made clear in a concise exposition. Although some of these notes have been submitted by engineers and professional writers, the editors particularly solicit contributions from the average reader. All material accepted, including photographs, will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas.*

—THE EDITOR.

A Simple Wave Trap

WHEN WLW opened up with full fifty kilowatts at Mason, about twenty miles from Cincinnati, I experienced a bit of interference from this station. Rummaging around the collection of used parts generally found in the enthusiast's shop, I speedily assembled the essentials of a simple wave-trap, and had it operating satisfactorily an hour after WLW came in the air.

While there is nothing new in the trap idea, or in the design advocated by the writer, the economy of the arrangement will recommend itself to many readers, particularly in these days of consistently increasing power.

The essential parts are a variable condenser, a standard r.f. coil to match the condenser (if coverage of the full wavelength range is desired), a panel, and a dial.

The primary and secondary connections to the coil should be definitely located. The primary winding generally can be identified by the initialing P and B+, and the secondary by G and F. If no stamping is apparent, as may be the case on some r.f. transformers, the secondary winding has more turns than the primary coil.

The condenser should be mounted on a small panel, about five inches square, and the coil mounted to the condenser frame. The secondary winding is then connected across the variable condenser. This completes the wave-trap, illustrated in Fig. 2.

The primary winding is connected in series with the antenna lead to the receiving set, the connections being indicated in Fig. 1.

D. H. BOYD, Cincinnati, Ohio.

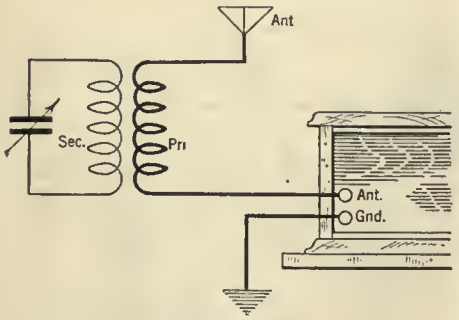


FIG. 1

The wave-trap circuit. The primary coil of the r. f. transformer is connected in series with the antenna lead.

STAFF COMMENT

The method of operation is simple. First, the receiver is tuned to the station *it is desired to eliminate*. The wave-trap is then adjusted until this station is weakest. Leaving the wave-trap at this setting, the desired station is now tuned in—generally with little or no interference from the first transmitter. If there is insufficient trapping action, five to ten additional turns of wire should be wound on the primary coil, in the direction of the original winding. Of course, the extra turns should be included in the antenna circuit.

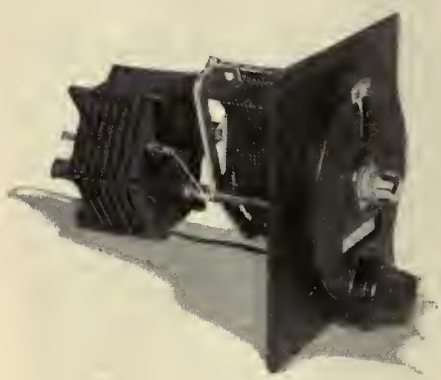


FIG. 2

A simple wave-trap made with a standard radio-frequency transformer and variable condenser.

A Source of Accurate Meters

EVERY experimenter needs meters to determine accurately the values of the current and voltage with which he is working. However, with reliable meters costing from $7.00 to $20.00 a piece, this important item is often necessarily neglected.

Accurate d.c. meters may easily be made from zero-center moving-coil ammeters readily obtainable at any automobile junk yard for fifty cents. Older models of high-priced cars were equipped with moving-coil instruments, such as Weston models 301 and 267. These meters have a 50-millivolt movement, and require from 10 to 20 milliamperes for full-scale deflection.

The shunt should first be removed from the meter, and the needle swung to the extreme left by moving both the zero adjuster and the corresponding adjustment found at the under side of the movement. The meter may then be calibrated as a low-reading milliammeter. By using shunts of proper values, milliammeters or ammeters of any range may be had.

The small operating current required by these meters readily permits their use as voltmeters having a sensitivity of from 50 to 100 ohms per volt by merely connecting the proper resistance in series.

EARL H. MILLER, Bellefonte, Pa.

R.F. Choke Coil

AN EFFICIENT radio-frequency choke coil of the plug-in type may be made from a burned-out filament ballast. The ballast tube should be wound with about 250 turns of number 34 silk-covered wire. The wire may be wound in a haphazard fashion and the ends soldered to the caps of the ballast plug.

This choke will be effective over the entire broadcast range and down to about 100 meters. For shorter wavelengths a 150-turn coil would be better.

ALLAN HAMILTON, Houston, Texas.

More Output Ideas

PUSH-PULL amplifiers generally are provided with an output transformer to which the loud speaker is connected. In some cases better results may be obtained by connecting the loud speaker directly to the primary through two 2-mfd. condensers, as suggested in the diagram Fig. 3. Posts 1 and 4 are used for any single loud speaker, while a very satisfactory combination of cone and horn loud speakers can be effected by connecting one reproducer to posts 1 and 2 and the other to posts 3 and 4.

H. M. THOMPSON, Vancouver, B. C.

A Band Selector for the Universal Receiver

I HAVE always been a booster of the RADIO BROADCAST Universal circuit, my only possible criticism of the arrangement being the lack of selectivity when operated in congested broadcast localities.

However, by utilizing the familiar link circuit, as suggested in Fig. 5, the selectivity was improved to an entirely satisfactory degree with a negligible loss of volume.

The following describes the coils indicated on the diagram:

Coil A, 10 turns wire on a $2\frac{3}{4}$ inch diameter tube;

Coil B, 48 turns of wire spaced $\frac{1}{4}$ inch from coil A;

Coils C and D each have 10 turns of wire on $2\frac{1}{2}$-inch tubing;

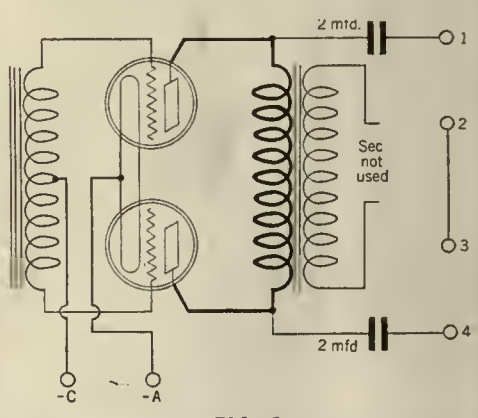


FIG. 3

An output arrangement that is occasionally superior to the transformer circuit, and which provides for one or two loud speakers.

Coil E is wound on a 2¾-inch tube with 48 turns of wire.

Coils C and D slip inside of coils B and E, respectively, permitting any desired variation of coupling.

The condensers tuning these coils may be ganged.

H. T. Gallaher, Rock Island, Ill.

STAFF COMMENT

The arrangement suggested by our correspondent functions in many respects as a band filter—a system of station discrimination that characterizes the best of modern receivers. The arrangement suggested in Fig. 5 can be applied to practically any receiving circuit, it particularly recommends itself for use with the receivers having only one stage of tuned radio-frequency amplification.

Frequency Compensation on Moving-Coil Speakers

MOVING-COIL speakers, when used with some types of audio amplifiers, have a tendency to over-accentuate the bass notes. The deep rumbling tone is a characteristic to which many people take exception when hearing this type of speaker for the first time. The cause is apparently due to a slight peak on the low tones in most of the present-day audio transformers, originally intended to make up for the losses suffered in the usual magnetic speaker.

I have found that a very simple filter can be inserted easily in the input stage to eliminate this effect. The secondary of an old audio transformer, with core removed, is connected across the primary of the first transformer through a variable high resistance of about 100,000 ohms. Any desired balance may be had by simply adjusting this resistance.

George H. Miller, Buffalo, N. Y.

STAFF COMMENT

The apparent preponderance of low notes when first using a properly baffled moving-coil speaker, is often a psychological contrast with the deficiencies of other loud speakers. The genuine cases of over-emphasis of low frequencies with which this department has had experience, were resonant effects, several moving-coil speakers having decided resonant peaks in the neighborhood of fifty cycles.

Over-reproduction of low notes, if the reader is convinced that such exists, can be corrected by moving the speaker slightly away from the baffleboard. By varying this distance, any degree of low-frequency response can be obtained.

This department editor's experience with moving-coil speakers has been more or less confined to high-frequency emphasis when the loud speaker is operated from a push-pull amplifier, employing the proper output transformer in the amplifier rather than that in the loud speaker. This substitution eliminates the high-frequency compensation circuit included in many speakers to flatten out the hump above five-thousand cycles. These high frequencies are, therefore, over-reproduced, with an unpleasant fringe on certain types of broadcasting, noticeably on tenor and baritone soloists.

This effect generally can be compensated by shunting a 0.00025-mfd. fixed condenser across the secondary of the first audio-frequency transformer.

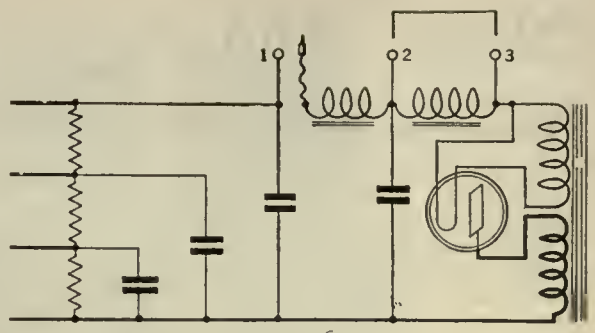


FIG. 6

Prearranging the power-supply circuit for the possible use of a moving-coil speaker with a high-voltage field-excitation coil.

Razor-Blade Condenser

THE fixed condenser described below is highly efficient and is constructed with rigid-metal air-spaced vanes. It costs but a few cents to make, as old safety-razor blades of the "Gillette" type are utilized.

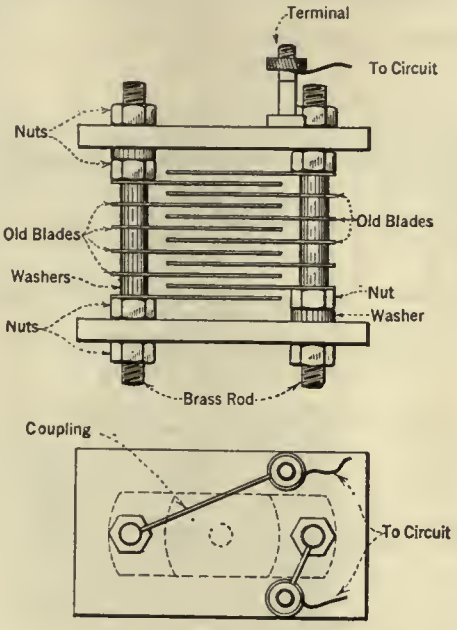


FIG. 4

A home-made razor-blade condenser. This air-dielectric condenser is excellent as an antenna series capacitor in short-wave transmitting circuits.

The materials needed for constructing the condenser will be found in the cellar or workshop of any radio enthusiast. The necessary parts include: two pieces of ebonite, each 3" by 2" by ¼"; two threaded rods, $\frac{3}{16}$" in diameter, and about 3½" long; eight nuts to fit the rods; two terminals; twelve "Gillette" razor blades; and twelve metal washers. Washers are placed between the blades to separate them properly.

In assembling the condenser, the two rods are bolted to the piece forming the base, a washer being added to one of them. The blades and spacing washers are then assembled alternately on the rods to interleave without touching, adding a washer to the other rod to level the top when all the blades have been added. The two top nuts are then screwed down tight, and the top ebonite plate, with terminals mounted, is bolted in place. The connections are made as suggested in the diagram, Fig. 4. A test should be made to determine that the vanes are not "shorting" and the condenser is then ready for use.

The condenser will have a capacity of about 0.0001 mfd., and it will prove as satisfactory as the best condenser of this type on the market. By increasing the number of blades, one may, of course, increase the capacity.

Edward Piranian, Philadelphia, Pa.

STAFF COMMENT

This ingenious condenser recommends itself particularly as an antenna series capacitor in short-wave transmitting circuits.

Novel Power-Supply Device

BEING called upon very recently to design and build an amplifier and power supply for use with a power tube and an ordinary magnetic speaker, but also having in mind the possibility of later using the device with a moving-coil speaker requiring a field supply of 110 volts d.c., I designed the arrangement illustrated in Fig. 6. Each terminal of the choke except the last was brought out to a binding post. A flexible lead with a phone tip soldered to the end was attached to the last terminal. The three binding posts were mounted on a bakelite strip.

When an ordinary magnetic speaker is to be used the flexible tip from the choke is connected to binding post 1. This places the choke in operation and the speaker is attached in the usual way. When a moving-coil speaker is to be used, however, the flexible lead is disconnected from binding post 1 and the field winding of the moving-coil speaker is connected to binding posts 1 and 2. A jumper made of bus wire is connected between binding posts 2 to 3; this cuts out the first section of the choke while the second section is replaced by the winding of the moving-coil speaker.

Karl F. Oerlein, Philadelphia, Pa.

STAFF COMMENT

Such an arrangement has much to commend it. It is generally unsatisfactory to connect the field-winding terminals of the moving-coil loud speaker in series with the filter system of the power supply, since the additional resistance of the field winding may cause a considerable decrease in output voltage.

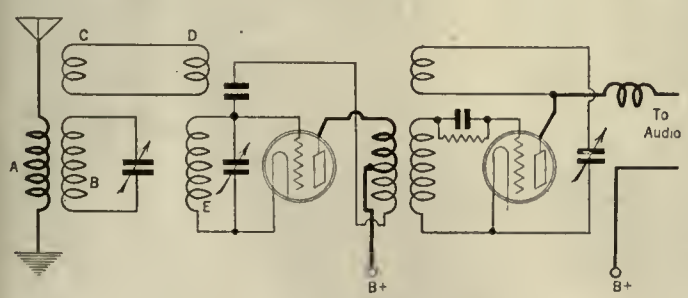


FIG. 5

This "link" circuit, when used with the R. B. Universal receiver, will add selectivity to the set. Its design is such that it functions somewhat as a band selector.

New Apparatus and Its Applications

Transformers Now Available for Linking Dynamic Loud Speakers With Push-Pull Amplifiers

AGAIN this month a change is made in the method of presenting new apparatus in these pages. Parts submitted by different manufacturers usually are treated as separate items, but in this issue several dynamic-speaker output transformers of the push-pull type are described in one article. In this way it is possible to give a more lengthy discussion of the applications of these devices, as space is not wasted in duplicating descriptions. A second article under this heading describes a dual push-pull public-address amplifier. A complete list of parts is specified in the text, and much valuable data is given on the design of amplifiers of this type.

THE story is told of a man and woman who, while riding through California, expressed great curiosity regarding some immense fields of French artichokes, with which they were unfamiliar. It was explained to them what these vegetables were, what a toothsome dish they provided, and the suggestion made that they try them. To which the gentleman replied with utmost finality, "Oh, no! We never eat strange foods." An antipathy towards "strange foods" is fortunately not a characteristic of radio enthusiasts to whom new things are a staff of life.

The newest "strange food" to which many of us have probably devoted considerable thought during the past few months is concerned with moving-coil loud speakers—how good they are, how to operate them, and so forth. This article is devoted to one particular angle of the subject, the reason for the use of a coupling transformer between the moving coil of the loud speaker and the plate circuit of the power tube.

The coupling transformer, T, in a moving-coil loud speaker is connected in the circuit as indicated in Fig. 1, and it has one major purpose in life—to "match" the impedance of the moving coil to the plate resistance of the power tube. It is true that the transformer will also serve to keep the d.c. plate current of the tube out of the moving coil, but this purpose is secondary in comparison with that previously mentioned. Now, since the purpose of the transformer is to match the tube to the moving coil, it would seem to follow that manufacturers would have to put into the moving-coil loud speaker a coupling transformer that can only be used with a tube of a definite plate resistance—unless it is possible to design the transformer so that it will be satisfactory for use with all types of tubes. Let us see if we cannot answer this question very briefly.

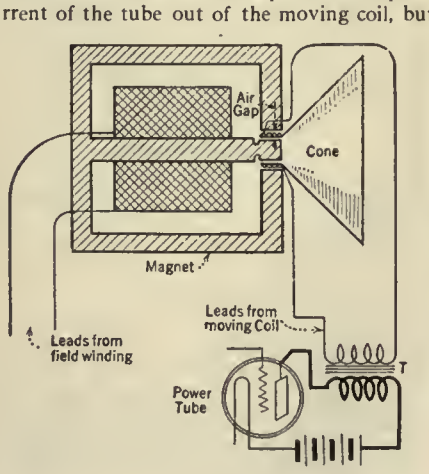


FIG. 1

It is not our purpose in this article to enter into a discussion of transformer characteristics. From such a discussion we would finally reach the following conclusions: (a) that a properly constructed coupling transformer designed to work out of an impedance of 5000 ohms, corresponding to a 112A- or 210-type tube, will also work satisfactorily out of 2000 ohms, corresponding to a 171A- or 250-type tube, and

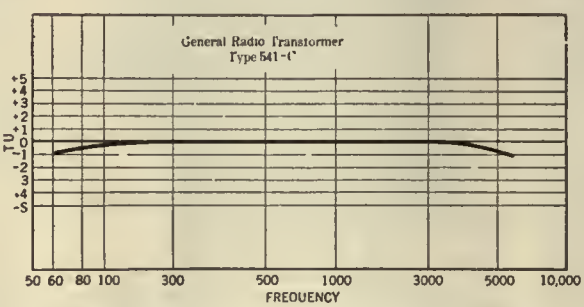


FIG. 2 CHARACTERISTICS OF GENERAL RADIO TRANSFORMER

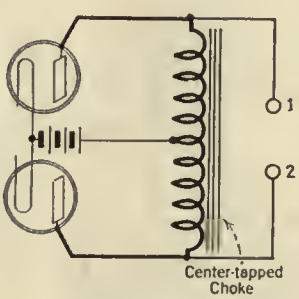


FIG. 3

(b) that a transformer designed to work out of an impedance of 2000 ohms, corresponding to a 171A- or 250-type tube, *will not operate* satisfactorily out of a 112A- or 210-type tube, because with such a transformer the two latter types of tubes would operate with a load impedance in their plate circuit of less than twice the plate resistance of the tube and, for this reason, the plate current-grid voltage characteristic of the tube will be curved and distortion will result.

For these reasons we find that the coupling transformers which always are built into a moving-coil loud speaker are designed according to (a), and the transformer will, therefore, work satisfactorily out of a 112A-, 171A-, 210-, or 250-type tube.

In some cases, however, we may want to operate a moving-coil loud speaker out of a push-pull stage. When this is to be done, two possibilities are open to us—we

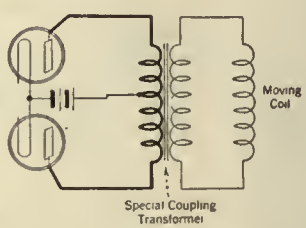


FIG. 4

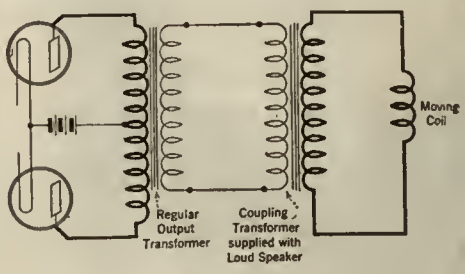


FIG. 5

can either remove the transformer supplied with the loud speaker and substitute one designed for use between the moving coil of such a loud speaker and a push-pull stage, or we can just connect the output terminals of the present push-pull transformer in the set to the input terminals of the coupling transformer incorporated in the loud speaker. If we use the former arrangement the resultant circuit will look like Fig. 4, and if we use the latter arrangement the circuit will look like Fig. 5.

Whether the arrangement of Fig. 4 or Fig. 5 is used depends upon various circumstances which are listed below:

(a) If the present output push-pull transformer in the receiver is a *good* one designed for use with ordinary cones with a nominal impedance of about 2000 or 4000 ohms, then the circuit of Fig. 5 may be used with satisfactory results. The power loss due to the use of two transformers will only be about 2 TU—a negligible loss.

(b) If the present push-pull output transformer in the set is thought to have a poor frequency characteristic it will be best to remove it and use the circuit arrangement Fig. 4.

(c) If a choke output circuit, Fig. 3, is used in the output of the push-pull tube then the circuit of Fig. 5 may be used (i.e. terminals 1 and 2 of Fig. 3 may be connected to the leads from coupling transformer supplied with the loud speaker) if 171A tubes are used in the push-pull amplifier, provided that each of the choke coils have an inductance of not less than 30 henries.

(d) If a choke output circuit is usedwith 210-type tubes then the chokes and the coupling transformer in the loud speaker should be removed, and a special transformer substituted and arranged in the circuit as per Fig. 4.

There are listed in the following table a number of special transformers, designed to replace the coupling transformer of a dynamic speaker:

Manufacturer	Type	Type tube for use with Single	Push-Pull
Amertran Sales Co.	300		210 or 112A
	362		171A
Dongan Electric Company	2112	171A	
	1189	250	
	1192		171A or 210
	1183		250
Ferranti, Inc.	OP–2	112A or 171A	
	OP–4C		All types
General Radio Co.	585–O	All types	
	541–C		All types
Sangamo Electric Co.	GX–210		112A or 210
	HX–171		171A or 250
Thordarson Electric Mfg. Co.	T–2902	171A or 250	
	T–2903		171A or 250
	T–2629		112A or 210

New Dual Push-Pull Public-Address Amplifier Provides 15 Watts of Power



GENERAL VIEW OF PUBLIC ADDRESS AMPLIFIER

The amplifier pictured above employs three transformer-coupled stages and has an undistorted output of 15 watts. The unit, which is completely a.c. operated, was designed for use in large theatres

THE item of new apparatus described in this article is a three-stage light-socket-operated audio amplifier possessing ample amplification to boost the output of a radio set's detector tube, a microphone, or a magnetic phonograph pick-up unit up to a volume level sufficient for a large theatre or an outdoor crowd. The gain-frequency characteristics of the amplifier are such that an effect of naturalness for human voice or music will be conveyed to every listener.

This amplifier has little application in the average home radio outfit. Its real appeal, rather, is to those experimenters and professional set-builders who have found that there is much real demand for public-address amplification that cannot be adequately met by ordinary equipment designed primarily for home use. To such individuals, this amplifier offers the possibility of sale or rental to moving-picture theatres, skating rinks, schools, race tracks, and conventions, not to mention other uses. The fine possibilities of such sales can be grasped when one considers that a skating rink or theatre can avoid the considerable expense of even a small orchestra with a pair of phonograph turn-tables and record pick-up units, a supply of good records, one to four loud speakers, and this amplifier. Whereas the smaller theatre or rink could only afford a a small mediocre orchestra at most, the amplifier installation brings out music played by the orchestras of Paul Whiteman, Vincent Lopez, the New York Philharmonic, the Boston Symphony, etc., with all of its original color, tone and volume, yet the total cost need not be more than three- to five-hundred dollars! To the movie exhibitor, the radio fan, and the wide-awake professional set-builder, no more need be said.

POWER REQUIRED

IN DESIGNING this amplifier, much experimental work was done to determine the approximate power needed for various classes of coverage. In 1000- to 2000-seat theatres, for instance, five to seven watts, taken from one UX250 tube, was found sufficient in most cases to give realistic reproduction. As the desire of many exhibitors was to produce greater than natural volume, more power was found necessary for such "volume hounds." Conclusions reached experimentally indicated that for such conditions an undistorted power of fifteen watts would give coverate of theatres seating up to 2000 or 3000 people, under conditions of maximum absorption and with all seats occupied. Outdoor tests indicated that this same power would give natural understandable speech and music at volume sufficient for crowds of 10,000 to 15,000 people. From a gain-frequency standpoint, it was found that an accentuation of bass frequencies was desirable, particularly as phonograph records and radio programs are generally lacking in the lower bass registers. Practical experience indicates that if the amplifier accentuated frequencies between 60 and 200 cycles (lower notes being used infrequently in music and speech), the most pleasing effect would be obtained.

With this information at hand, a power output stage was first developed, after which suitable input stages were designed to insure the operation of the output stage at its full capacity with the lowest input voltage to be anticipated in practise. Adjustment of the transformer characteristics was made to obtain the desired gain-frequency curve. The power-handling capacity of the input stages was made so great that no overloading would occur in them, even though the output stage were operated at well over its maximum capacity. The whole amplifier was then adapted for full a.c. operation.

The requirement that 15 watts of undistorted power be available from the output stage automatically eliminated the possibility of using tubes smaller than the 250 type, and since the maximum output of one tube is 4.65 watts, a push-pull circuit with two 250-type tubes seemed to be a good starting point. From tests it was determined that, with a load impedance equal to four times the R_p of one tube, the requirements set down could be satisfied with a plate potential of 450 volts, and a grid voltage of 80, maximum safe values for *selected* 250-type tubes. An undistorted output of 15.75 watts was obtained from the two 250-type tubes in push-pull with a specially developed output coupling impedance.

The results of some gain measurements are shown in Fig. 1. It will be noticed that 10 watts may be developed without any appreciable decrease in gain (which would indicate distortion). The curve of Fig. 1 varies only 2 TU between 1 and 15.75 watts output and, as 2 TU is the

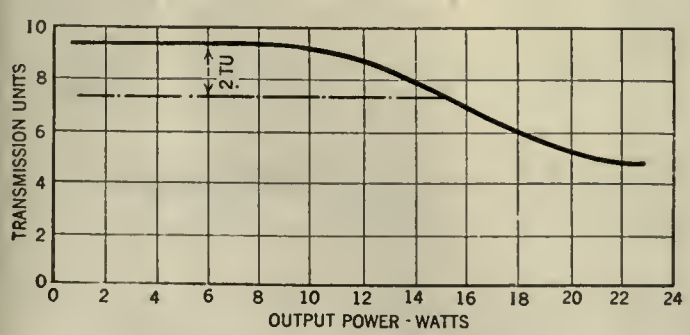


FIG. 1. OUTPUT CHARACTERISTICS

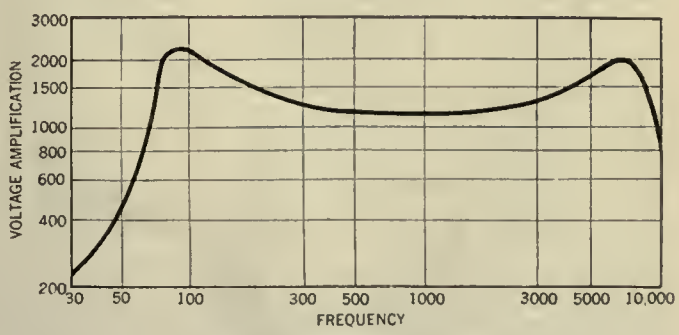


FIG. 2 FREQUENCY CHARACTERISTICS

minimum sound variation perceptible to the average ear in a musical selection, a 2 TU variation may be taken as a very conservative limit on allowable distortion. Distortion becomes more serious at 18 to 22 watts, although the average person will not be disagreeably affected even at such an overload. While Fig. 1 is the power output curve for the final push-pull stage selected, it was actually taken on the whole amplifier, so that it is also a measure of such overloading as might occur in preceding stages.

ANALYSIS OF AMPLIFIER

AN ANALYSIS indicated that the signal voltage applied to each 250 tube at the 14.35-watt point on the curve of Fig. 3 was 90 volts. (The advantage of the push-pull stage is here well demonstrated—the grids were actually 16 volts positive over the 80-volt bias, yet distortion which would have been serious with such an overload on one tube has not become perceptible to most ears with the push-pull stage.) With 90 volts required at the 250 grids, and allowing conservatively for a 0.2 volt-signal at the input of the amplifier the voltage gain needed to develop 90 volts from a 0.2 volt-signal would be $90 \div 0.2 = 450$ times. This is a conservative figure, since the averge detector tube will turn out 0.3- to 0.4-signal volts, and average pick-up unit will deliver as much as 1 to 2 volts. Further measurements indicated that the standard Clough system transformers (described in July, 1928, RADIO BROCADAST), and one 226-type tube would give a gain of 120.5, obviously insufficient to operate the push-pull stage to capacity. At this point, one 226-type tube was found to be unable to operate the push-pull stage to capacity without overloading. A 171A-type tube preceding the push-pull stage was tried with considerable success, as well as two 226-type tubes in push-pull. The latter were found most desirable, due to the simplification of filtration and isolation that the push-pull stage permitted, as well as its greater undistorted output.

Suitable transformers of the Clough type were then designed to feed from one standard amplifier tube into a push-pull stage, and to feed from one push-pull stage into a second push-pull stage. These transformers were provided with a low-frequency cut-off below a hump ranging from 65 to 200 cycles and with a flat curve up to about 8000 cycles. (Incidentally, they will be welcomed by the many fans who have written to the designer asking for just such transformers.) An amplifier was then set up and measured, using one 4.3:1-ratio transformer feeding into a 227-type tube, one 1.75:1 push-pull input transformer feeding into two 226-type tubes in push-pull, and one 1.75:1 interstage push-pull transformer feeding from the 226-type tubes to the 250-type tubes. The output of the 250-type tubes was fed, through the specially designed adjustable output impedance previously mentioned, into several different speakers, and measurements were made. Fig. 2 shows the result in the form of an overall gain-frequency characteristic from input to power tube grids. The desirable bass hump is present, and above 3000 cycles common coupling through the power supply produced a second hump which was left in the amplifier to compensate the sideband cutting in radio reception. Many observers liked the effect produced by the rise at high frequencies but if the writer's dislike of this effect is shared by others, a needle-scratch filter across a record pick-up, or a 0.00015-mfd. condenser across the input transformer secondary, will flatten it out effectively. This hump would not appear in battery operation, and its effect consequently must not be exaggerated by the reader who has previously been shown only curves taken on battery-operated amplifiers, which curves would not show regeneration almost sure to develop where standard power-supply units were substituted for batteries. The curve of Fig. 2 is not a "hand-picked" laboratory product—it is a true measure of performance at signal voltages developing actual operating output powers in actual loud speakers.

A.C. OPERATION

ADAPTING a high-gain amplifier giving good response at 60 cycles to a.c. operation was no easy task. Fortunately, two push-pull stages simplified the process, but the high overall gain made special precautions necessary for the input stage. The B supply for the push-pull output stage was found to need no filtering, while a resistance-capacity filter in the B wire was adequate for the intermediate push-pull stage. Filament balances were non-critical on both push-pull stages. Such good fortune did not hold for the input stage. A very high inductance choke, in an unusual resistance-inductance-capacity filter proved necessary for B and C supply, and in addition the input transformer had to be oriented to minimize induction from the power-supply transformer which was 18" away. In the final models a.c. hum was reduced (when using airchrome-, dynamic- or cone-type loud speakers) to a point where it was not objectionable for home use.

Final models, operated with one dynamic speaker placed at an open window on a crowded boulevard, provided understandable speech and good music over traffic noise a city block away. Twelve air-column speakers distributed about three floors gave such effective coverage of 30,000 square feet of factory floor space that one could not hear conversation at normal speaking volume.

The assembly of the amplifier is well illustrated in the accompanying picture and the physical layout will be found to follow very closely the general arrangement of the schematic wiring diagram in that the amplifier progresses from left to right with the power-supply apparatus at the extreme right of the wooden baseboard. The 255 transformer is not screwed directly down to the baseboard, but should be wired into circuit loosely so that it can be adjusted for the minimum-hum position in actual operating tests. After its proper position has been determined (and outlined upon the baseboard with a pencil), it is clamped down by means of the steel tie-bar and two of the short-threaded brass rods with their nuts, the holes for them in the baseboard being counterbored.

The wiring of the amplifier is comparatively simple and is accomplished by using the flexible hook-up wire cut to proper lengths with insulation pushed back and ends soldered to proper soldering lugs or fastened directly under tube socket terminal screws. Amplifier grid and plate leads should be isolated as far as possible from each other and from other wiring, and can be made quite short due to the layout of parts. All filament and power wiring should preferably be run in a common cable as far as possible, which may be laced with waxed shoemaker's thread after testing. The two loud speaker connections to the S-M 248 universal output choke should be terminated in battery clips so that they may be moved about to the different groups of soldering lugs on the choke in preliminary tests.

LIST OF APPARATUS

THE following is a complete list of the apparatus employed in the construction of the power amplifier described in this article:

C_1, C_2, C_3, C_4 Potter condenser bank, type 673;
L_1 One S-M Universal output choke, type 248;
R_1 One Carter potentiometer, type AP-15;
R_2 One Yaxley resistor, 2000-ohm, type 72000;
R_6, R_8 Two Frost tapped resistors, type FT-64;
R_3, R_4 Two S-M resistors, type 659;
R_7, R_8 Two Polymet resistors, 750-ohm;
S_1 One S-M tube socket, type 512;
S_2 to S_7 Six S-M tube sockets, type 511;
T_1, T_4 Two S-M a. f. transformers, type 255;
T_2 One S-M push-pull transformer, type 257;
T_3 One S-M push-pull transformer, interstage-type, type 227;
T_5 One S-M filament transformer, type 247;
T_6 One S-M power transformer, type 328;
One phone cord and plug, five-foot;
One roll of S-M hook-up wire, type 818;
Five Fahnestock clips;
One S-M wooden chassis, 21-$\frac{7}{8}$" x $\frac{5}{16}$" x $\frac{1}{2}$".

The total cost of the apparatus is $93.36.

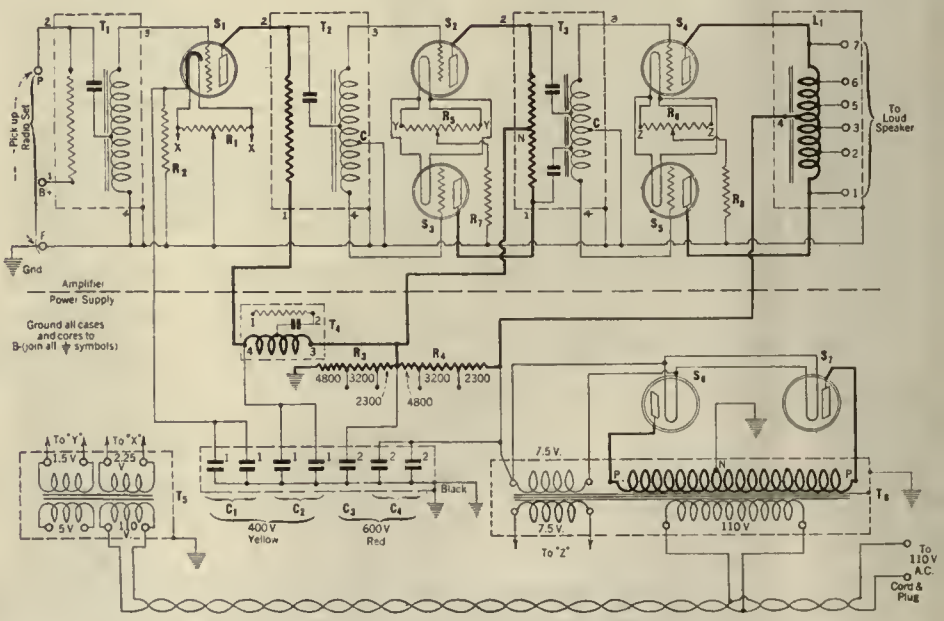


FIG. 3. COMPLETE DIAGRAM OF PUBLIC-ADDRESS AMPLIFIER



A RECEIVER OF MODERN DESIGN FOR THE DX FAN

More Data on the Sargent-Rayment

By HOWARD BARCLAY

AT THE time the article entitled "The Sargent-Rayment Seven Receiver" was prepared for October, 1928, RADIO BROADCAST, the writer, as a result of testing a model receiver attendant upon the preparation of his article, had become firmly convinced that this receiver was an unusual example of a fine kit, and that, in short, it would be heard from in no uncertain terms once a number had been built. Circumstances have since proven that the silent prophet is not always unhonored in his own country. Believing that the comments of some experienced experimenters who have built and tested the set may be of interest, as well as a bit of additional engineering data and a few timely operating suggestions, this, the writer's second article upon the Sargent-Rayment Seven Receiver, has been prepared.

Extended experience with western conditions on the part of the designers of this receiver had effectively convinced them of the necessity of a far more selective set than would in all probability ever be developed in the East, due to the peculiarities of western reception conditions. In consequence, it would seem that if the Sargent-Rayment receiver were capable of giving a good account of itself on the West Coast, it would certainly be able to do so in any other location in the United States. Such is actually the case. As an example of results obtained from a typical Sargent-Rayment set, a report received from Lloyd Breck, 110 Pacific Avenue, Piedmont, California, is most interesting. In the course of two evenings' tuning, Mr. Breck was able to tune in a total of 116 stations upon the receiver he had built. Out of the total of 116 stations, 44 were located in the East, and Mr. Breck's log included CYJ and CYA of Mexico City, KFQD of Anchorage, Alaska, KHGU of Honolulu, Hawaii, and PWX of Havana, Cuba. The log is interesting, for there are only approximately 100 transmission channels in the broadcast band, and the reception of 116 stations meant that several transmission channels were heard from twice!

Turning from Mr. Breck's results, the comments of F. Edwin Schmitt, of New York City, upon the performance of a Sargent-Rayment located at White Plains, New York are interesting as coming from the opposite coast. Mr. Schmitt reports that between the hours of 8:00 and 12:00 P. M. on an evening late in October, one station in Portland, Oregon, one in Seattle, Washington, one in San Diego, California, three in Los Angeles, one in Denver, one in Fort Worth and many closer by were heard with excellent volume on the loud speaker through the barrage of stations located in and about New York City. These comments, together with reports of average logging of from 50 to 100 stations in an evening from many different builders, indicate that the receiver is evidently adequately selective for present-day conditions.

THE Sargent-Rayment receiver was first described in our October, 1928, issue. This article gives additional operating notes and other comments which are sure to interest those who have built the set and probably will be of interest to those who may now be planning to build one.

—THE EDITOR.

REGARDING COIL DESIGN

IN FIGS. 2 and 3 are some interesting amplification curves made upon several typical r.f. stages tested in the development of the Sargent-Rayment receiver. In order to determine the most satisfactory type of coil for the general type of mechanical assembly which seemed desirable, a family of coils, each of approximately the same inductance, were constructed and placed in a single stage compartment for measurement. It was observed that with constant coupling maintained for each coil, the amplification obtained increased with decreases in coil size, due to a reduction in shielding absorption. The most satisfactory coil of the various types tested consisted of 72 turns of No. 25 enamelled wire wound upon a bakelite tube $2\frac{1}{2}$" in diameter, threaded 32 turns to the inch. When measured unshielded, this coil actually was inferior to a larger type which, also wound upon a $2\frac{1}{2}$" tube, consisted of 80 turns of No. 20 enamelled wire, threaded 20 turns per inch. This larger coil, being affected to a much more marked degree by the presence of the shielding than was the smaller coil, actually delivered lower amplification in practise. This is indicated by the curves, Fig. 2, showing the amplification obtained with four different values of screen-grid voltage when using the larger coil with a primary consisting of 35 turns of No. 34 d.c.c. wire slipped into the secondary at the filament end of the latter. Amplification with 45 volts on the screen grid ranges from 17. to 26.5 between 550 and 1450 kilocycles, with selectivity varying 3.9 to 1.21 for the different frequencies.

The curve of Fig. 3 taken upon the smaller coil with a 25-turn primary shows a considerable improvement in amplification over the larger coil, and a very appreciable improvement in selectivity as indicated by the selectivity figures appearing in the curve. (These selectivity figures represent the ratio of amplification of the desired signal to the amplification of another signal 10 kilocycles off resonance, and to the engineer the merit of the stage represented in Fig. 3 will be appreciated as being quite high.)

HOW SENSITIVITY IS OBTAINED

TO THE average reader, the values of amplification per stage shown in Fig. 3 may seem quite low, but it must be borne in mind that in designing the Sargent-Rayment receiver

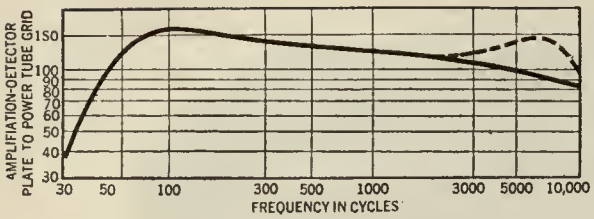


FIG. 1

the thought was to employ as many stages of suitable r.f. amplification as were needed to give the desired degree of amplification, rather than to obtain the highest possible amplification per stage. This decision made, the designers were left free to concentrate upon the problem of selectivity rather than amplification in each stage. The wisdom of this policy is indicated by the fact that the selectivity of each r.f. stage is practically that of the tuned secondary circuit alone without the deleterious effects of coupling a preceding amplifier tube into this circuit through a primary large enough to obtain the highest possible value of amplification which always halves the selectivity factor. Lest, however, the casual reader should be inclined to regard the amplification of the Sargent-Rayment receiver as being of a very low order, it is interesting to compare the r.f. amplification of typical six-tube, one-dial receivers averaging about 1000 times between antenna and detector grid with the r.f. gain of the Sargent-Rayment, neglecting entirely its tuned antenna input circuit with its large potential amplifying possibilities. The r.f. gain of the Sargent-Rayment, operating in a perfectly stable manner has a value adequate to allow the receiver to go down to the lowest noise level; this is equivalent to many times the gain given by many of the receivers of the type mentioned above.

An over-all amplification curve for the two-stage audio amplifier employed in the Sargent-Rayment is shown in Fig. 1, this curve being

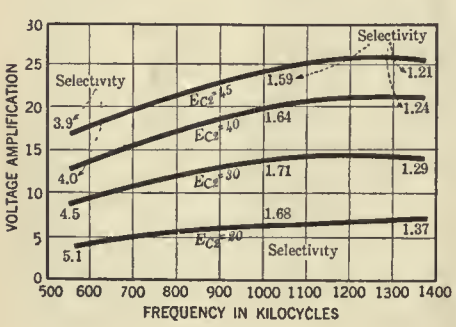


FIG. 2

made with 112A-type tubes in the detector and first audio positions, and a 171A-type tube in the second audio position, with recommended operating voltages. It is, however, quite feasible to employ a 210- or 250-type power tube in the output stage of the receiver through the use of a high-voltage power-supply unit. The standard S-M 675ABC kit is especially suitable for this purpose providing, as it does, 7.5 volts for filament lighting through an adapter plug inserted between the power tube and the second audio socket, together with B voltage and C bias for the entire receiver including a 210- or 250-type power tube. With this combination and the substitution of the 1-mfd. 600-volt condenser, as specified in the circuit diagram on page 355 of October, 1928, RADIO BROADCAST, the Sargent-Rayment receiver provides an unusually fine combination of tone quality, sensitivity, and selectivity.

ANTI-MOTORBOATING FILTER

UNFORTUNATELY, the set is not without its one drawback, though this drawback is in itself the accompaniment of the extremely high amplification developed by the receiver. When used with standard B-power units, there occasionally develops a tendency for the receiver to "motorboat," particularly at one setting of the volume control regulating the screen-grid voltage to the r.f. tubes. Messrs. Sargent and Rayment have recommended a non-motorboating filter which they have termed a "stabilizer." It consists of a small choke coil, similar to the S-M 251 output transformer, connected in the 45-volt screen-grid lead and a 50,000-ohm resistor connected in the positive B lead to the detector plate. Each of these circuits is then bypassed back to the receiver chassis, a 4-mfd. condenser being used for the screen-grid bias and a 1-mfd. for the detector-plate lead. The circuit is shown in Fig. 4.

INCREASING THE SENSITIVITY

AN EXAMINATION of the receiver circuit diagram (October RADIO BROADCAST) indicates that the input from antenna to first r.f. tube is through a rejector type of wave filter which, in its general characteristics, is essentially similar to that of the tuned r.f. stages. The thought has occurred to some builders that through shifting the screen-grid connection of the left-hand screen-grid tube from the antenna connection (2) of the coil L_1 to the free end of the tuned secondary coil (3) of the wave filter, an increase in amplification may be obtained. Whether or not this is necessary is for individual decision, for the performance of the receiver is perfectly stable with the recommended connection, and the amplification is high enough to go down to the most favorable low-noise level. The change in connection to utilize the rejector circuit as a tuned r.f. stage will usually tend to make the receiver oscillate, with oscillation controlled by the volume knob. The effect, however, of the regeneration introduced through this change is to reduce the effective repeater amplification, so that only a very slight actual gain in sensitivity results. Nevertheless, under extremely favorable conditions, as, for instance, early in the morning when listening for Japanese or Australian stations, this connection has sufficient merit to justify its trial, at least, for it will result in some boost of a very weak signal.

As stated above the writer is of the opinion that the receiver possesses ample sensitivity, as well as selectivity, in its present form. This view is more or less substantiated by letters from many experimenters who have built the receiver. Two of these communications are particularly interesting and excerpts are printed below. The first is from Frank McDonell, president of Rossiter, Tyler and McDonell, a well-known engineering and service organization located in New York. After testing the Sargent-Rayment receiver in a steel-frame building in the heart of the lower New York business district, Mr. McDonell write as follows:

"You will be interested in a word of comment on the Sargent-Rayment receiver. I want to put myself on record right now as saying that it is without question the best receiving set of any type or description that we have ever demonstrated. During the evening demonstrations, we were able to tune-in at will almost anything in the country that we desired, getting such stations as Fort Worth, Atlantic City, Atlanta, Ga., and literally hosts of others, with as much volume as any ordinary receiving set receives WEAF in this locality. Incidentally, our receiving conditions here are most abominable."

FIVE JAPANESE STATIONS HEARD

TURNING again to the opposite Coast for confirmation of such performance, the report of Kenneth G. Ormiston, the technical editor of *Radio Doings*, a Los Angeles publication, is interesting. Mr. Ormiston commented as follows:

"We are impressed with the very obvious sensitivity of the Sargent-Rayment receiver, due to its ability to reach the noise level with the sensitivity control but half on. The volume of WGN, when he signed off, inspired us to set the

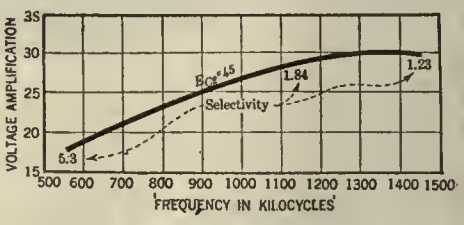


FIG. 3

alarm clock for 4 A. M., and, when we turned the set on at that hour, five of the "Japs" and 4QG in Brisbane were received with good volume. Also, WFAA, WMMJ, KMA and some Easterners were heard on the air with their early morning programs.

"In all, we were very well satisfied with the performance of the receiver. Not alone satisfied, but considerably surprised! No repeats or harmonics, very fine tone quality, on both local and DX, and its ease of operation are factors which are bound to make the set popular with those fans who believe that d.c. tubes, operated from either batteries or a socket-power unit, give peak performance."

Apparently Mr. Ormiston started the ball rolling, for immediately after receiving word of his reception, reports came in from many different West-Coast builders of reception of Japanese and Australian stations, not to mention a large number of eastern American stations. In particular, E. W. Gardner of Del Monte, California, reports the reception of six Japanese broadcast stations.

Considering the fact that the comments quoted from and referred to herewith are but a very few of the large number of favorable reports which have been received from builders, it may be assumed that the Sargent-Rayment receiver provides an unusual degree of selectivity and amplification (as we write this, a Chicago experimenter reports reception of what were apparently Japanese programs upon the wavelength of JOAK on November 6.)

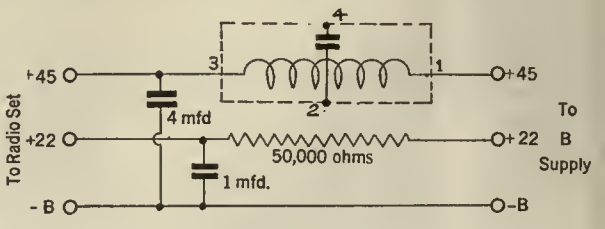


FIG. 4. AN EFFICIENT FILTER CIRCUIT

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on this page. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. 1928 revised booklet, with circuit diagrams of popular kits. RADIALL COMPANY.

5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.

17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

32. METERS FOR RADIO—A catalogue of meters used in radio, with diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

37. WHY RADIO IS BETTER WITH BATTERY POWER—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.

46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.

47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.

48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.

53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.

56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.

57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.

58. HOW TO SELECT A RECEIVER—A common-sense booklet describing what a radio set is, and what you should expect from it, in language that anyone can understand. DAY-FAN ELECTRIC COMPANY.

67. WEATHER FOR RADIO—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. TAYLOR INSTRUMENT COMPANIES.

69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit; list of American and Canadian broadcast stations. RADIO CORPORATION OF AMERICA.

72. PLATE SUPPLY SYSTEMS. Technical information on audio and power systems. Bulletins dealing with two-stage transformer amplifier systems, two-stage push-pull, three-stage push-pull, parallel push-pull, and other audio amplifier, plate, and filament supply systems. AMERICAN TRANSFORMER COMPANY.

73. RADIO SIMPLIFIED—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. CROSLEY RADIO CORPORATION.

76. RADIO INSTRUMENTS—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. JEWELL ELECTRICAL INSTRUMENT COMPANY.

78. ELECTRICAL TROUBLES—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. BURTON ROGERS COMPANY.

81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

89. SHORT-WAVE TRANSMITTING EQUIPMENT. Data and wiring diagrams on construction of all popular short-wave transmitters, operating instructions, keying, antennas; information and wiring diagrams on receiving apparatus; data on variety of apparatus used in high-frequency work. RADIO ENGINEERING LABORATORIES.

90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification are given. ALDEN MANUFACTURING COMPANY.

ON THIS page are listed radio manufacturer's booklets which may prove of interest to readers of RADIO BROADCAST. The list is revised each month and a constant effort is made to keep it as accurate as possible. In all cases the booklets listed have been selected because of the valuable information which they contain. Among the new booklets of interest to service men are the following: 135, 139, 140, 145, 146, 152, and 154.

95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. INTERNATIONAL RESISTANCE COMPANY.

98. COPPER SHIELDING—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. THE COPPER AND BRASS RESEARCH ASSOCIATION.

99. RADIO CONVENIENCE OUTLETS—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set, also antenna, ground and battery connections. YAXLEY MANUFACTURING COMPANY.

101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. SAMSON ELECTRIC COMPANY.

102. RADIO POWER BULLETINS—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. RAYTHEON MANUFACTURING COMPANY.

104. OSCILLATION CONTROL WITH THE "PHASATROL"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. ELECTRAD, INCORPORATED.

105. RECEIVING AND TRANSMITTING CIRCUITS. Construction booklet with data on 25 receivers and transmitters together with discussion of low losses in receiver tuning circuits. AERO PRODUCTS COMPANY.

108. VACUUM TUBES—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. ARCTURUS RADIO COMPANY.

112. HEAVY-DUTY RESISTORS—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. WARD LEONARD ELECTRIC COMPANY.

In sending the coupon below, make sure that your name and address are included and are plainly written. Also make sure that the listing of booklets from which you choose is that of the latest issue of the magazine, as Radio Broadcast cannot guarantee the delivery of booklets not listed in its current issue.

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113. CONE LOUD SPEAKERS—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. THE MAGNAVOX COMPANY.

114. TUBE ADAPTERS—Concise information concerning simplified methods of including various power tubes in existing receivers. ALDEN MANUFACTURING COMPANY.

115. WHAT SET SHALL I BUILD?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. HERBERT H. FROST, INCORPORATED.

118. RADIO INSTRUMENTS. CIRCULAR "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. WESTON ELECTRICAL INSTRUMENT CORPORATION.

120. THE RESEARCH WORKER—A monthly bulletin of interest to the engineer and home builder. Each issue contains special articles on radio design and construction with special emphasis on resistors and condensers. AEROVOX WIRELESS CORPORATION.

121. FILTER CONDENSERS—Some practical points on the manufacture and use of filter condensers. The difference between inductive and non-inductive condensers. POLYMET MFG. CORP.

123. B SUPPLY DEVICES—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. ELECTRAD, INC.

124. POWER AMPLIFIER AND B SUPPLY—A booklet giving several circuit arrangements and constructional information and a combined B supply and push-pull audio amplifier, the latter using 210 type tubes. THORDARSON ELECTRIC MFG. CO.

125. A. C. TUBE OPERATION—A small but complete booklet describing a method of filament supply for a.c. tubes. THORDARSON ELECTRIC MFG. CO.

126. MICROMETRIC RESISTANCE—How to use resistances for: Sensitivity control; oscillation control; volume control; regeneration control; tone control; detector plate voltage control; resistance and impedance coupling; loud speaker control, etc. CLAROSTAT MFG. CO.

129. TONE—Some model audio hook-ups, with an explanation of the proper use of transformers and chokes. SANGAMO ELECTRIC CO.

130. SCREEN-GRID AUDIO AMPLIFICATION—Diagrams and constructional details for remodeling old audio amplifiers for operation with screen-grid tubes. THORDARSON ELECTRIC MFG. CO.

131. THE MERSHON CONDENSER—An illustrated booklet giving the theory and uses of the electrolytic condenser. AMRAD CORPORATION.

132. THE NATIONAL SCREEN-GRID SHORT-WAVE RECEIVER—Constructional and operating data, with diagrams and photographs. JAMES MILLEN.

133. THE NATIONAL SHIELD-GRID FIVE—A circuit diagram with constructional and operating notes on this receiver. JAMES MILLEN.

134. REMLER SERVICE BULLETINS—A regular service for the professional set builder, giving constructional data, and hints on marketing. GRAY & DANIELSON MFG. CO.

135. THE RADIOBUILDER—A periodic bulletin giving advance information, constructional and operating data on S-M products. SILVER-MARSHALL, INC.

136. SILVER MARSHALL DATA SHEETS—These data sheets cover all problems of construction and operation on Silver-Marshall products. SILVER-MARSHALL, INC.

139. POWER UNIT DESIGN—Periodical data sheets on power unit problems, design, and construction. RAYTHEON MFG. CO.

140. POWER UNIT PROBLEMS—Resistance problems in power units, with informative tables and circuit diagrams. ELECTRAD, INC.

141. AUDIO AND POWER UNITS—Illustrated descriptions of power amplifiers and power supplies, with circuit diagrams. THORDARSON ELECTRIC MFG. CO.

142. USE OF VOLUME AND VOLTAGE CONTROLS. A complete booklet with data on useful apparatus and circuits for application in receiving, power, amateur transmitter, and phonograph pick-up circuits. CENTRAL RADIO LABORATORIES.

143. RADIO THEORY. Simplified explanation of radio phenomena with especial reference to the vacuum tube, with data on various tubes. DE FOREST RADIO COMPANY.

144. LOW FILAMENT VOLTAGE A. C. TUBES. Data on characteristics and operation of four types of a.c. tubes. ARCTURUS RADIO COMPANY.

145. AUDIO UNITS. Circuits and data on transformers and impedances for use in audio-amplifier circuits, plate and output impedances and special apparatus for use with dynamic speakers. SANGAMO ELECTRIC COMPANY.

146. RECEIVER CIRCUIT DATA. Circuits for using resistances in receivers, and in power units with descriptions of other apparatus. H. H. FROST, INC.

147. SUPER-HETERODYNE CONSTRUCTION. Construction and operation of a nine-tube screen-grid super-heterodyne. SET BUILDERS' SUPPLY COMPANY.

148. SHORT-WAVE RECEIVER. Constructional and operation data on a four-tube short-wave receiver. KARAS ELECTRIC COMPANY.

149. FIVE-TUBE SCREEN-GRID RECEIVER. Blueprint with full constructional details for building a broadcast receiver using two screen-grid tubes. KARAS ELECTRIC COMPANY.

150. FIVE-TUBE A.C. RECEIVER. Blueprint for constructing a five-tube a.c. receiver employing the "equamatic system." KARAS ELECTRIC COMPANY.

151. THE SECRET OF THE SUPER. Constructional and operation data on the Lincoln 8-80 One-Spot Super. LINCOLN RADIO CORPORATION.

152. POWER SUPPLY ESSENTIALS. Circuits and data on power-supply devices, and descriptions of power apparatus. POLYMET MANUFACTURING COMPANY.

153. WHAT THE EVEREADY FIDELITY CURVE MEANS TO RADIO RECEPTION. An analysis of the frequency range of musical instruments and the human voice which shows how these tones are reproduced by a receiver with an audio range of 60 to 5000 cycles. NATIONAL CARBON COMPANY.

154. AMPLIFIER AND POWER SUPPLY CONSTRUCTION MANUAL. A booklet giving descriptions, circuit diagrams, and lists of parts of several popular amplifier and power supply circuits. ACME WIRE COMPANY.

Sound Motion Pictures

(*Continued from Page 182*)

But in the talking movies how is the director to know, when the action is recorded, what the audiences are going to do? His spacing is a matter of guesswork. He can, of course, have an audience present and try it on them, but, as every actor knows, different audiences do different things.

To return to volume control, however—what is the remedy for some of these defects? My answer is no better than that of anybody else, but I will venture a few suggestions. One consists in disagreement with the dogma that volume control is all taken care of in recording and, after the initial gain setting is made in the projection room, the faders should be left alone. This is good theory, but it doesn't always work in the present state of the recording art.

Part of the trouble is that the recording engineers, especially when they are working with discs, always have to worry about the ground noise. Their tendency is to bring up the gain on low portions and to iron out the record to one level. When the changes are not too rapid this could be fixed in projection. A wider range in volume can be secured there without excessive background disturbance, since lowering the reproducing gain brings down the ground noise with the signal. And, in general, accurate control of volume in recording, particularly in rush production, awaits future developments in instruments and technique. In short, while the best answer would be to record so well that projection could take place without any change in gain, with the present technique of recording skillful gain adjustment in the theatre could do a lot of good.

The projectionist, clearly, cannot be relied on for this. For one thing, he has too many other things to do. Secondly, he is not listening in the house, but in a more or less noisy and uncomfortable projection room. Thirdly, he is seldom fitted by temperament for an audio monitoring job.

A POSSIBLE SOLUTION

ONE solution is to use automatic, electrical, or mechanical means of some sort to vary the amplification in the theatre within certain limits. This adds to the complications, but it is a possible future development.

In the meantime the best answer may be a limited gain control manipulated from a point in the house by someone who has nothing else to watch. This man may be a theatre musician, whose judgment is likely to be good on such matters as proper volume of speech and music. He will operate a remote gain control permitting a latitude of, say, 15 or 20 TU. The setting in the booth will be such that the house gain control can be brought up to the maximum without causing overloading or any such difficulties. The operator of the house control will preview the film several times with the house manager or someone in authority. In this way he will be able to arrange a cue sheet, which can readily be memorized after the first few trials, enabling him to turn out a much smoother performance than under present conditions in most theatres. For example, if there is an abrupt change in selections, he will at least be able to fade down to low volume during the shift. He will be able to drop an appropriate number of units for dialogue, bring up the gain once more for heavy musical accompaniments, tone down pianissimos which have been recorded with too much amplitude, and in general graduate the performance. I suspect that such a man, judiciously chosen, would more than earn his salary, and that his presence would help, in some measure, to preserve the life of the goose which is laying the golden eggs.—CARL DREHER

An Inexpensive Audio Oscillator

(*Continued from Page 187*)

condensers used in connection with the circuit. The greater the capacity across L_1, the lower the frequency. It is suggested that the oscillator be calibrated from either tuning forks or a reliable frequency standard. If only the middle part of the audio-frequency scale is desired, the oscillator can be calibrated from a piano keyboard by striking a key that corresponds to the frequency generated by the oscillator.

An audio-frequency transformer with a fairly good characteristic between 60 and 6,000 cycles should be used in connection with the oscillator, otherwise the higher frequencies will be cut off or will come through so weak that additional amplification will be necessary to step up the voltage of the oscillator.

The question of harmonics will probably be brought up by the readers of this article; it is admitted that the percentage of harmonics with this type of oscillator is rather high. However, the results obtained with the oscillator are sufficiently good for most experimental purposes.

WHAT PARTS TO USE

THE picture of the oscillator on page 186 shows Western Electric tubes; any type of tube may be used instead of the ones shown; a power-type tube is suggested, such as the 112 or 171A, depending on how much power is desired. The C bias of the amplifier tube should be carefully adjusted so that no distortion may take place in this part of the circuit. The normal bias for the 171 with 90 volts on the plate is about 16.5 volts.

In the following list of parts, the writer has indicated few trade names; the reason is that any well-constructed apparatus will work as well as any other. The only special part in the list below is the Ford coil, and even here the name Ford indicates nothing more than that such a coil may be used—any similar spark coil will do as well.

The complete list of apparatus follows:

C_1—Several small fixed condensers of various capacities.
C_2—Two fixed mica condensers, 0.00025– and 0.005–mfd.;
C_3—One paper condenser from Ford unit (about 0.01 mfd.);
L_1 L_2—One Ford ignition coil used on Model T cars;
R_1—One grid leak, 2 megohms;
R_2—Two Federal potentiometers, 600-ohm;
R_3—One rheostat, 6-ohm;
Sw_1. Sw_2—Two small multipoint switches (Carter, Frost, Yaxley, etc.)
T_1 One audio transformer of good characteristics.

To place this oscillator in operation, the following will be needed:

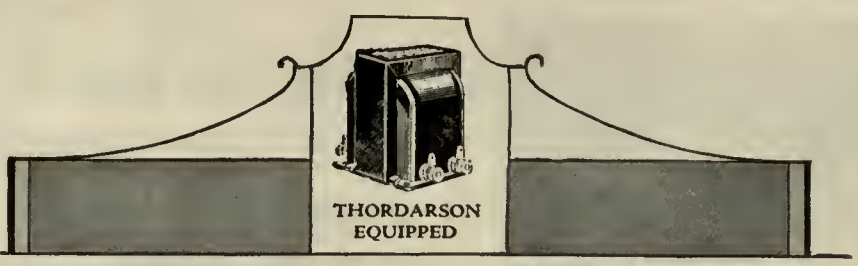
Two power tubes, 112A– or 171A– type;
One storage battery, 6-volt;
B batteries or equivalent power supply, 90-volt;
One C battery, 16.5–volt.

As the Broadcaster Sees It

(*Continued from Page 185*)

intensely practical problems as the frequent conflict between optimum development for the picture and optimum development for sound, comparisons between different systems of recording, and other problems which are being widely discussed and some of which will be considered in this department. The movie people, of course, have the same difficulty in the other direction.

At present a lot of skillful bluffers from both camps are getting by and drawing their imposing salaries. This will not last. One dark morning the deflation of experts will begin, and the exproperty men and fourth-rate broadcast operators will be propelled back into the rear ranks. As a practical criterion at the present juncture, I should say that no one should be allowed to qualify as an engineer in sound movie work who cannot understand all the articles on broadcast and audio-frequency technique in the *Proceedings of the Institute of Radio Engineers* and the *Journal of the American Institute of Electrical Engineers*, as well as the papers on sound movies in the *Transactions of the Society of Motion Picture Engineers*. That is a reasonable minimum; of course if he can follow some of the optical material in the latter publication, and the electrical and radio-frequency discussions in the former two, he is better qualified to hold the position and is of much greater value to his employers.



Do You Realize the Importance of this Endorsement?

Each successive year that we use Thordarson transformers strengthens our faith in your organization. Both our laboratory tests and our experience have proven conclusively that Thordarson transformers are in perfect accord with the high standards maintained throughout in Zenith Receivers.

E. F. McDonald Jr.

President
Zenith Radio Corporation



IN the last analysis, there is no test for the merits of any product that is more conclusive than an investigation of the customer clientel of its manufacturer. Among the users of Thordarson Radio Transformers you will find the aristocracy of radio . . . leading radio set manufacturers whose receivers are universally hailed as musical instruments of undisputed superiority.

Such an endorsement of performance means much to any purchaser of radio apparatus. It means that Thordarson radio transformers have passed successfully the most exacting tests under the eagle eye of the laboratory.

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Clear Silver Tones ~ *from the microphone to you*

EXPERT workmanship, correct design and the careful selection and testing of all materials are responsible for the great popularity of CeCo tubes.

You'll find a CeCo tube will last longer, perform better and give you more genuine enjoyment from your set.

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CeCo Radio Tubes

The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE aim of the Radio Broadcast Laboratory Information Sheets is to present in a convenient form, concise and accurate information in the field of radio and closely allied sciences. It is not the purpose of the Sheets to include only new information, but to present practical data, whether new or old, that may be of value to the experimenter, set builder or service man. In order to make the Sheets easier to refer to, they are arranged so that they may be cut from the magazine and preserved, either in a blank book or on 4" x 6" filing cards. The cards should be arranged in numerical order.

Since they began, in June, 1926, the popularity of the Information Sheets has increased so greatly that it has been decided to reprint the first one hundred and ninety of them (June, 1926–May, 1928) in a single substantially bound volume. This volume, "Radio Broadcast's Data Sheets" may now be bought on the newsstands, or from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Inside each volume is a credit coupon which is worth $1.00 toward the subscription price of this magazine. In other words, a year's subscription to RADIO BROADCAST, accompanied by this $1.00 credit coupon, gives you RADIO BROADCAST for one year for $3.00, instead of the usual subscription price of $4.00.

—THE EDITOR.

No. 249 RADIO BROADCAST Laboratory Information Sheet January, 1929

A Resistance-Coupled Amplifier

PARTS REQUIRED

ON LABORATORY Sheet No. 250 is published the circuit diagram of a resistance-coupled amplifier illustrating the use of filter circuits in the plate and grid leads. As explained in Sheet No. 243, lack of proper filter circuits will cause distortion due to common coupling in the plate supply. It will frequently be worth while to incorporate such filter circuits in existing resistance-coupled amplifiers, especially if the amplifier exhibits a tendency to "motorboat" or distort.

In operating a resistance-coupled amplifier it is especially important that overloading be prevented by keeping the volume down to the point where none of the tubes draw grid current, and it is up to the user of the amplifier to operate it so that grid current does not flow.

In constructing the amplifier illustrated on the next sheet the following parts will be required:

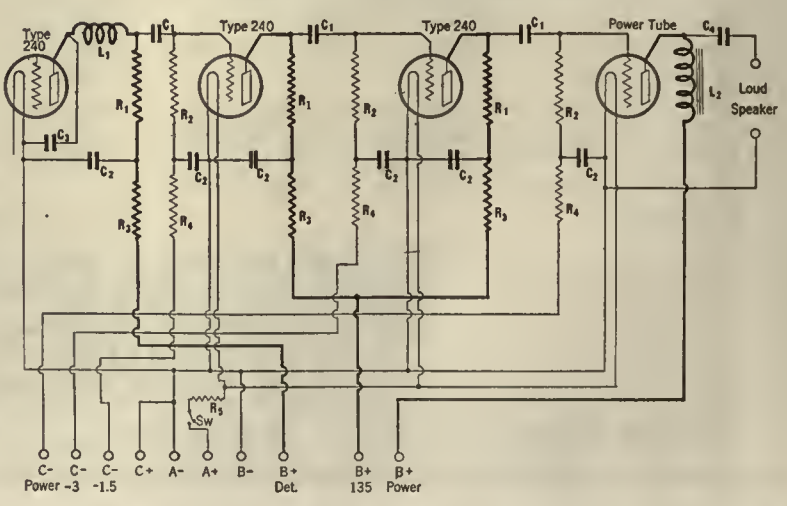
R_1—Three plate-coupling resistors, 250,000-ohm;
R_2—Three grid resistors, 2-megohm;
R_3—Three plate-circuit filtering resistors, 25,000-ohm;
R_4—Three grid-circuit filtering resistors, 50,000-ohm;
R_5—Filament rheostat, 6-ohm;
C_1—Three coupling condensers, 0.01-mfd.;
C_2—Six by-pass condensers, 1-mfd.;
C_3—One by-pass condenser, 0.0002-mfd.;
C_4—Output condenser, 4-mfd.;
L_1—R.F. choke coil;
L_2—Output choke coil, 30-henries;
Sw—Filament switch.

The detector and the first two of the audio amplifiers may be 240-type tubes and the power tube may be any type, depending upon the personal preference of the builder. The voltages applied to the B-plus power terminal and the C-minus power-terminal will, of course, depend upon the type of power amplifier; it is recommended that a 171A-type power tube be used.

The simplest and most satisfactory construction to follow in building a resistance-coupled amplifier is to mount the tube sockets and the resistor mounts for the grid- and plate-coupling resistors all in a line. With this arrangement the grid and plate leads between the tubes and the coupling resistors are very short.

No. 250 RADIO BROADCAST Laboratory Information Sheet January, 1929

A Resistance-Coupled Amplifier



Read what BIG money these fellows have made in the RADIO BUSINESS

$375 One Month Spare Time



"Recently I made $375 in one month in my spare time installing, servicing, selling Radio sets. And, not so long ago, I earned enough in one week to pay for my course."
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$1597 In Five Months



"The N. R. I. is the best Radio school in the U. S. A. I have made $1597 in five months. I shall always tell my friends that I owe my success to you."
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Tarpon Springs, Fla.

$1164 Spare Time Profits



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1409 Shelby St., Sandusky, Ohio.

I will show you too how to start a spare time or full time Radio Business of Your Own without capital



Radio's amazing growth is making many big jobs. The world-wide use of receiving sets and the lack of trained men to sell, install and service them has opened many splendid chances for spare time and full time businesses.

Ever so often a new business is started in this country. We have seen how the growth of the automobile industry, electricity and others made men rich. Now Radio is doing the same thing. Its growth has already made many men rich and will make more wealthy in the future. Surely you are not going to pass up this wonderful chance for success.

More Trained Radio Men Needed

A famous Radio expert says there are four good jobs for every man trained to hold them. Radio has grown so fast that it simply has not got the number of trained men it needs. Every year there are hundreds of fine jobs among its many branches such as broadcasting stations, Radio factories, jobbers, dealers, on board ship, commercial land stations, and many others. Many of the six to ten million receiving sets now in use are only 25% to 40% efficient. This has made your big chance for a spare time or full time business of your own selling, installing, repairing sets.

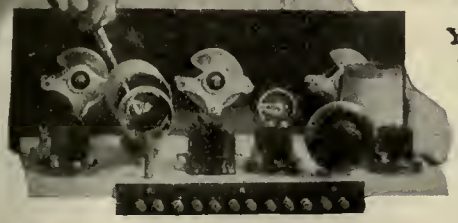
So Many Opportunities You Can Make Extra Money While Learning

Many of our students make $10, $20, $30 a week extra while learning. I'll show you the plans and ideas that have proved successful for them—show you how to begin making extra money shortly after you enroll. G. W. Page, 1807-21st Ave., S., Nashville, Tenn., made $935 in his spare time while taking my course.

I Give You Practical Radio Experience With My Course

My course is not just theory. My method gives you practical Radio experience—you learn the "how" and "why" of practically every type of Radio set made. This gives you confidence to tackle any Radio problems and shows up in your pay envelope too.





You can build 100 circuits with the Six Big Outfits of Radio parts I give you. The pictures here show only three of them. My book explains my method of giving practical training at home. Get your copy!





I Will Train You At Home In Your Spare Time

I bring my training to you. Hold your job. Give me only part of your spare time. You don't have to be a college or high school graduate. Many of my graduates now making big money in Radio didn't even finish the grades. Boys 14, 15 years old and men up to 60 have finished my course successfully.

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Safeguard Your

A. C. Installation

SATISFACTORY and economical operation of A. C. receivers is contingent upon maintaining close regulation of operating voltages, by means of suitable A. C. measuring instruments. This is necessary because of the wide fluctuation in the potential of secondary lines furnishing current to house lighting circuits.

Set manufacturers, dealers and electric light and power companies everywhere are cooperating to the end that voltage regulation, both on supply lines and in connection with voltage control equipment of the receivers themselves, may be effected for the better operating service of all set owners. For this reason, as well as for other testing requirements outlined in the following, all purchasers of A. C. receivers are urged to provide themselves with an instrument such as is shown in the illustration—known as the Weston Model 528 A. C. Voltmeter, range 150/8/4 volts.

When you find that there is an excessive in-put voltage, it follows that there is too high a voltage on the filament which shortens the operating life of the rectifying tubes. The Model 528 Voltmeter therefore checks the line supply voltage at all times and indicates when adjustments should be made to manually operated line voltage regulators between the power supply and the power transformer.

This voltmeter also indicates when the line voltage is over-rated, thus enabling the operator to make an adjustment in the set for the higher line voltage so that normal life can be obtained from his tubes.

The Model 528 is also made as Ammeters which are especially useful in checking the total load of the A. C. Set—in conformity with set manufacturers' instructions. The determination of A. C. filament flow in A. C. tube filament circuits is easily obtained by means of this instrument.

Write for your copy of Circular J fully describing the Weston Radio Line.

Weston Electrical Instrument Corporation

604 Frelinghuysen Ave.,

Newark, N. J.

WESTON
RADIO
INSTRUMENTS

No. 251 RADIO BROADCAST Laboratory Information Sheet January, 1929

Moving-Coil Loud Speakers

DESIGN OF THE COUPLING TRANSFORMERS

WHEN an engineer designs a moving-coil loud speaker, he also has to design the input transformer which is used to couple the loud speaker and receiver. The impedance ratio of this transformer will depend upon the impedance of the moving-coil system and upon the plate resistance of the power tube in the receiver. Since the engineer doesn't know what type of power tube the buyer of the loud speaker is going to use, upon what facts does he base his decision regarding the impedance ratio of the transformer which is finally incorporated in the loud speaker?

The fact has been mentioned many times in these data sheets that the maximum undistorted output is obtained from a tube when the load into which it works is equal to twice the plate resistance of the tube. A curve was also given on Laboratory Sheet No. 237 showing how the power output changed with variations in load impedance and this curve indicated quite clearly that a large percentage of the maximum amount of undistorted power was still available in the load, even though the load resistance was 5 or 6 times greater than the plate resistance of the tube. Suppose the engineer designed the coupling transformer so that looking into the primary the impedance is 4000 ohms. The plate resistance of a 171A-type tube is 2000 ohms and if this tube were used the maximum undistorted power output would be obtained (since 4000 ohms is twice the plate resistance of a 171A). If, however, this loud speaker were to be used with a 112A- or 210-type tube, both of which have a plate resistance of about 5000 ohms, then only 40 per cent. of the maximum available power would appear across the loud-speaker circuit. Also, when a high plate resistance tube is used with a low-impedance load the tube characteristic is curved (see Laboratory Sheet No. 124) and this produces distortion. Evidently then, if such a design were decided upon, the power loss would be somewhat greater than half when using a 112A- or 210-type tube and also distortion would be produced due to curvature of the tube's characteristic.

If the transformer were designed so that from the primary the impedance was 10,000 ohms then the maximum amount of undistorted power would be obtained from a 112A- or 210-type tube, since they are both 5000-ohm tubes. On the other hand, if a 171A-type tube with a 2000-ohm plate resistance were used with this transformer we still would obtain 70 per cent. of the maximum power, and, since the plate load, 10,000 ohms, is much greater than the tube resistance, 2000 ohms, distortion would not be introduced due to curvature of the characteristic. This design of the transformer is obviously the correct one.

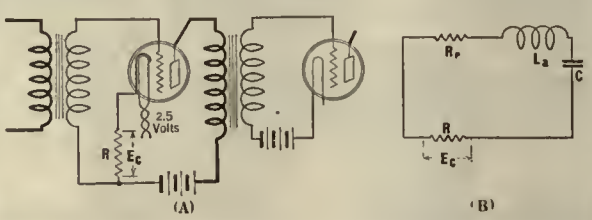
No. 252 RADIO BROADCAST Laboratory Information Sheet January, 1929

Audio Amplifiers

IMPORTANCE OF BY-PASS CONDENSERS

IN SKETCH A on this sheet we illustrate the circuit of a single-stage audio amplifier, Resistor R, being connected in series with the cathode of the tube, functions to supply C bias to the grid of the tube. Should the resistance, R, be bypassed with a condenser?

If this circuit were casually analyzed one would be inclined to answer this question negatively, since this resistance is in series with the primary of the audio transformer, T, and the impedance of this circuit is very high. Consequently the a.c. currents around through the plate circuit and through the resistance ought to be very small. If, however, we draw out the equivalent circuit, as we have done in sketch B, a different condition is seen to exist. This equivalent circuit represents what the tube and transformer look like at high audio frequencies, L_a being the leakage inductance in the transformer and C the distributed capacity reflected into the primary. R is the grid resistor and R_p the plate resistance of the tube. At high frequencies this is a series resonant circuit and the currents are, therefore, quite large. For this reason a comparatively large voltage may be developed across the resistor R which supplies the C-bias voltage, E_c, to the grid of the tube. This voltage, E_c, should obviously be only a d.c. voltage, but, since the circuit is a series resonant one, considerable a.c. voltage will be developed across the resistance and be impressed back on the grid of the tube. This voltage impressed back on the grid will be out of phase with the original voltage and it will, therefore, reduce the amplification at high frequencies.



These facts were checked on an amplifier in the Laboratory a short while ago and proved to be true. The low-frequency response of the amplifier was unaffected by the condenser across the C-bias resistor. At high frequencies, however, there was a very considerable loss in gain unless a by-pass condenser of 1 or 2 mfd. was placed across the resistance. It is therefore recommended that home constructors always make certain that all the C-bias resistors are properly bypassed.

No. 253 RADIO BROADCAST Laboratory Information Sheet January, 1929

Shielding

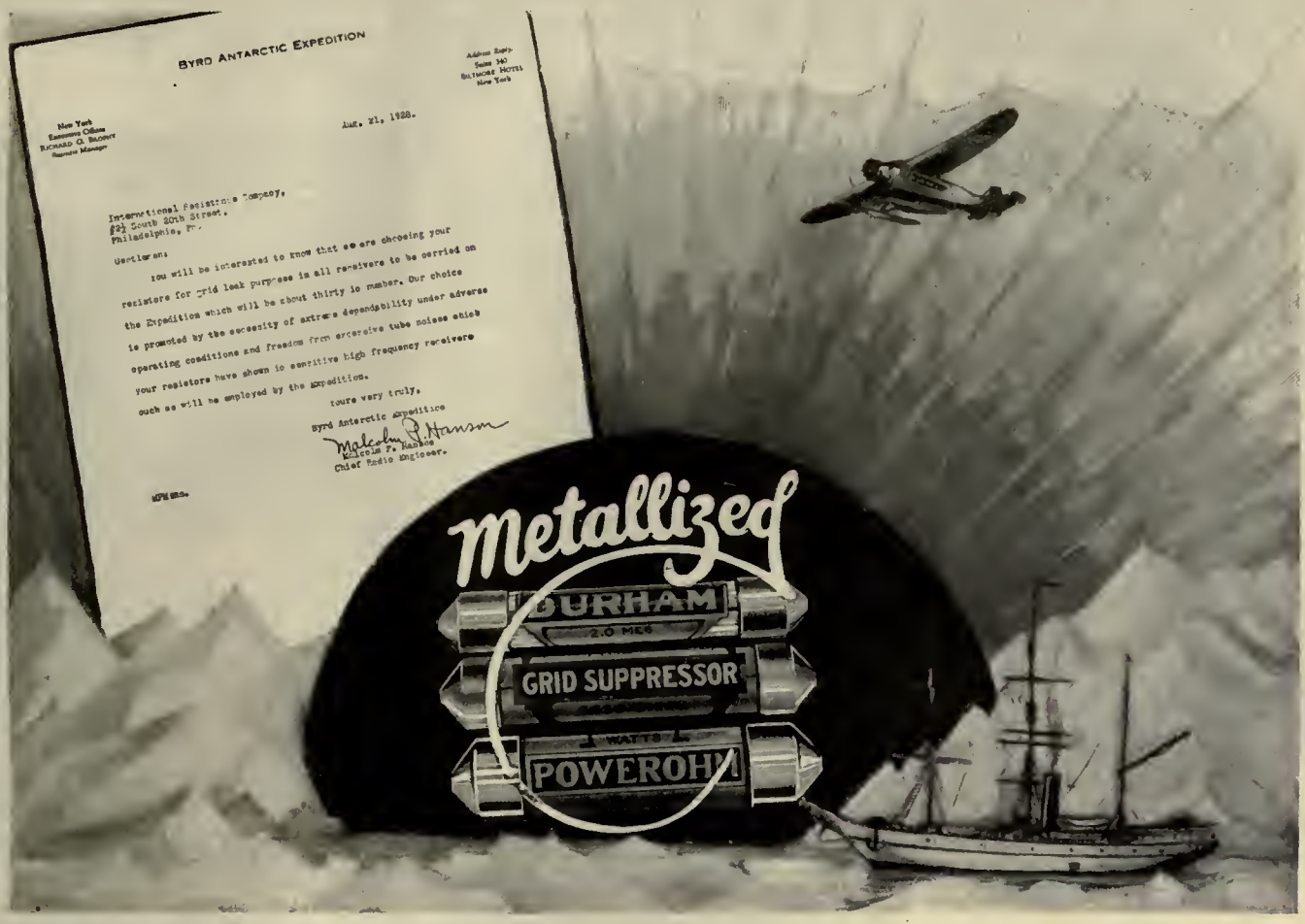
SUGGESTIONS REGARDING ITS USE

SHIELDING is used in radio receivers for two purposes. First, it prevents direct pick-up, by the coils in a receiver, of signals from powerful local stations, for, when such pick-up exists, the receiver is likely to be non-selective. Second, the use of shielding prevents electrostatic and electromagnetic coupling between the various parts of the circuit, particularly the various inductance coils. Electrostatic coupling is readily prevented, thin sheets of shielding material between the apparatus to be shielded generally being sufficient. Electromagnetic coupling is more difficult to prevent. The prevention of such coupling necessitates the use of very complete shielding, the joints must be tight and a material with a low electrical resistance must be used.

The shielding in a receiver should be used for only one purpose—shielding. It should not be used to conduct currents, for example, between a coil and a condenser. If this is done the usefulness of the shielding frequently will be destroyed due to the fact that these currents flowing through the shielding material constitute circuits which can readily produce coupling to adjacent conductors.

All the shielding in a receiver should be grounded and connected also to negative-B, negative-A, and plus-C wires. Except for the fact that the shield may be used for the A-minus conductor, the wiring of the set should be done as though the shielding were not present. In other words, the fact that some condenser, for example, one of the tuning condensers, is connected to the shield should not cause us to connect one end of a tuning coil to the shield and thereby complete the circuit through the shielding material. Instead a lead should be run from the tuning coil to the tuning condenser so that the currents in this circuit will pass through this lead and not through the shielding.

The coils in a receiver should preferably be located about central within the shielding compartment, since in this position the increase in resistance of the coil due to the shielding will be a minimum. If these simple rules are followed in constructing a shielded receiver, many difficulties will be prevented.



On the Byrd Antarctic Expedition Only DURHAMS are Used! — another tribute to the DURHAM Metallized principle! — another tribute to the extreme care with which DURHAM Resistors, Powerohms and Suppressors are made! — another tribute to DURHAM accuracy and utter dependability! — read the above letter from Chief Radio Engineer Malcolm P. Hanson of the Byrd Antarctic Expedition. In effect he says "We are using DURHAMS exclusively because past experience has taught us that they can be relied upon for perfect performance under even the most adverse conditions". DURHAM Resistances are available for every practical resistance purpose in radio and television work from 250 ohms to 100 Megohms and in ratings for all limited power purposes. Used in leading radio laboratories, endorsed by leading engineers and sold by leading jobbers and dealers. Descriptive literature on the entire line of DURHAM products will be gladly sent upon request.

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Look for the monogram (L) *on the top of each tube and insist on them by name.*

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NEW YORK - CHICAGO
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No. 254 RADIO BROADCAST Laboratory Information Sheet January, 1929

A. C. Tubes

EFFECT OF FILAMENT VOLTAGE

IT IS becoming increasingly common to find manufacturers designing the filament windings on power transformers to supply voltages somewhat less than those rated for use with 226- and 227-type a.c. tubes. One parts manufacturer is marketing a filament transformer designed to supply 2.25 volts to the filament of a 227-type tube, although the rated voltage of this tube is 2.5 volts. A study of the circuit diagrams of manufactured receivers published in RADIO BROADCAST will bring to light other cases where a.c. tubes are supplied with somewhat lower than rated voltage.

The life of a vacuum tube depends very much upon the filament voltage with which it is supplied, and frequently a very small increase in voltage above the rated value will cause a considerable shortening in the life of the tube. With a.c. tubes this problem has assumed especial importance, for these tubes are subjected to variations in filament voltage in accordance with any fluctuations of the line voltage. If the line voltage becomes somewhat higher than that value at which the set is designed to operate, the various tubes receive excessive filament voltage and their life is shortened to a marked extent. It is for this reason that manufacturers have designed the power transformer to deliver somewhat lower than rated voltage to the tubes so that even if the line voltage rises above normal the tube filaments will not be overloaded.

A.C. tubes, types 226 and 227, will give entirely satisfactory operation at less than the rated voltage. The table on this sheet, obtained from figures in the *Cunningham Tube Data Book*, gives the characteristics of the 226-type tube with a filament voltage of 1.3 volts and 1.5 volts, the latter value being that at which the tube is rated. The slight increase in plate resistance and decrease in mutual conductance which results when the tube is operated at 1.3 volts is not sufficient to affect its operating characteristics. The 227-type tube saturates at about 1.9 volts on the filament and, therefore, it also may be operated at somewhat less than its rated voltage with satisfactory results.

TUBE	FILAMENT VOLTAGE	PLATE IMPED-ANCE	MUTUAL CONDUC-TANCE	AMPLIFI-CATION FACTOR
226	1.3	10,000	750	8.3
226	1.5	9,000	830	8.3

No. 255 RADIO BROADCAST Laboratory Information Sheet January, 1929

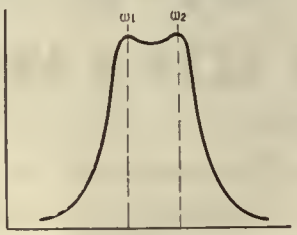
Band-Pass Circuits

WIDTH OF BAND

BAND-PASS filters, as used in radio receivers, consist of an arrangement of coils and condensers which produce a resonance curve of a form approximating that illustrated in the drawing on this sheet. It is possible to design a circuit to have a band-pass characteristic by the use of two separate tuned circuits, each tuned to exactly the same frequency and coupled. The coupling may be produced by condensers, by a separate coil, or by simply placing the coils of the tuned circuits in such relation that there is some coupling between them. One of the most important characteristics of a band-pass circuit is the distance between the two peaks in the curve, marked ω_1 and ω_2.

J. H. Morecroft in *Principles of Radio Communicotion* gives some formulas for coupled circuits. If two circuits are coupled inductively, then the width in kilocycles of the band between ω_1 and ω_2 is equal to the resonant frequency of either circuit alone multiplied by the percentage coefficient of coupling, k, between them. For example, we might take two coils and two condensers, arrange them in the form of two tuned circuits adjusted, say, to 1000 kilocycles. When there is 1 per cent. coupling between them then the width of the band will be equal to

band with $= \omega_1 \times k$
$= 1000 \times 0.01$
$= 10$ kc.



The width of the band is, therefore, 10 kilocycles. It should be noted that the band width is directly a function of ω_1 (or ω_2 since they are both tuned to the same frequency). Therefore, if the percentage coupling remains constant then the width of the band at 500 kc. is 5 kilocycles and at 1500 kc. is 15 kilocycles. The fact that the width of the band varies over the broadcast band in a ratio of 3 to 1 (5 kc. to 15 kc.) is a disadvantage, it being desirable, of course, that the width of the band should be constant over the entire broadcast range. If the circuits were capacitatively coupled the characteristic would be opposite to that when inductive coupling is used, i.e., at 1500 kc. the band width would be 5 kc., at 1000 kc. the width would be 10 kc., and at 500 kc. the band width would be 15 kc.

No. 256 RADIO BROADCAST Laboratory Information Sheet January, 1929

Power Output

HOW MUCH IS REQUIRED?

HOW much available power in the output tube of a radio receiver does one need for ordinary home reception when using a standard loud speaker? This is a question about which one can find many diverse opinions. In Laboratory Sheet No. 245 we quoted George Crom to the effect that the usual loud speaker requires an input of 1 to 1.5 watts for a volume of reception slightly above normal. In the *Cunninghom Tube Data Book* (which costs $2.50 and which we recommend that you purchase, if possible) we read, "For home reception, with a speaker of average sensitivity, a tube capable of supplying at least 100 milliwatts (0.1 watt) maximum undistorted power output is recommended. The use of a tube giving lower output is almost certain to result in distortion appreciable to the listener. It is very desirable to have additional reserve power available, up to approximately 500 milliwatts, if the "B" power required can be conveniently supplied. Under such conditions the quality will not suffer if the volume is turned a little above normal, as may be required in a large room or for dancing, or if the loud speaker is somewhat low in sensitivity."

The average of George Crom's figure is 1.25 watts and Cunningham recommends 0.500 watt. The mean of these two is 875 milliwatts, 0.875 watt. If the table of Laboratory Sheet No. 246 is referred to it will be found that the smallest power tube giving approximately this output is the 171A which is capable of supplying a maximum of 700 milliwatts to the loud speaker.

It, therefore, seems fair to state that any installation using a power tube or combination of tubes in the output such that the available power is about 0.7 watt, that this amount of power will be sufficient to permit loud-speaker reproduction at fair volume without overloading.

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Our graduates are in big demand everywhere. They enjoy greater success because they're posted right-up-to-the-minute in *everything* in Radio. Radio's progress each year is measured by the accomplishment of the great engineers at work in the research laboratories of Radio Corporation of America. This Radio organization sets the standards for the industry, and stands back of every lesson in the course.

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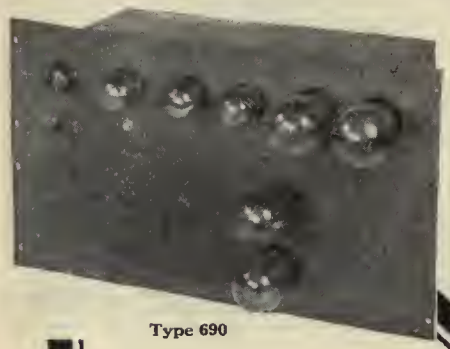
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SM

The Peer of All Theatre or Stadium Sound Amplifiers

Now Offered to the Public for the First Time



Type 690

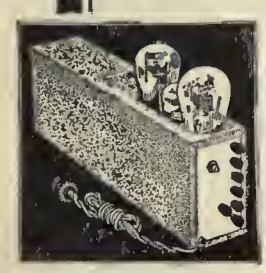
EVER since the revolutionary improvement in tone quality created by the Clough audio system when first demonstrated to the trade last June, the S-M laboratories have been working day and night to make this discovery available for the largest theatres, auditoriums, football stadiums, and such assemblages at a low cost.

As the culmination of these labors, S-M takes the greatest pride in announcing the 690 Super-Power Amplifier. *Three* stages—*two* of them push-pull—microphone, radio, or single or double record input—two 250 type tubes in the last push-pull stage giving 15,000 to 16,000 milliwatts output, with uniformly high tone quality down to 50 cycles such as only S-M Clough Audio Transformers can produce—the same quality that is drawing crowds into S-M-equipped movie theatres throughout the United States.

With such a unit available completely wired at $245 list price, less tubes—knowing as you do the tremendous present demand for sound amplifiers of the highest grade—can you as a setbuilder or service man afford to neglect the installation opportunities which this new S-M amplifier offers you?

For the Smaller Theatre, or the Home—

The new 2-stage S-M 678PD Phonograph Amplifier is priced so low that, while particularly adapted for dance halls and small theaters, it is ideal for the home also. Used with any 110 volt D.C. dynamic speaker, it takes input from any magnetic phonograph pickup, or from the detector tube of a broadcast or short-wave receiver, and, by means of its S-M Clough-system audio transformers, supplies to the speaker *undistorted* the full power output of its 250-type tube. Tubes required are: 1—226, 1—280, 1—250 type. All input power is taken from the 110 volt A.C. house-lighting mains. Price (less tubes), WIRED, $73.00; complete KIT, $65.00.



Type 678D

These New S-M Transformers Make It Possible

Built on the Clough System, with curves flat from below 50 cycles to well above 5000—these transformers give to "push-pull" a new and really startling significance. And their prices, like their quality, are unbeatable!

257 Push-Pull Input Transformer, to operate from one amplifier tube into two 171A, 210, or 250 tubes. Price, $7.00

227 Push-Pull Interstage Transformer, to feed from two 112A, 226, or 227 tubes into two 112A, 226, 227 or 171A, 210 or 250 tubes.....$8.00

258 Tapped Output Impedance, to feed from two 171A tubes into any standard speakers.....$5.00



Type 257

248 Universal Output Choke, to feed out of two 210 or 250 tubes into one to six or more standard speakers; provided with several impedance-matching taps. It will handle over 20 watts without core saturation.
Open-mounted..$7.00
228 (248 in case like 227).....$8.00



Type 227



Type 248

Get 250 Tone Quality in Your Present Receiver

Or you can get 250-tube power *right in your present set* by inserting a 250 tube (with an adapter) in the last socket of the set, and using the S-M 675ABC Power Supply. Presto!—the 675 supplies all ABC power to the new power tube (without a single change to the set) and replaces all B batteries or other B eliminators as well. (It will also supply A and C power to A.C. tubes).

Add a 675 to your set and you have all the advantages of the fine, full sonorous tone the super-power tubes bring—tone you find only in $300.00 to $500.00 factory-built sets—yet you can add it to your set for $54.00 plus two tubes!

The 675ABC power supply is priced at only $54.00 for the kit, or $58.00 fully wired with adapter.

Remember—S-M guarantees these push-pull transformers to have a finer frequency characteristic than any and all competitive types—bar none.

Silver-Marshall, Inc.
838 W. Jackson Blvd., Chicago, U. S. A.
....Please send me, free, the complete S-M Catalog; also sample copy of The Radiobuilder.
For enclosed.....in stamps, send me the following:
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.... $1.00 Next 25 issues of The Radiobuilder
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....No. 4. 223, 225, 226, 256, 251 Audio Transformers
....No. 5. 720 Screen Grid Six Receiver
....No. 6. 740 "Coast-to-Coast" Screen Grid Four
....No. 7. 675ABC High-Voltage Power Supply and 676 Dynamic Speaker Amplifier
....No. 8. Sargent-Rayment Seven
....No. 9. 678PD Phonograph Amplifier
.....Name
.....Address

Are you getting The RADIOBUILDER regularly? No. 9 (Jan. 1929) describes these new push-pull transformers, and the 690 Amplifier, as well as the new (and different!) S-M Dynamic Speakers. No. 7 (Nov. 1928) described in detail, with complete circuits, a 750-volt rectifying system. Sample copies may be had without charge as long as they last; use the coupon.

If you build professionally, by all means ask for information on the S-M Authorized Service Station proposition; its money-making opportunities are greater than ever.

SILVER-MARSHALL, Inc.

838 West Jackson Blvd., Chicago, U. S. A.

RADIO BROADCAST. February, 1929. Published monthly. Vol. XIV, No. 4. Published at Garden City, N. Y. Subscription price $4.00 a year. Entered at the post office at Garden City, N. Y., as second class mail matter. Doubleday, Doran & Company, Inc., Garden City, N. Y.

SM

On Top of the World—S-M Screen Grid Six and Sargent-Rayment Seven

Get these Record-Breaking Kits from W. C. Braun Co.

(All testimonials here quoted were entirely unsolicited)

"Just to say that I have one of your 720 Screen-Grid Six's with 670B power unit . . . Picked up Japan, 1:00 A. M.—came in strong—four stations in Chicago and everything up and down the coast . . . "
—F. A. Forbes, Oakland, Calif.

"Think of the thrill of getting your dinner concert from KFI on a 6-tube receiver away up here in Northern Wisconsin . . . At the end of the dial twisting session I had 28 stations over 1000 miles away, from 21 states and 3 provinces of Canada, and WKAQ, Porto Rico . . . "
—Clinton B. DeSoto, Withee, Wis.

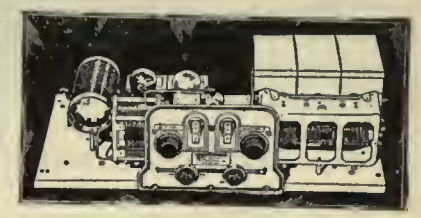
"I am writing to tell you about the results I am getting from the 720 Screen-Grid Six. I have brought in stations from New York to Japan with good volume on the speaker and the tone quality is very natural . . . The following are some of the stations I have received: JOIK, Sapporo, Japan, WHAM, Rochester, N. Y. . . . . I had two other Japanese and some other foreign stations, but I haven't the call letters yet. WLW, WGN, KWKH come in good almost every nigh?." —Alonzo Henderson, Mossy Rock, Washington.

"I am having great success with the 720 and 740 sets. Only today, I received 3 orders for 720s and one for a 730. In all my experience of building kits for fans, I have never had the feeling of really giving value till I took up your line. I think it is the best that money can buy in its class and my long list of satisfied customers surely is the proof that their sets are wonderful."
—Howard Brett, New York City.

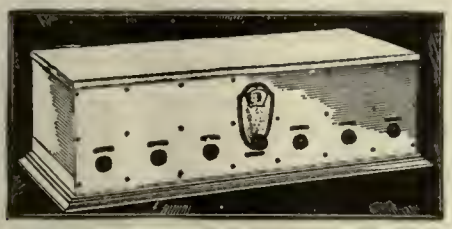
"Last night picked up Halifax, Nova Scotia with such volume that I had to turn the volume control half off. We then proceeded to pick distance to the satisfaction of the prospect . . . I got his order then and there.
—L. Frank Miller, Brooklyn, N. Y.

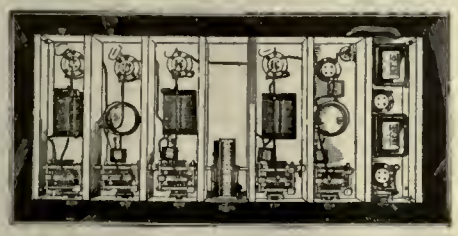
The plain cold facts are simple. The Silver-Marshall 720 is a six-tube t.r.f. set using three screen-grid tubes, a detector, and two stages of S-M Clough audio amplification. It's an all-metal, shielded assembly, just like the finest ready-made sets, with its own attractive two tone brown metal shielding cabinet, its antique brass escutcheon plate with two dials, volume knob, and a small selectivity knob. Yet this set with its three stages of screen grid r.f. amplification, and its audio system that money can't buy in a ready-made set, costs you but $72.50 for the S-M packed kit, or $102.00 for an S-M custom-built wired receiver, complete with cabinet.





"Boss of the Air"—Doubt It?—Read These:





The Sargent-Rayment Seven is the first and only set to offer four stages of screen-grid tuned r.f. amplification, and the unsurpassed tone quality of the S-M Clough audio system—the first and only set to give one-dial control, yet at the same time individual stage trimmers that mean the last drop of sensitivity when you want it. And its seven tubes, with 171, 210, or 250 power tube, give fine tone or hair-splitting selectivity, super-distance or local programs with thrilling quality. Shipped from stock: KIT $130.00—or FACTORY-WIRED $175.00. Both complete with handsome satin aluminum shielding cabinet.

THE MUNICIPAL COURT OF CHICAGO
Samuel H. Trude, Judge

"I am very much pleased with the custom-built 710 Sargent-Rayment receiver. . . which I have been using in connection with a cone-type loud speaker at the South Shore Country Club, Chicago.

"This is a remarkably good receiver for all kinds of radio reception. I have found that distant broadcasting stations can be tuned in on all wave channels over the entire broadcasting band—one and only one at a time with the single tuning drum." —Samuel H. Trude

"It may interest you to know that the first station I tuned in was KOA (1500 miles away) and that last Saturday morning from 3 to 4 A.M. we listened to three stations in Japan—JOAK, JOGK, and JOAH."
—Walter A. Reeves, Seattle, Wash.

"Some time ago I bought a 710 Sargent-Rayment set from Mr. Toolan of Lansing, Michigan. . . It has marvelous tone, volume, sensitiveness, and selectivity. I am right across the street from WTAM and can tune them out. . .in a few points." —J. W. Carvey, Cleveland, Ohio.

"I have just finished building one of your 710 Sargent-Rayment kits. I am delighted with its performance. It is the only set that I know of that will bring in stations here in the day time. . . It does it with good volume.
—Claude H. Matthews Roswell, N. M.

"The most I can say is—it was worth waiting for—the Sargent-Rayment 710. The most wonderful set I ever had anything to do with—goes together beautifully and makes a handsome job in its silvery-white finish."
—The Radio Shoppe, H. O. Hornbake, South Brownsville, Pa.

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As official wholesale distributors for the products of the Silver-Marshall laboratories, W. C. Braun Co., Wholesale Radio Headquarters, offers you this hig line of radio merchandise with the assurance that your orders will be filled on the very day they are received. Our plant is located very close to the Silver-Marshall factories and we can give you service on your orders impossible to secure anywhere else. Order your favorite S-M parts, kits and supplies here. You'll save time and money.

In addition to the complete Silver-Marshall line, we offer you a complete line of everything in the radio field—sets, radio furniture, tubes, power units, portable receivers, dynamic and other speakers, parts and kits for all popular circuits advertised in the leading radio publications, short wave and television supplies, short wave transmitters, radiophones, public address systems, novelties, etc.

Special departments include auto tires and tubes, auto accessories, electrical goods, lighting fixtures, wiring material, household appliances, stoves, vacuum cleaners, washing machines, camping equipment, sporting goods, golf and baseball supplies, outing clothing and thousands of everyday necessities.

Our centralized location insures fast service to customers in all parts of the country.

Thousands of choice bargains are shown in the big 1929 Braun Catalog. If you haven't a copy, send for it at once. It is free—mail the handy coupon now.

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W. C. BRAUN CO.,
528 W. Randolph St., Chicago

Dear Sirs: I am not receiving the W. C. Braun Co. Catalog regularly. Please put my name on your mailing list of set-builders and dealers, giving me the prices and information on S-M parts and other merchandise. My letterhead is attached.

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St. & No.....

City.....State.....

RADIO BROADCAST

ENGINEERING · THE LABORATORY · SERVICING

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EDGAR H. FELIX . . . *Contributing Editor*

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The contents of this magazine is indexed in *The Reader's' Guide to Periodical Literature*, which is on file at all public libraries

. . . *among other things*

THE unit heretofore employed by engineers to express power ratio—the TU—has been superseded by another which means the same thing, but has a more logical name The new unit is the Bel and the decibel, abbreviated DB, expresses exactly the same numerical relations at its predecessor, the TU, did. All references in this magazine from this issue on will employ the new term. For those who wish to refresh their memory on the point—and the whole question of the transmission unit—Home Study Sheet No. 15 on page 253 of this issue furnishes an unusually complete review.

THE present issue contains a vast deal of interesting and useful information. In especial, Kendal Clough's article should prove of importance to those who are trying to solve audio problems requiring the use of an amplifier furnishing a large amount of undistorted power for such uses as public-address systems, etc. The article by Keith Henney on page 250 discussing the value of complete filtering in audio amplifiers is thoroughly practical and the conclusions are supported by careful measurements. The second appearance of Carl Dreher's department devoted to sound motion pictures contains information invaluable to those working in the field. And those who have followed Mr. Dreher's "As the Broadcaster Sees it" will recognize the same material under its new heading "Broadcast Engineering," a title which more properly describes his regular contributions.

THE present issue differs in appearance from those which preceded it. The changes in the text pages make for increased readability. The cover, of which we are very proud, was designed in New York by A. R. Tobias, one of the best known and ablest of present-day designers. The typography of the text pages was done by W. B. Dutcher of the Art Department of Doubleday Doran & Company.

RADIO dealers and servicemen are writing us in great numbers with the most enthusiastic praise for the sections of this magazine written especially to help them. Our plans for the coming months include many articles which no serviceman or dealer can afford to miss. Of especial interest is the article by John S. Dunham on page 237 of this issue on the business problems of service work. The March number will be a special tube issue with a wealth of information in a very useful form. In addition are special articles on an ingenious r.f. distribution system for apartment houses, Prof. Terman of Stanford University on "Detection," K. S. Weaver of Westinghouse on the UX-250, Frank Jones on "Dynamic Loud Speaker Measurements," C. T. Burke on a "Discussion of Impedance," an interesting circuit for automatic volume control, and our special departments, packed full of useful information.

WILLIS KINGSLEY WING.

TERMS: $4.00 a year; single copies 35 cents, ...

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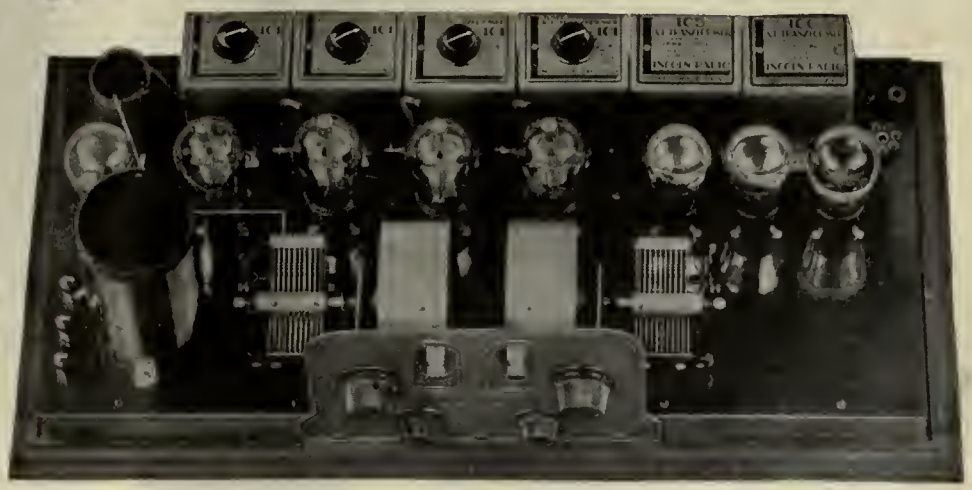
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That's the performance of the Lincoln 8-80 in the heart of Chicago

SET BUILDERS REPORT

Telegram Nov. 28th—"JAPANESE STATIONS RECEIVED ON LINCOLN SUPER JOAK, JOIK, JOBK." TOKYO, JAPAN; SAPPORO, JAPAN; OSAKA, JAPAN; BROUGHT IN THROUGH THE MANY STATIONS AROUND 300 METERS.

"SIX PACIFIC COAST STATIONS WITHOUT ANTENNA OR GROUND."—From Illinois.

"After using it several days I can truthfully say that it is the first set that I ever heard or owned that performs as per the advertisements of the manufacturers, in fact, if possible, it is a little better than advertised."

"Being an ardent DX fan and having constructed and used practically all of the standard supers and tuned radio frequency outfits and having personally constructed and experimented with intermediate super transformers and equipment, I find the Lincoln 8-80 the best answer to all DX requirements. Only an experienced set builder can fully appreciate what it means to have solved for him such problems as having a proper means of matching an intermediate transformer to any tube's individual characteristics. Tone quality, simplicity of operation, the ease with which outside stations can be brought in and the fact that the price is within range of all, make this the first set that I feel I could conscientiously recommend to everybody."

"75 stations logged before the new allocation of stations from a Chicago Hotel where 75 other receivers could not get out."

Practically every Lincoln 8-80 owner reports this wonderful reception.

NOT A SINGLE BUILDER HAS ASKED FOR HIS MONEY BACK OR WISHED TO RETURN HIS LINCOLN 8-80.

A WORD TO THE CUSTOM SET BUILDERS

You can out-demonstrate, out-perform any competitive equipment in your territory. You can pull in station after station in every degree of the dial with perfect tone quality of your local station. All this without a squeal, and only using a small part of your available power, and at a price without competition. You can convince your customer in one short demonstration.

The price of complete kit for the Lincoln 8-80 is *$92.65.*

Due to the new principles involved every 8-80 works exactly alike, and you can get the same results as our finest laboratory model.

If you want an evening full of straight-from-the-shoulder super-heterodyne dope written by an engineer who has played with every super going in the last few years, send 25 cents for William H. Hollister's "*Secret of the Super*" using the coupon below.

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Order to-day for immediate shipment any of the following Lincoln-Guaranteed complete kits:

Sargent-Rayment Seven (S-M 710) kit	$120.00	Tyrman 80-super—less power pack	$134.50
S-M 720 Screen Grid Six	72.50	Tyrman 72 receiver kit	98.50
S-M 720 Screen Grid Six—factory wired	102.00	Tyrman 72AC, with power pack	153.50
1929 Laboratory Superheterodyne	95.70	H. F. L. Isotone 10-tube super	195.00

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329 South Wood St., Chicago, Ill.

.....Send me your big free catalog, listing a complete line of 1929 kits for custom building.

.....Enclosed find 25c, for which send me William H. Hollister's new book, "The Secret of the Super."

Name .....

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LIFE TEST FOR ALL TYPES OF RADIO VACUUM TUBES

In the Van Cortlandt Park Laboratories of the Radio Corporation of America there are facilities for testing 18,000 tubes simultaneously. The power required to furnish the plate current for these tubes is 400 kilowatts and the power used in heating the filaments is 240 kilowatts! So great is the heat dissipated by the tubes under test that a special ventilating system is necessary. The above picture shows a section of the racks in which the tubes are tested.

Dr. Alfred Norton Goldsmith

A FIGURE IN RADIO PROGRESS

By EDGAR H. FELIX

NO ONE is quoted more frequently by the press on radio subjects than Dr. Alfred N. Goldsmith. Newspaper men ask his views because he is always ready with accurate information and considered opinion. He has a succinct and vivid power of expression, readily quotable, and easily understood by the layman. Through the continuous contact which Dr. Goldsmith maintains as Chief Broadcast Engineer of the Radio Corporation of America with the research and development work conducted at many important radio laboratories in this country and abroad, he has first-hand information on the significance of almost every new development in the radio field.

In more technical circles, Dr. Goldsmith is recognized as an authority in every phase of radio research. His fund of knowledge is literally enormous. He is not a specialist in a single branch of radio science; his forte is coördination so that each step in technical progress may be used most effectively in commercial service and be welcomed as new and improved products for introduction to the public.

When an engineer desires to know if, how, when, and by whom any phase of radio engineering, however remote, has been investigated, he may pursue one or two courses. He may consult all the host of technical periodicals published all over the world and communicate with the heads of research departments of electrical concerns in the United States and abroad, or he may ask Dr. Goldsmith. The second method is the more efficient.

This facility for knowing the facts is the product of a lifetime devoted to the acquisition of detailed and complete information. First an honor student at the College of the City of New York, then lecturer, and finally professor at his Alma Mater, consulting expert on radio matters, Director of the Communicating Engineering Laboratories, then Chief Broadcast Engineer of the Radio Corporation, and, now, added to those duties, Chairman of the Board of Consulting Engineers of the National Broadcasting Company, and Vice-President in Charge of Engineering and Production of the RCA Photophone Corporation—this is, in brief, the career of Dr. Goldsmith. A few weeks ago the title of Vice President of the Radio Corporation of America was conferred upon him. His profession has given him its highest honor, the presidency of the Institute of Radio Engineers. Since its beginnings, Dr. Goldsmith has been a prime mover in making the Institute the recognized international technical organization of the radio field. He has edited its *Proceedings* and has earned them their well-merited reputation of the most comprehensive and complete technical journal devoted to a specialized field.

Dr. Goldsmith's injection into radio was as well ordered a process as his later pursuit of the art. During his college work, physics attracted him and physics led him to mathematics, the unfailing guide of the physicist. In electricity, he found the ideal confluence of physics and mathematics for, in no phase of all-embracing physics, are the laws of mathematics so dutifully and systematically applicable.

Having, by so logical a process, devoted



The Van Cortlandt Park Laboratories of the Radio Corporation of America which Dr. Alfred N. Goldsmith directs

himself to radio, the young student at once set himself a definite goal of achievement. Following the established practice of the mathematician, he set forth a theorem as the goal of his efforts. As he expressed that theorem to me, it was "To make possible the appearance of an individual, or any number of individuals, both in their vocal and visual embodiment, instantaneously, through any terrestrial distance by the agency of radio." In the crude state of the radio art, when that objective was set up, it was a rather ambitious conception. To-day, we no longer discuss the correctness of the theorem; it is only a matter of a reasonably short time before the proof of its correctness will be a practical demonstrated fact. That this conception of the possibilities of radio was his from the time Dr. Goldsmith dedicated himself to radio, is borne out by the singleness of purpose with which he has devoted himself to it and how intimately he has been associated with its attainment.

Goldsmith graduated from the College of the City of New York in 1907, and in 1911, won his Ph. D. from Columbia. His scholastic career was brilliant; he captured numerous prizes and honors but, unlike most exceptional students, he never lost his delightful sense of humor. Indeed, it has stood him in good stead during the many trials which have beset the growth of radio.

A log of Dr. Goldsmith's experimental work is a history of the progress of radio. He did not, like most students, acquaint himself with the experiments of Heinrich Hertz by dutifully reading his physics book. He actually performed most of Hertz's recorded experiments in the college laboratory with physical duplicates of that great investigator's equipment. In the same manner, he has, step by step, submitted every important experiment and development in radio having promise of commercial application, to critical test in his laboratory.

Was College Instructor

AFTER his graduation, Dr. Goldsmith remained instructor at the College of the City of New York, at first using a small room for experimental purposes, which later grew to become a series of laboratories for extensive engineering and research study. To-day, Dr. Goldsmith still has a laboratory which he directs, a large well-equipped five-story building at the southern end of Van Cortlandt Park in New York City. New radio devices are tested and passed for approval in these laboratories before they go into production. Thereafter, a percentage of the output is tested with every kind of measuring instrument, in order to assure uniformity.

As a part of Dr. Goldsmith's work as technical advisor of the National Broadcasting Company, the receiving apparatus for the rebroadcasting of programs from Great Britain is being developed in his laboratory. While going through the building with him, I heard 5sw of Chelmsford, England, coming through with loud-speaker volume from a special super-heterodyne. The principal problem awaiting solution, or rather awaiting final development, is that of a special receiving system, including an automatic fading compensator, so as to assure a constant signal.

It is not essential to rehearse all the details of Dr. Goldsmith's technical achievements. I need mention only two incidents in that extensive career to confirm his devotion to his theorem—to make possible the instantaneous appearance, both visual and vocal, through any terrestrial distance by the agency of radio.

As early as 1915, when the first vacuum tubes capable of radiating any appreciable power were available, Dr. Goldsmith began broadcasting from the College of the City of New York. Station 2XN, with 1500 watts in the antenna, having as its audience a handful of amateur experimenters, broadcast unblushingly to all the states of the Union. So definite was the Doctor's conception of a broadcasting service in 1915, that he invariably dedicated his programs to the entertainment of listeners over this extensive territory by carefully reading the entire list of states as a part of the preliminary announcement.

This procedure, as we view it to-day, may appear to have been almost impertinent, were not the range which this meagre power covered fully appreciated. One purpose of the rather lengthy announcement was to enable listeners to tune and to adjust their all too delicate receivers before the program began. But a second justification for the announce-



Dr. Alfred N. Goldsmith manipulating a special remote-control amplifier for broadcast transmission

ment was the fact that 2XN's programs were actually reaching a large part of the country. One of its regular listeners was Dr. A. Hoyt Taylor, then at the University of North Dakota at Grand Forks, N. D., and now in charge of the Naval Communication Laboratories near Washington.

First Remote-Control Station

ANOTHER distinction which this early broadcasting station possessed is that it was the scene of the first experiments in remote-control broadcasting. As a convenience, Dr. Goldsmith arranged an outlet for the telephone circuit so that he could call the college from his home on lower Fifth Avenue, have the telephone receiver at the college connected with the broadcasting transmitter, and thus broadcast from uptown on Morningside Heights, while listening to his own voice returning by radio. In the pressure of work, Dr. Goldsmith evidently had not read his contract with the telephone company and presumably the company was in ignorance of these early experiments.

Thus identified with the first remote-control broadcasting and the first long-range broadcasting, it is interesting to observe that Dr. Goldsmith also took part in the first public demonstration of radio picture reception, broadcast from a general broadcasting station and received in his home. There had been previous instances of picture broadcasting from WJY, WGY, and WOR but, in connection with none of these, was the reception publicly conducted. Out of the original experiments in remote-control radio telephony has grown a nationwide, wire-interconnected, broadcasting system, operated under the technical supervision of Dr. Goldsmith. Thus, the first prophecy of his conception of radio service, namely the vocal appearance, is now transferable instantaneously through any terrestrial distance. He now awaits accomplishment of the second and the progress made is a matter of public record.

There have been some recent additions to Dr. Goldsmith's laboratory building and, on my most recent visit, he offered to show me the new facilities. But he first paused for a moment in the reception room to find a waiting friend to accompany us. The friend proved to be a bright-eyed youngster of twelve, who strode with us in silent amazement through the upper floors of the laboratory. Here an entire floor of new testing equipment had been installed to measure the operating characteristics and life of alternating-current tubes which are now being manufactured in large quantities. There are facilities for testing 18,000 tubes simultaneously and the power required to furnish the plate current for these tests is 400 kilowatts! The power used in heating the filaments of these tubes is 240 kilowatts. So great is the heat dissipated by the tubes under test that a special ventilating system is necessary which pumps a complete renewal of air into the test room every three minutes.

Other Testing Equipment

ALTHOUGH many specialized lines of radio and acoustic research and development are carried on at this laboratory, the greater part of its facilities are devoted to exacting testing of the Radio Corporation's commercial products. A percentage of the output of all the factories contributing to the RCA line is sent here for test. Under the most elaborate and systematized scrutiny, the constants and life of tens of thousands of vacuum tubes annually are determined and the uniformity of their performance maintained. Receiving sets are likewise tested for every factor which determines their ultimate reliability and service to the user. One amazing device automatically plots an audio-frequency response curve and writes an infallible record of its fidelity of reproduction without the influence of human judgment. Extensive original work in circuit design and reproducer development is also conducted under Dr. Goldsmith's direction.

The theory, design, and operation of both receiver test equipment and vacuum-tube production testing was described in the November, 1928, *Proceedings*, Institute of Radio Engineers, in papers entitled "Quantitative Methods Used in Tests of Broadcast Receiving Sets" and "Vacuum Tube Production Tests," both by A. F. Van Dyck and F. H. Engel of the Technical and Test Department of the Radio Corporation of America.

Walking through this laboratory and listening to Dr. Goldsmith's explanation of the purpose of the major experiments taking place, accompanied by the young enthusiast, reminded me of a day, some fifteen years ago, when I, at about the same age, had walked through Dr. Goldsmith's laboratory at the College of the City of New York. Indeed, it was that visit which confirmed my conviction that radio would always be both my work and my hobby. But it is no peculiar distinction to have been wedded to the radio art by Dr. Goldsmith.

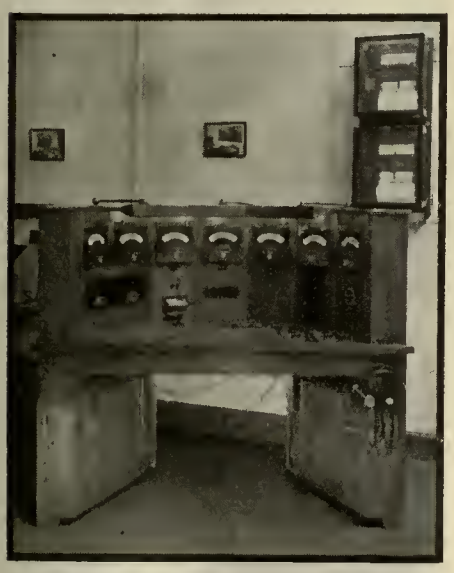
In Dr. Goldsmith's office are many mementoes of his career, ranging from autographed photographs from Marconi, Steinmetz, and Einstein to a significant radio emblem from the sculptor Edward Field Sanford, Jr., made for Dr. Goldsmith. But none of these seems closer to him than a bronze plaque, given him by the five students of the first radio engineering course which he conducted at the College of the City of New York. One of the names I noticed was that of J. D. R. Freed, now President of the Freed-Eisemann Company, another Carl Dreher, until recently staff engineer of the National Broadcasting Company, now Chief Engineer of RCA Photophone

Company and well known to all readers of RADIO BROADCAST, J. Marsten and H. Kayser, both well-known radio engineers. In succeeding years, without counting the thousands of men who studied radio while the College of the City of New York became a training ground for Signal Corps radio men with Dr. Goldsmith in charge of instruction, many have definitely started on a radio career through Dr. Goldsmith's influence.

The Youngster's Reaction

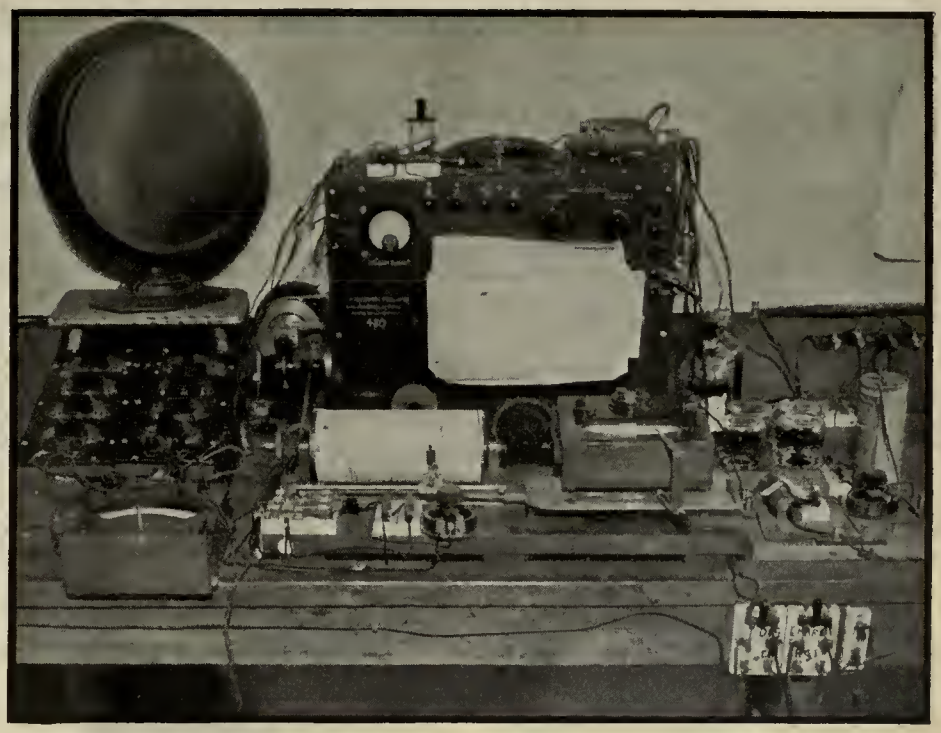
WHETHER the youngster who accompanied us will become a radio engineer as a result of this visit, I am hardly qualified to state. During most of the time we went through the laboratories, his eyes bulged in uncomprehending astonishment, much as mine, in 1912, had bulged at the sight of a three-stage, audio-frequency amplifier. It was the largest collection of tubes which I had ever seen at any one place at one time. When phones were connected in the output of this magnificent equipment, I heard, for the first time, the tinkling signals of European and mid-Pacific stations. The youngster of 1928 was more impressed by a demonstration of three power speakers with large baffles, reproducing simultaneously and with amazing volume, a Moran and Mack record. Astonishment soon gave way to laughter at the witticisms of the comedians.

The period from 1918 to the present day has witnessed not only amazingly rapid technical progress in the radio art but a great increase in the ramifications of the radio industry. When I first visited Dr. Goldsmith in 1912, radio communication in the United States was controlled by the British-owned Marconi Wireless Telegraph Company. Shortly after the War, the Radio Corporation of America was formed to take over its ship-to-shore business and to build up a world-wide transoceanic communication system. The Corporation's activities were limited strictly to radio-



Special bridge used in the Van Cortland Park Laboratories for measuring the electrical characteristics of radio vacuum tubes

telegraph communication. Its successful activities in this field have been largely overshadowed by the business incidental to radio broadcasting. More recently, it has entered the talking motion-picture field and it is rapidly acquiring motion-picture studios. By



This audio-frequency oscillator is used in the Van Cortlandt Park Laboratories for acoustic measurement work

alliances with chains of vaudeville and motion picture theatres, it is establishing its own outlets for the sound films which it is to produce. Radio transmission of pictures, both across the ocean and to various points in the United States, is slowly developing and is likely to lead ultimately to home television. But, in spite of these broadening activities, radio broadcasting remains, for the time at least, still a field of paramount interest.

One of the cardinal principles to which Dr. Goldsmith is committed is the use of high power in broadcast transmission. He believes that we now have a disproportionate system, launching only moderate power into the ether and requiring, in turn, excessive sensitivity and amplification in the receiver to secure a satisfactory volume in reproduction. As a penalty for this unbalance, the receiving equipment responds to every kind of electrical disturbance, even though minute. But, no matter how great the power of the broadcasting station, it cannot hope to overcome every kind of power interference.

"Radio is a comparatively young art and it has not yet had time to influence the electrical industry as a whole," said Dr. Goldsmith. "Within ten years, the manufacture of electrical equipment which causes undue disturbance to radio reception of signals of reasonable strength will be barred, not by legislation, but as an obviously necessary measure in the interests of public convenience, just as the muffler has become a part of every automobile. It is quite possible to design elevator motors, cash registers, bell-ringing equipment, electric refrigerators, and any kind of machine involving the making and breaking of electric circuits so that it will cause little fluctuation or disturbance in the power system of which it is a part. It will require time to accomplish these things, but unquestionably it will be done. With greater power in broadcasting and greater amplification in the receiver, necessitating a smaller pick-up device, the annoyance of static has been reduced to a point where it may be considered negligible. The next to go will be excessive man-made electrical interference with normal signals."

Picture Broadcasting

WITH respect to the broadcasting of pictures, Dr. Goldsmith feels that the possibility of amateur participation in picture experiments should be encouraged, but that apparatus so far developed is not sufficiently simple and reliable to appeal to any but the experienced set-builder and experimenter.

"While I believe experiment should always be encouraged and the participation of amateurs in practical picture reception will hasten the day that the apparatus will be of a form suited to general sale, I do not believe the public should be deprived of entertainment by the broadcasting of pictures for the benefit of a few experimenters. Picture broadcasting, when conducted for experimental purposes through broadcasting stations, should be primarily confined to such hours that the average listener does not use his radio. This consideration confines most experimental picture broadcasting to the early morning hours. It should remain thus restricted until substantial audiences are built up, a possibility only when practical and foolproof apparatus is available. It may then be necessary to transfer picture transmission to other and more suitable wave bands."

This observation reveals the underlying foundation of Dr. Goldsmith's attitude toward the public. Zealous as he is to encourage picture broadcasting, he does not believe it should be permitted to interfere with regular entertainment until it is ready, by reason of low cost and reliability, for general public consumption. And likewise, every new development of the laboratory, however promising in its experimental stages, must stand the test of public service before it is truly a practical device. Bridging the gap from the laboratory to the public is the problem to which Dr. Goldsmith has so ably devoted himself.

MEASUREMENTS ON BROADCAST RECEIVERS

By L. M. HULL

Formerly, Engineering Department, General Radio Co.

THE general subject of overall measurements on any kind of a radio set is one about which engineers do a great deal of talking but not much writing. Thus, the literature of the subject is in a rather unsatisfactory state, although the technique of providing small measured radio-frequency voltages at definitely localized points is quite generally understood, and is now being employed extensively for the standardization of broadcast receivers, even in laboratories which do not profess to be centers of research.

Most laboratory measurements on a radio receiver are based upon the assumption that the action of a wave field upon an exposed antenna, in building up a high-frequency voltage across a receiver input impedance at the base, may be simulated so far as the receiver is concerned by a locally generated signal which is fed into the receiver through a local impedance having reactive constants equivalent to those of the antenna. For example, the effective height of an antenna is any length in meters which makes a conventional formula give the right numerical result. But on many occasions in this cruel competitive age the design engineer is forced into the embarrassing responsibility of deciding whether receiver A will give more service per dollar than receiver B, without having the leisure or the facilities for operating both A and B in a hundred different localities on a hundred different antennas. The problem of making a laboratory measurement from which valid generalizations can be derived is then of vital importance which cannot be resolved by definition.

The practice of measuring a receiving set by assuming an "equivalent" local or dummy antenna and impressing a voltage in series with it would seem to be justified by theory. This theoretical argument, as outlined, is not new. It was recently summarized by Colebrook (*Experimental Wireless and the Wireless Engineer*, p. 567, Nov., 1927) and objections to it may be answered by two kinds of experimental evidence as follows:

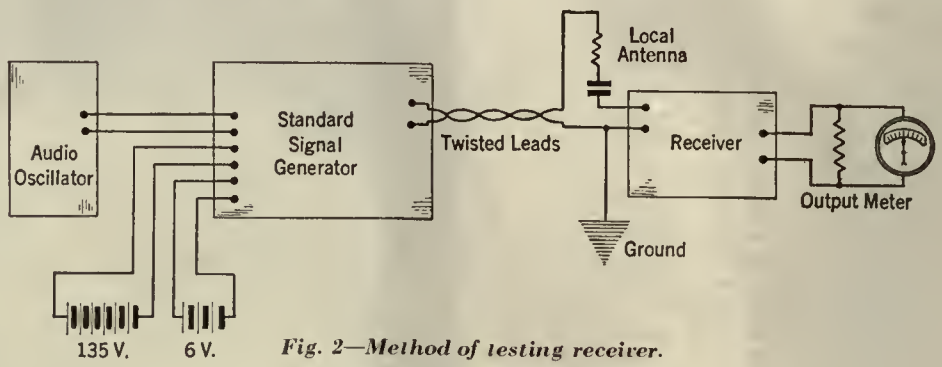


Fig. 2—Method of testing receiver.

This article by Dr. Hull, formerly of the Engineering Staff of the General Radio Company, treats of a subject that has been hotly discussed pro and con by engineers ever since there were any broadcast receivers. How to measure accurately the overall gain of radio sets has been a serious problem and the device which Dr. Hull describes here is, as far as we know, the first of its type to be generally available. Some of the material in this article was presented by Dr Hull in a paper delivered before the Radio Club of America.

—THE EDITOR.

Experimental Evidence

FIRST, if an antenna excited by a wave field is series-tuned to some frequency lower than its fundamental, and various resistances are inserted at the base (enough to vary the current at the base over a wide range) a linear relation will be obtained between current and resistance, indicating that the voltage due to the wave field acts like a constant voltage in series with some impedance, which is substantially independent of the current, at least over certain ranges. Second, if a tuned receiver input circuit is compared with a pure resistance on an antenna excited by a wave at frequencies below the fundamental, and then compared at the same frequency excited by a local generator through an impedance equal to the antenna impedance as measured at the base, the relative factors of merit will be the same for each form of measurement.

Thus it may be concluded that the use of a local signal in measuring antenna-operated receivers is partially justified by the theory I have outlined, and is better justified by experience.

A primary necessity for such measurements is a local signal generator of such a form that a known minute radio-frequency voltage may be produced between two particular terminals and *nowhere else*. With this available we can forsake the pernicious practice of measuring the individual amplifier stages, detectors and what not, independently, and multiplying the results together to arrive at the performance of the set. I do not question the value of the piecemeal measurements; they constitute essential steps in the design. But what we are now concerned with is an appraisal of the final result.

There are two schools of thought with regard to the design of refined local sources. One advocates the inductive-coupler method, in which a measured current is passed through an exposed coil and the small test voltage is picked up on a second coil having a small calculated mutual inductance with the first. A

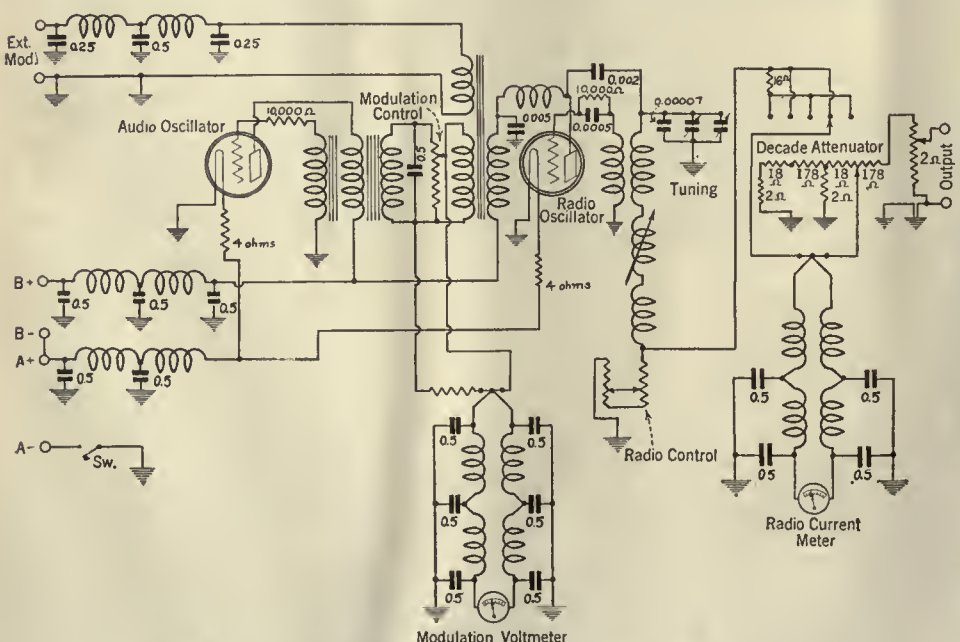


Fig. 1—Schematic diagram of standard signal generator.

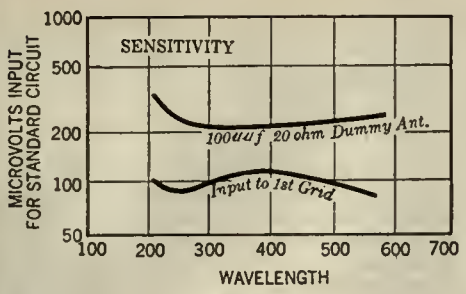


Fig. 3

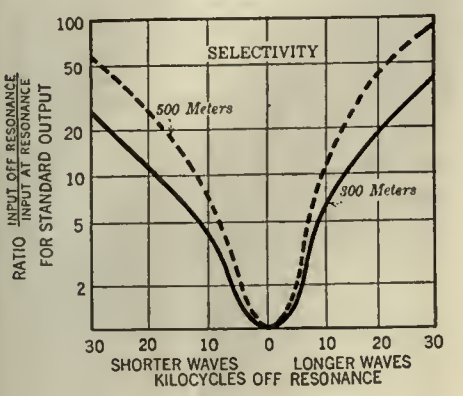


Fig. 4

typical design has been described by Rodwin and Smith. (*Proc.*, I.R.E., Feb. 1928, p. 155). It is open to certain objections as to both convenience and accuracy. The current in the generator coil must be varied over a wide range, necessitating either a series of thermal meters or a radio-current transformer, and the mutual inductance between the coils may be modified by different amounts at different frequencies, by adjacent shields, or other conductors. On the other hand, the method has the advantage of impressing a field directly upon the loop designed for use with a receiver under test, instead of impressing a voltage in series with the loop, from which the equivalent field must be calculated.

In accordance with the second method, the test voltage is developed across a small known resistance which terminates a resistance attenuation network fed by a measured radio current. This method presents the general advantage of allowing all current-carrying impedances to be buried in shields, exposing only a single terminal which is above the shield by the amount of the test voltage. It allows a rating which is directly expressible in field strengths for normal signal in the case of an antenna-operated receiver.

An outfit which I think is interesting in that it is moderately portable and yields results comparable in accuracy with more bulky equipment, is the one which I am about to describe.

A Standard Signal Generator

THIS outfit was developed to fulfil four conditions:

(1) A portable source equipped for use with external, unshielded batteries.

(2) A range of output voltages from one microvolt up, with sufficient shielding to prevent the induction by stray fields of voltages in any adjacent tuned circuit comparable with the output voltage.

(3) An accuracy well within the consistency of measurements with highly stable receivers.

(4) The whole outfit to be reproducible by ordinary skilled shop labor.

A diagram of the circuits employed is shown on Fig. 1. A single audio oscillator tube is provided within the apparatus, for modulation at a fixed frequency of about 400 cycles. This is the frequency normally used for the most common sensitivity and selectivity measurements. This oscillator includes the tube shown at the left of the drawing and the iron-core transformer tuned by a fixed condenser. This transformer feeds a modulation transformer through a resistance voltage divider marked "Modulation Control." The audio voltage is impressed by the modulation transformer through a one-to-one ratio upon

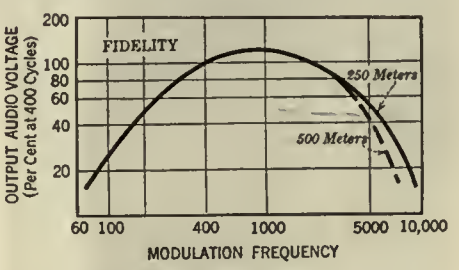


Fig. 5

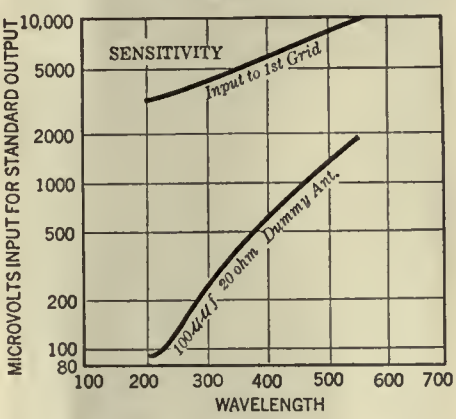


Fig. 6

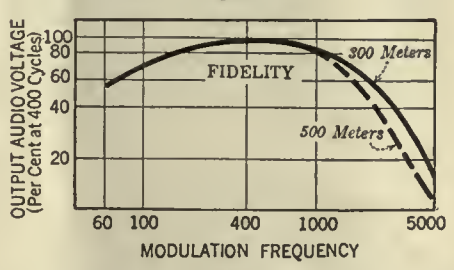


Fig. 7

the plate circuit of the radio oscillator tube, and is measured by a thermal voltmeter comprising a resistance, a thirty-ohm thermocouple, and a panel-mounting d.c. galvanometer shown at the lower part of the figure. A low pass permits the use of an unshielded external audio oscillator which may be positioned anywhere with respect to the signal generator and the receiver under test, and which may be connected to the signal generator through unshielded leads. The radio oscillator tube has a "parallel feed" plate circuit consisting of the secondary of the modulation transformer and a radio-frequency choke coil in series with the positive B battery terminal and the plate. The tuned circuit of the radio oscillator consists of a "vario-coupler" inductance which is connected by a metal belt to the variable tuning condenser, both being operated by a tuning dial on the front panel. A small variable condenser is provided in shunt with the main condenser for fine tuning adjustments. The tuned circuit is closed through an attenuator, which is bypassed to ground by a non-inductive variable resistance marked "Radio Control." This resistance thus furnishes a means for adjusting the modulated radio-frequency current flowing into the attenuator. The current which passes into the attenuator is measured on a four-ohm thermo-couple connected through a twin two-section filter into a panel-type d.c. galvanometer which is exposed on the front panel of the outfit. The output end of the attenuator terminates in a two-ohm non-inductive slide-wire which is connected to the output terminals on the front panel. This slidewire consists of a short piece of No. 38 manganin wire stretched over a copper return path with an insulation strip 0.01 inch thick between them.

Fig. 10, is an external view of the outfit. The various instruments and controls will be recognized from the description previously given. The external dimensions are 17 x 15 x 12 inches.

Fig. 2 shows a conventional method of connecting the signal generator through a local or dummy antenna to a receiver under test. For the sake of completeness an external audio oscillator is shown. The receiver may be positioned at any convenient point near the source and twisted leads a foot or so in length do not introduce an appreciable error since the impedance at the generator end is never more

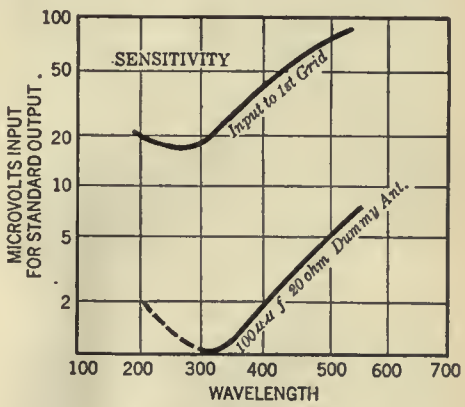


Fig. 8

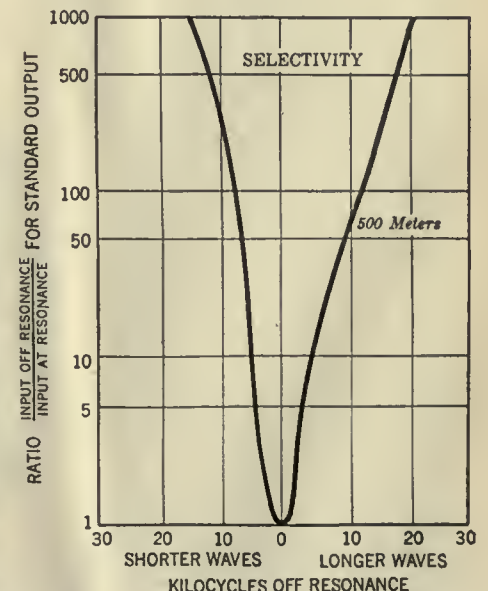


Fig. 9

than two ohms. The error in any ratio on the slidewire or decade attenuator is not greater than 3 per cent. at any frequency above 1500 kc.; (2) The error in the absolute value of the voltage between the generator terminals is not greater than 4 per cent. at any frequency and is probably much less for potentials above 10 microvolts.

The accepted practice in measuring and rating receivers is to impress the known voltage from the generator in series with the local antenna circuit and the input terminals of the receiver. The output of the receiver is equipped with a resistance load appropriate to the power tube or tubes which terminate the audio amplifier. A "normal signal" is specified for all receivers, usually 50 milliwatts. All measurements are referred to the radio-frequency voltage, with a specified percentage modulation and a specified antenna, which will produce normal signal in the output load of the receiver. With an output load of 2000 ohms, for example, normal signal corresponds to about 14 volts which is a reasonable loud-speaker voltage. A simple "output meter" is required for all such measurements. It may be a vacuum-tube voltmeter or a thermal meter. Furthermore, sensitivity measurements are usually made with a modulation frequency of 400 cycles and 30 per cent. modulation.

General Shielding

THE radio- and audio-oscillator circuits are mounted in a heavy copper box with a removable lid. This main internal shield is fitted to a metal sub-panel, which is attached by metal studs to the outside panel, also of metal. The outside panel is screwed tightly to a copper-lined cabinet and forms with it the outside shield. The various filters are each distributed, part inside the internal shield and part between the internal and external shield. All controls are brought through both shields to the front panel on *insulated* shafts. Metal shafts are undesirable because they frequently make rubbing contacts with one or both shields and produce unexpected and disturbing phenomena.

All battery lines, the external modulation lines, and the lines to the two d.c. meters pass through filters. These particular filters were evolved from a number of different laboratory outfits and finally reduced to the minimum amount of inductance and capacity which maintain the insulated terminals at negligible radio-frequency potentials above the external shield. The coils in all the filter sections consist of bobbins wound with No. 20 wire to an inductance of about 400 microhenries, and each mounted in an individual copper shielding cell. All the capacities in the battery and instrument lines are 0.5 mfd. The end capacities on the modulation filter are 0.25 mfd., making this line an impedance of about 30 ohms throughout the audio-frequency band, as looked at from the external modulation terminals. The modulation transformer winding, which is fed through this line, is correspondingly a low-voltage winding.

The resistance attenuator is built of small non-inductive units in which no wire larger than No. 38 manganin is employed. It will be noted that no single resistance unit is larger than 178 ohms. This permits the use of the reversed-loop form of winding which experience has shown to be more reliable as a radio-frequency voltage-drop resistance at 1500 kc. than the so-called bifilar or parallel-strand winding. Capacity effects in the reversed-loop winding would be important, even with wire as small as No. 38, if high resistances were employed. Suitable methods of using radio-frequency slidewire in radio gain-measuring outfits have already been developed and an adaptation of the older technique is employed. Voltage ratios of over 10 to 1 may easily be obtained on a wire not over one inch long. Thus, by the use of the slidewire to provide the necessary continuous variation, steps of 10 to 1 may be employed on the attenuator and a single value of current may be employed for all values of test voltage from the highest to the lowest, which is a great advantage from the standpoint of convenience.

By using the slidewire, then, we are enabled to employ a decade attenuator having only five steps. Using the values of resistance shown the attenuation ratios are as follows: 10,000 to 1, 1,000 to 1, 100 to 1, 10 to 1, and 1 to 1. The slidewire is normally provided with a calibrated scale of 20 divisions. Thus, with the current through the radio current meter adjusted to a fixed value of 50 milliamperes and the attenuator at the last point on the left, a radio potential of one microvolt is impressed between the output terminals with the slidewire on its first scale division, and 10 microvolts with the slidewire at maximum. The slidewire scale is correspondingly multiplied in microvolts output at other points on the attenuator. The current may also be operated at twice the foregoing value without forcing the meter off scale, which provides a maximum output voltage of 200,000 microvolts.

The sliding-contact switch shown above the decade attenuator in the diagram of Fig. 1 is simply a device for throwing a fixed resistance of approximately 16 ohms in series with the attenuator on alternate points in order to keep the total resistance in the radio-frequency circuit constant and prevent current variations as the attenuator is shifted. This compensating resistance is controlled by a separate switch mounted on the same shaft with the attenuator switch because it and its associated leads must be carefully shielded from the right-hand or low-voltage portion of the attenuator. The shielding of this attenuator is a delicate and rather complicated matter, brought about by the fact that for convenience we elected to start with large radio-frequency currents.

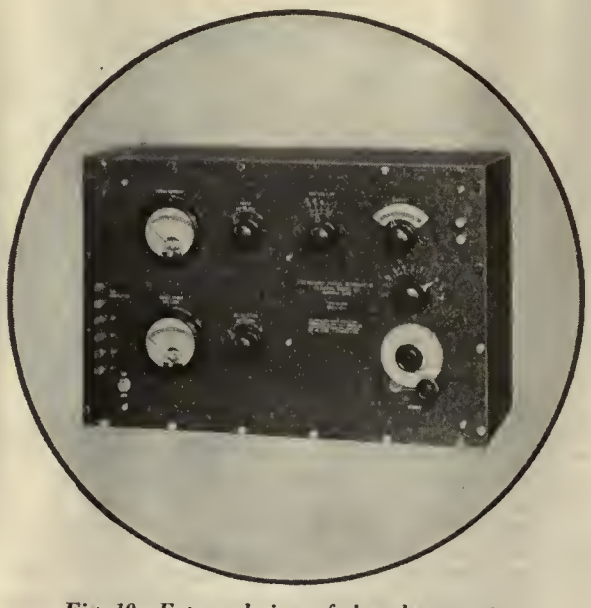


Fig. 10—External view of signal generator.

Actual Receiver Performance

THE next few illustrations show some receiver performance curves made with an outfit of the character described above. These were merely picked at random as illustrative of the general types of information yielded by these measurements, and are by no means intended as a complete study of any one receiver. All these curves were taken with a local antenna of 20 ohms resistance and 100 mmfd. capacity. This does not affect the selectivity and fidelity appreciably but for a study of sensitivity, various antenna combinations should be employed.

Figs. 3, 4, and 5 show the sensitivity, selectivity and fidelity of a receiver which has two tuned radio-frequency stages, stabilized by grid suppressors with a third radio-frequency tube at the input fed by an untuned antenna circuit—six tubes in all, with three tuned circuits. It is not very sensitive with a small antenna, owing to the voltage loss in the untuned input circuit. This is shown by the lower curve which was taken for comparison with the antenna circuit cut out (Fig. 3).

Fig. 6 shows the sensitivity of a high-grade five-tube set containing two well-balanced radio stages and a good audio amplifier. It is shown to bring out the effect of using a high turns ratio in the radio transformers in order to obtain selectivity in a non-regenerative set having only three tuned circuits. Fig. 7 shows the excellent low-frequency fidelity resulting from the use of heavy audio transformers. The high-frequency part of the curve indicates that the designer might profitably have decreased the losses in the audio transformers in view of the amount of side-band cutting present in the radio amplifier.

Fig. 8 is an example of extreme and mostly undesirable sensitivity. This receiver has four tuned, balanced radio stages with five tuned circuits. At 300 meters, one microvolt in an antenna of 100 micro-microfarads capacity produces normal signal. The decrease in sensitivity below 300 meters is due to the fact that the gang condenser was not properly aligned. Fig. 9 shows the razor-like selectivity effect of five tuned circuits and also the effects of some accidental regeneration.

I am indebted to Mr. Malcolm Ferris of the Radio Frequency Laboratories for selecting these curves for me from his files.

The study of overall performance curves is fascinating because it offers endless opportunity for interpretation. I have by no means discussed all the measurements which can profitably be made on broadcast receivers even after their design is completed. But I do not wish to minimize the importance of constant listening to receivers and manipulation of them on actual reception of broadcast signals. I believe that an experimenter can best employ his facilities by making constant comparisons and correlations between the overall performance curves of any receiver and his reasoned impressions of its behaviour in actual signal reception. By such a procedure a mature and valuable experience in the interpretation of overall characteristics can be obtained without which they are apt to be nothing but scraps of paper.

The MARCH OF RADIO

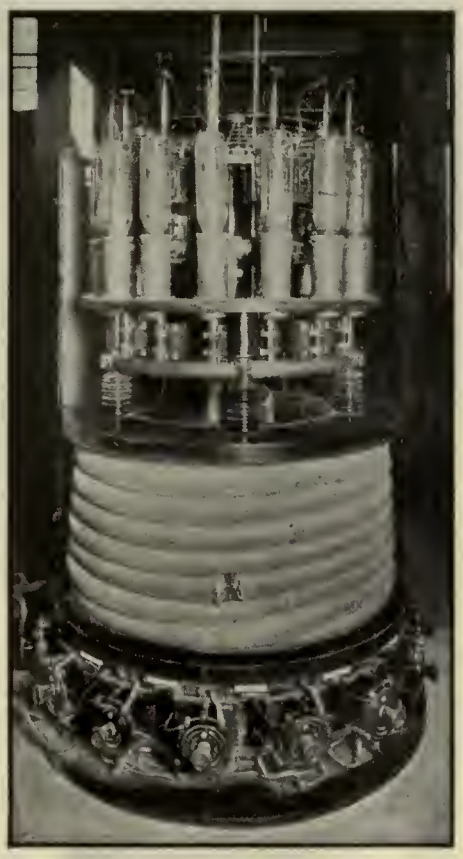
The Davis-Dill Publicity Barrage Begins

OPEN season for obscure Congressmen to focus public attention upon themselves by shooting holes in the unfortunate broadcast structure is again upon us. The first to seize upon this tried method of limelight winning were the familiar figures of Senator C. C. Dill and Representative E. L. Davis.

The theme of their 1928 short-session song hit is that the power of broadcast stations should be limited to 10,000 watts. "These high-powered stations," says Senator Dill, "dominate the dials of most receiving sets within a radius of 150 to 200 miles of the transmitter using immense power. Since the Commission will not protect the public, Congress is the only body that can do so. The people for whom Congress passed radio legislation are entitled to conditions under which they may listen to stations other than those of immense power. In practice, it is found that these high-powered stations cannot be separated by kilocycles."

Our listening post is so located that the effect of high-powered transmission may be observed under the most ideal conditions. Within twenty miles are WJZ and WEAF and 110 miles to the North is WGY. Utilizing a receiver costing less than $150, we heard, between sundown and 11 P.M. during the first ten days of the new allocation, while each of these "dominating" high-powered stations were broadcasting, WCAU, WWVA, WHAM, WFBR WRVA, WPG, WBT, WTAM, KYW, WHO, WBZ, KDKA, WCFL, CKCW, CFRB, WFIW, WCSH, WMAK, WLS, WENR, KWKH, CJCG, KOA, WHAS, WCCO, KTHS, WNC, WJR, WGN, WLW, WPTF, WMAW, WSM, WGBF, WTMJ, WIP, and WFI, each with intelligible loud-speaker volume. The local stations are not included in the list. Over half of these out-of-town stations were reproduced with sufficiently good quality to be comparable to locals. The entire spectrum of low- and high-powered local stations is spread adequately so that none interferes with another. There is not the slightest support for the Senator's statement that stations over 25,000 watts cause any greater trouble than 500- and 1000-watt stations at equal distances.

It is a well-known experience that, when power increases are first put into effect, poorly designed receivers in the immediate vicinity show up their inadequate selectivity. After a few weeks of operation, ancient receivers are replaced, excessively long antennas are reduced to more reasonable proportions and wave traps are installed at locations within four or five miles of such stations. These alterations are necessary, whether the new station is 5000 or 100,000 watts. Levelling the power to 10,000 watts does not eliminate the need for these reasonable modifications, nor does it increase by an iota the number of stations which may be loaded upon our broadcast channels without heterodyning. On the other hand, power curtailment reduces service to listeners in remote areas and increases the disturbing effect of interfering atmospheric and electrical noise upon reproduced programs tuned-in by both urban and rural listeners.



Circular bank of 15 water-cooled power-amplifier tubes used for transatlantic telephony. This unit has an output of 200 kw.

PUBLIC PREFERENCE

The public prefers the loudest station which offers an acceptable program. The higher the signal level, the less sensitive and less expensive the receiver required to reproduce it. As the signal level is reduced, the musical quality of reception is proportionately injured regardless of amplification power. Restricting broadcasting to low power deprives the rural listener of any real broadcasting service and, even with a most expensive receiver, whatever programs he is able to tune-in from low-powered stations are marred by excessive tube noise, static and electrical interference.

It was only with the advent of high-powered broadcasting that radio was lifted from a curiosity to a musical instrument. The senator is setting out to destroy the musical value of radio for all except those within the shadow of broadcasting stations. The greatest damage which would be wrought by the adoption of his proposed measure would be the farmer and the rural listener who finds radio an almost essential enhancement to his happiness. He usually is equipped with a less expensive receiver and will resent the loss of the only stations which give him a good loud-speaker signal.

The Senator's effusion is inspired by the fact that it enables him to make spectacular attacks upon the great electrical interests. Defending the weak against the strong makes good newspaper copy, even though, in the case of broadcasting, its prospective effect is to weaken radio signals and curtail broadcasting service. It is inevitable that the great electrical and radio interests should be the only ones willing to build great stations because small fry can neither afford to erect such stations nor to pay the immense cost of operation and maintenance involved. Hence, discrediting high power has that delightful anti-monopoly flavor which is so effective with the gallery and the press. In the last analysis, the listener is the one who would pay, were the Senator successful in forcing his proposal into law, by being compelled to buy a more expensive receiver and by the reduced quality of reception which the weakened signal would give him.

Senator Dill's bill to authorize a salary of $10,000 a year to the chief counsel of the Federal Radio Commission is a most constructive measure and we are pleased to commend his stand in this matter.

BROADCASTERS AS UTILITIES

Representative Huddleston of Alabama wishes to class broadcasting stations as public utilities because they wield great public influence. The principal effect of such classification would be to take from program directors the right to select entertainment and educational features according to the desires of the listening audience. According to public utility principles, whoever has the price of broadcasting would be entitled to the service of the microphone. Facilities must be provided to meet whatever demands the public makes for them. Considering that there is no way of increasing the number of broadcasting stations to the thousands necessary so that all who wish could broadcast, the proposal is no more unreasonable than requiring the President of the United States to take all persons of voting age for a joy ride in his limousine on the Fourth of July. Newspapers and motion pictures also have great public interest and they might, on the same plea Mr. Huddleston makes for public utility regulation of broadcasting, be compelled by Congress to publish all news and propaganda items submitted to them and to film all politicians at whatever cost they render such service to anyone.

We hope that the trade associations of the radio industry will profit from the painful lesson which they should have learned last year, when the destructive Davis Amendment was slipped over while the industry associations slept. Since the general public

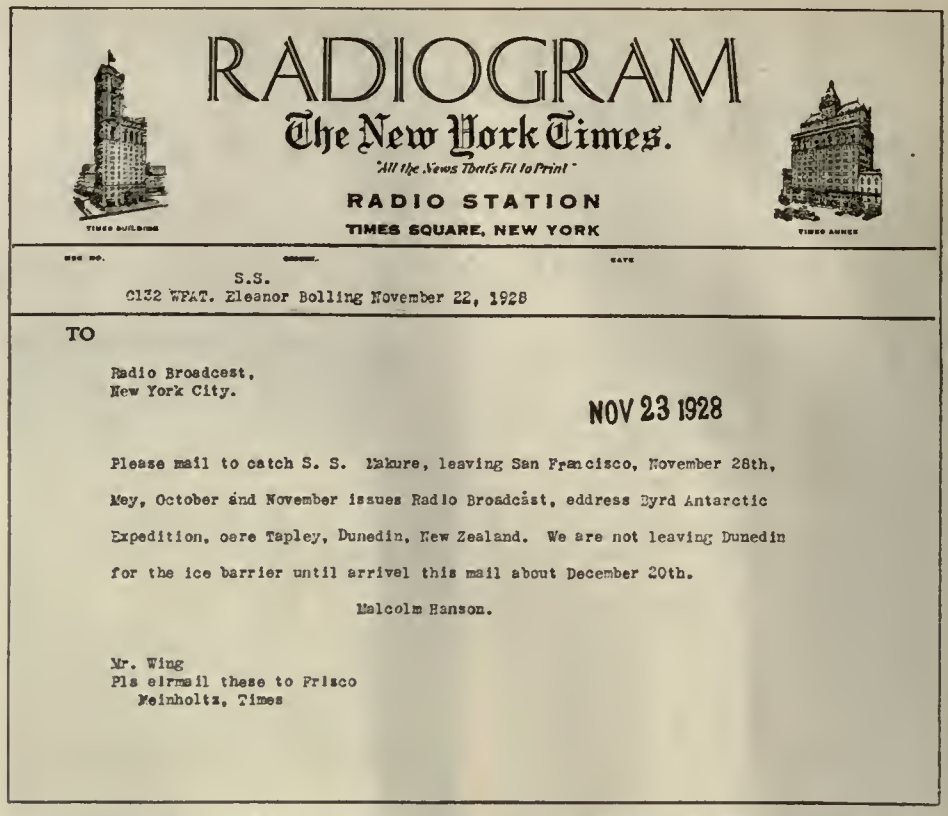
does not know what it is all about until after legislation is passed and the politicians playing with radio legislation do not intelligently protect the interests of the listener, it is highly essential that definite steps be taken by the radio industry to defend the threatened ether channels. Legislation tending to reduce broadcasting service should be vigorously opposed lest politicians, in their zeal for publicity, destroy the structure which has been so painfully built up.

Fitting Receivers to the New Allocations

IF THE new allocation structure survives the attack of self-seeking broadcasters and meddling politicians, it is likely to form the foundation upon which all future allocations will be based. A month's observation, under the new conditions brought about by the allocation, reveals an entirely new broadcasting world. In general, leading stations are now no longer marred by beterodyne whistles, with the consequence that their clarity of reproduction is greatly improved. On the other hand, in most localities, the number of points on the dial that near-by local stations are found bas been reduced. This is the case particularly in the congested districts of New York and Chicago. In the wide gaps between the local stations, the listener with the moderate prieed set is now served with good quality by stations several bundred miles distant. With a highly sensitive receiver, he can bear distant programs during the early evening hours as reliably as after midnight prior to the reallocation.

Tbese new reception conditions make tbose cbaracteristics of receiver performance, paramount in the embryo days of broadcasting, once more of great value. For the last two or three years, we bave been concerned principally with improved convenience in maintenance, secured by powering receivers directly from the light socket, and better tone quality, made doubly desirable by the availability of high-powered, high-quality transmissions. Although progress in these directions is by no means balted, it now becomes increasingly desirable to encourage greater sensitiveness and better selectivity. Both tbese objectives were once attained by using regenerative receivers, the selectivity and sensitivity of which increase proportionately to the amount of regeneration employed. Fortunately, the regenerative receiver is no longer with us because a slight move of the dial, when it is in its most efficient operating condition, converts it into a transmitting station. But, even with several stages of tuned radio frequeney, the best we can hope to do is to equal the selectivity obtainable with well-designed regenerative receivers. However, we cannot rely, in this day and age, upon regeneration. Regeneration sharpens tuning to the point that discrimination of audio as well as radio frequencies is obtained, so that either low or high tones are lost. This militates against the quality of reproduction, a characteristic no longer tolerated by the discriminating listener.

We must, therefore, find new means of securing the degree of selectivity which has now become desirable and useful without sacrificing tone quality. This may be attained by the band-pass filter systems, admitting full energy of a ten-kilocycle channel hand but discriminating sharply against any signals outside the desired channel. As progress is made in improving selectivity, the permissible power of broadcasting stations will increase greatly and consequently the listener may ultimately expect satisfactory programs on every dial position of his receiver. Furthermore, the number of stations which give him a clean signal, rising above local electrical noise and atmospheric disturbance, will increase in proportion to the power of the transmitting station. Forward looking manufacturers will take advantage of the opportunity which the new allocation brings hy departing from stereotyped designs and producing receivers possessing new standards of selectivity and sensitivity.


RADIOGRAM

The New York Times.

"All the News That's Fit to Print"

RADIO STATION

TIMES SQUARE, NEW YORK

S.S.

C132 WFAT. Eleanor Bolling November 22, 1928

TO

Radio Broadcast,
New York City.

NOV 23 1928

Please mail to catch S. S. Makure, leaving San Francisco, November 28th, May, October and November issues Radio Broadcast, address Byrd Antarctic Expedition, care Tapley, Dunedin, New Zealand. We are not leaving Dunedin for the ice barrier until arrival this mail about December 20th.

Malcolm Hanson.

Mr. Wing
Pls airmail these to Frisco
Meinholtz, Times

***This radiogram, signed by Lieut. Hanson, radio head of the Byrd Antarctic Expedition, shows that the explorers plan to keep abreast of the times on radio subjects by reading* Radio Broadcast**

Schedule of Broadcast Television Transmissions

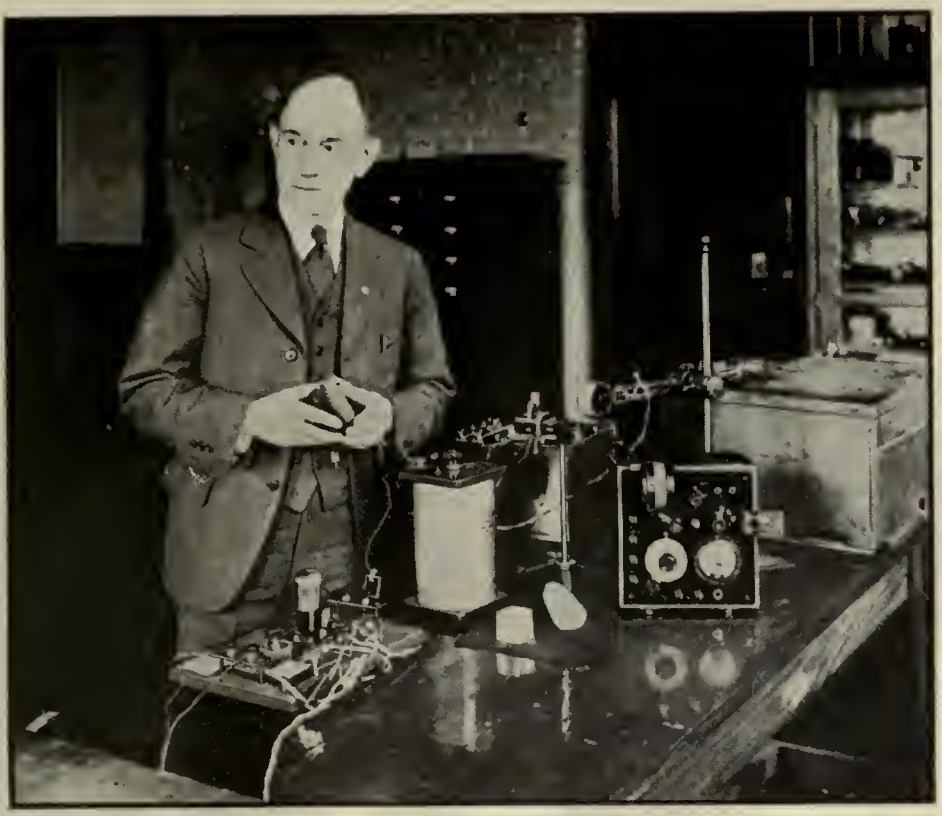
Call Letters	*Location*	*Wave-length*	*No. of Holes in Disc*	*Speed of Disc (R. P. M.)*	*No. of Pictures Per Second*	*Schedule of Transmissions E. S. T.**
W2XAF	Schenectady, N. Y.	31.5	24	1260	21	Tuesday 1:30 P. M.
W2XAD	Schenectady, N. Y.	19.6	24	1260	21	Sunday 11:15-11:45 P. M. Tuesday, Thursday, Friday 1:30-2:00 P. M.
W3XK	Washington, D. C.	46.7	48	900	15	Monday, Wednesday, Friday 8–9 P. M.
WRNY	New York City	326	48	450	7.5	5-10 minute periods every hour station is on air
W2XAL	New York City	32	48	450	7.5	
W9XAA (WCFL)	Chicago, Ill.	61	48	900	15	10 to 11 A. M. Daily except Sunday
WMAQ	Chicago, Ill.	447.5	45	900	15	Probably 11:30–12 P. M. Daily
W4XA (WREC)	Memphis, Tenn.		24	900	15	Irregular
W1XAY (WLEX)	Lexiogton, Mass.	62	48	900	15	9:30 P. M. Daily
W2XBU	Beacon, N. Y.					
W8XAV	Pittsburgh, Pa.	63.5	60	900	15	Irregular
W6XC	Los Angeles, Calif.	66	36	1080	18	1:30 to 2:30 A. M.

* As this issue goes to press the status of television on broadcast waveleogths is unsettled. The Commission has invited all interested parties to attend a meeting to discuss the advisability of allowing visual broadcasting within the band from 500 to 1500 kc. Also, the Commission has limited television transmission in this band to between the hours of 12 midnight and 6 a. m.

Aircraft Radio

IN HIS annual report, Major General George S. Gibbs, Chief Signal Officer of the Army, announces the development of a new, douhle-voltage, direct-engine-driven generator, replacing the wind-driven dynamoter, hitherto used for powering transmitters and receivers. The motor-driven power source can be used while the plane is on the ground and is considerably more reliable than the wind-driven type. One of the principal problems with wind-driven generators was the requirement that automatic, self-regulating propellors, which compensated the variations in speed of the ship, are required to insure reasonably constant voltages.

THE Bureau of Standards is improving its radio direction beacon by making it unidirectional. This will not only increase the beacon signal strength in the desired direction, but reduce the possibility of interference. A combination of vertical antenna with the two crossed coil antenna is used.



Dr. Walter G. Cady, head of the Department of Physics at Wesleyan University, has been awarded by the I. R. E. the 1928 Morris Liebmann Memorial prize for the year's outstanding accomplishment in radio

THE latest edition of the annual list of amateur radio stations in the United States includes the call letters, names, and addresses of the operators of 16,928 amateur transmitting stations. W. D. Terrell, chief of the Radio Division of the Department of Commerce, reports that 2983 applicants for commercial operators' licenses and 5687 for amateur licenses were given examinations during the current year.

With the Broadcasting Stations

HARRY BELLOWS, Manager of WCCO, Minneapolis, has announced his desire to utilize only those network programs he selects from the offerings of the N. B. C. and Columbia systems. While such freedom of choice is desirable from the standpoint of the local station manager, the widespread adoption of this attitude would make the economic position of the purveyors of wire-syndicated programs unstable. Wire networks cannot be conducted economically unless a reasonable number of hours are used by all the stations served. Furthermore, the commercial broadcasters, who make chain broadcasting possible, are not justified in excessively high talent cost unless a considerable number of stations distribute the programs.

Nevertheless, Mr. Bellows is pointing the way to a trend which will ultimately gain headway. With the improvement in recording musical programs upon films and records, we may eventually see a lessened use of the wire method of distributing programs. If this trend is ever carried to the point that wire distribution of programs becomes uneconomic, however, it would be a great loss to broadcasting in that permanently set-up, nation-wide networks could no longer be maintained. Then great broadcasting events, such as presidential speeches and sporting events, could no longer be broadcast on a nationwide scale simultaneously with their occurrence. Hence, this trend is acceptable only to the point that it does not affect the stability of wire-syndicated program service.

FOR the purpose of record, we present the following figures from the St. Louis *Post-Dispatch*, summarizing the now-forgotten, radio presidential campaign:

Time used in nationwide hook-ups, 50 hours to a side.

Stations broadcasting Smith's acceptance speech, 115, a record number.

Stations broadcasting Hoover's acceptance speech, 107.

Average price an hour, about $7500

Democratic appropriation for radio, $600,000; spent nearly $650,000.

Republican appropriation for radio, $400,000; believed to have spent practically as much as the Democrats.

Total radio expenditures of both parties, including local spot broadcasting, estimated at $2,000,000.

Replies from listeners: Democratic, 250,000 letters, 10,000 telegrams, $600,000 in cash contributions. Republican, 100,000 letters and heavy contributions.

Compare this with the very limited use of broadcasting in the previous campaign, amounting to forty or fifty thousand dollars for each party.

CONGRESSMAN EMMANUEL CELLER, appearing for WNYC in its efforts to replace WMCA, which shares its 570-kc. channel, stated that WNYC being a municipal station, operated by a government body, has superior rights over a commercial station. Were such a principle recognized, it would be unfortunate because municipal or state operation does not by any means insure superior service to the listeners. It would not be difficult, were municipal and state stations held superior to commercial stations, to completely dominate the dials with municipal, political, chamber of commerce, and state university broadcasting stations. Many of these, no doubt, serve a useful purpose, but they are very far from representing a substantial part of the listener's service.

THE Department of Commerce has ordered special radio receivers, equipped with accurate means of measuring frequencies, to check broadcasting stations. No matter how perfectly allocation is worked out, if stations do not adhere closely to their assigned frequencies, serious heterodynes are bound to result. Some of the deviations of channel assignments are sufficiently great to be observable with an ordinary commercial receiver, if the owner takes the time to plot a dial setting-frequency curve. Captain Guy Hill, the Federal Radio Commission's engineer in charge of broadcasting, reported, among others, deviations of WKBQ, 25,400 cycles high; WNJ, 18,000 cycles low; WEVD, 8900 cycles high; WAFD, 73,200 cycles low, and WSDU 20,100 cycles high. Such extraordinary deviations are adequate evidence of total technical incompetence, sufficient to warrant cancellation of stations' licenses. With the imperfection of even the best kind of crystal control, moderate and occasional deviations are not entirely avoidable, but some of the deviations noted amount to from two to five degrees on the ordinary radio receiver dial and only the most moderate technical skill is required to avoid them.

THE Federal Radio Commission's decision to revoke the 1000-watt construction permit granted WIL, after KWK had successfully prosecuted a hearing for full time on the 1350-kc. channel which WIL expected to share with it, is illustrative of the precarious character of the broadcasting business. Construction permits should not be granted on terms which involve curtailing the power or time of established stations without first obtaining a waiver from the stations involved. While we have little sympathy for anyone who constructs a broadcasting station in an area already receiving adequate service, we feel that those having the courage to invest in new broadcasting facilities should at least be given every reasonable protection. WIL will not even have the satisfaction of offering an opening program with its new 1000-watt transmitter, the construction of which was entered upon only after a proper permit had been obtained from the Commission.

ACCORDING to press reports of the evidence of Hugo Gernshack, appearing on behalf of his station, WRNY, before the Commission, the Edison Hour has cost the New York Edison Company as much as $20,000 in a single week. This is the highest cost for talent ever reported for a single feature of that character. The Edison Orchestra is not at all unusual and it is amazing to learn that this feature costs twenty times the average of similar features of equal program merit.

Progress in Short- and Long-Wave Radio

A COMPREHENSIVE report concerning high-frequency allocations, prepared for the Federal Radio Commission by T. A. M. Craven, emphasizes the importance of accurate maintenance of assigned frequen-

cies. The standard used should have an accuracy of 0.025 per cent., although 0.005 per cent. is within the range of practical possibility. He recommends that no licenses be granted to any who do not demonstrate that they can maintain their assigned frequencies within 0.05 per cent.

A FEATURE of the *Vestris* disaster which has escaped general attention was the discovery that the American steamer *Montoso* was hardly 25 miles from the sinking ship but, being unequipped with radio, did not hear of the disaster until its arrival in Boston several days later. The *Montoso*, having less than the minimum number of passengers or crew required to make radio equipment compulsory, cannot be criticized for its failure to be so equipped. Nor would it be justifiable to increase the requirements so that thousands of small steamers, most of which do not venture into seas where they are likely to be of value in saving life, are required to maintain radio service. It would be possible, however, to design receiving equipment which is automatic and which would require no personnel to operate. When a characteristic distress signal is received, such a device can actuate an alarm bell and also automatically place in service a signal-recording device, built upon the principles of a picture recorder. Then, by reference to a code book, the message could be interpreted by any person, however unskilled in the radio art. Such equipment would not be excessively expensive either in installation or maintenance and could be required upon all ships above a thousand tons which travel more than fifty miles on the high seas.

[*News of the Radio Industry*

THE Radio Corporation of America has voted to form a separate communication company as a step toward the ultimate sale of its communications interests either to the International Telephone & Telegraph Company or the Western Union. It is necessary that the White Act be amended to make such a sale possible but, in view of the precedent set in England, where legislation was passed to permit merger of cable, telegraph and radio communications interests, there is considerable hope that Congress will relax its hostile attitude toward the R. C. A. sufficiently to pass such an amendment.

David Sarnoff has been promoted to the title of Executive Vice-President of the Radio Corporation of America. Dr. Alfred N. Goldsmith becomes Vice President and Chief Broadcast Engineer, Manton Davis, Vice-President and General Attorney, and Elmer Bucher, Executive Vice-President of R. C. A. Photophone. Hiram S. Brown has been elected President of Radio-Keith-Orpheum. He was formerly President of the United States Leather Corporation.

THE Jenkins Television Corporation, a subsidiary of the deForest Company, has been formed with a capitalization of ten million dollars. Two and a half million dollars' worth of the stock is offered the public. C. Francis Jenkins is Vice President in charge of engineering. Presumably the short-wave shadowgraph reproducer will be marketed by the company. The subject of transmissions is taken from silhouette films and the reproduction is enlarged by means of lenses and mirrors to about six by six inches. From what we have seen of Jenkins' apparatus, it has considerable curiosity value, but great strides must be made in detail and shading before it can be said to have entertainment value. Mr. Jenkins' long experience in television research makes progressive improvement certain, but how long it will take before the unsolved problems of channel conservation, necessary to television of educational and entertainment value, will be solved is still more a guess than a prediction.

THE Traffic Committee of the Radio Manufacturers' Association has presented detailed demands for reduced and equitable freight rates applying to radio receivers, before the Joint Classification Committee of the principal railroads. Bond P. Geddes, Executive Vice-President, and W. J. M. Lahl, Manager of the R. M. A. Traffic Bureau, appeared for the R. M. A. on this question, which is of vital interest to the radio industry.

THE Department of Commerce reports the value of radio output in 1927 at $191,848,665, an increase of 8.4 per cent. over 1925. The production of tube type sets fell 19.1 per cent. in number but rose 0.7 per cent. in value. Socket power devices constituted 13.4 per cent. of the total value of radio apparatus manufactured during the year.

PIERRE BOUCHERON, for many years advertising manager of R. C. A., has been placed in charge of the new R. C. A. southern district sales office at Atlanta.

KOLSTER RADIO CORPORATION has closed contracts with Wired Radio, Inc., a subsidiary of the North American Company, effecting a patent interchange arrangement and requiring that one-third of Wired Radio's requirements be manufactured by Kolster at cost plus 25 per cent. basis.

Decisions of the Courts

IN AN opinion handed down by Judge John C. Knox of the Federal District Court for the Southern District of New York, Dubilier patent 1,497,095 and Horton patent 1,572,604, held by the Dubilier Condenser Company, were held invalid and, therefore, not infringed by the Aerovox Wireless Corporation.

THE Federal District Court of New Jersey upheld R. C. A., G. E., and A. T. & T. in their joint action against the Shamrock Manufacturing Company. The defendant unsuccessfully held that the parties in the suit represented misjoinder of action.

THE Hazeltine Corporation won a decision over Atwater Kent in the Brooklyn Federal Court. Atwater Kent contended that, because of earlier patents granted Alexanderson, under which they are licensed, they did not infringe the Hazeltine patents. Judge Grover M. Moscowitz enjoined Atwater Kent from further infringement and ordered an accounting. An appeal has been entered.

THE Supreme Court of the United States declined to review the injunction issued by the Federal District Court for Delaware, restraining the R. C. A. from enforcing Clause 9 of its license to receiver manufacturers, to which objection was brought by a group of vacuum tube manufacturers.

E. H. F.







These pictures show the Fultograph apparatus which is used by the British Broadcasting Company for the broadcasting of pictures. (above) The apparatus being set in motion at Station 2LO, (left) adjusting the paper to the receiving cylinder, and (right) a cartoon as it is received on the cylinder

THE BUSINESS SIDE OF RADIO SERVICING

By JOHN S. DUNHAM

QRV Radio Service, Inc.

THE ensuing article, which has been permitted, by the Grace of God and lack of penetration of the Editor—no matter what he may be saying about it from his box seat on the right—to appear in this august (or February) publication, does not contain one word of technical problems, but rather of general service questions which we believe are both outstanding and common to most of us who are in the service game. You may, therefore, with entire propriety—and very little loss—omit reading it and wait for the more or less technical problems which we hope to vigorously attack in following articles.

In order to discuss any subject intelligently it is first necessary to know what that subject embraces, to effect an orderly division of its phases, and then to discuss each phase separately. If we are talking about our own problems as servicemen, then it will help clarify the situation to classify not only our problems but also to divide up into groups the different kinds of servicemen. We believe that servicemen may be divided into three general classifications, into which fall at least 90 per cent. of all the men in the country who are doing any sort of radio service work.

The first, and we believe the largest, class is composed of those who are working alone in their own residence neighborhood, and devoting either all of their time or only a part of it to servicing broadcast receivers. This class comes from the amateur ranks, professional set-builders, high school and home experimenters, commercial and Navy radio operators, electricians, radio "institutes," and many other sources. A large number of them, like Topsy in Uncle Tom's Cabin, "just growed."

The second class is composed of those who are working as servicemen for service organizations, or in the service departments of radio dealers. The vast majority of such men has been recruited from the ranks of those who first started working for themselves around the neighborhood, although some of them are from as many different sources as is the first class itself.

The third class is made up of those who are the employers of other servicemen, either as executives of their own service or sales-service organizations or as heads of service departments. This third class, which is largely responsible for the beginnings of general organization in the service field, has grown up from both of the other classifications. The author, who has done various kinds of radio work since 1912, including amateur, commercial, and Navy operating, has been successively in each of the three classifications of servicemen since KDKA started broadcasting.

Every serviceman is a potential employer or director of other servicemen. Most employers and directors have been servicemen. Those few who have not are indeed unfortunate. The problems of the man who is an employee are also those of the other two classes. The man who is working alone has a great many problems and responsibilities which his brother, who is an employee, does not have to share, but his problems *are* shared by the third and smallest class, the employers, who, besides all the troubles of all other servicemen, have thrust upon them enough additional problems to keep them awake nights. In this article we shall treat of those problems which are confined chiefly to the lone serviceman and the employer, but in which, we think, every ambitious service employee is also interested.

While the radio serviceman is eager for every scrap of technical information he can get to help him in his daily problems, technical information, unfortunately, is not all he needs. There are business problems to be faced and woe unto him who neglects them, for, even if he be technically beyond reproach, if his business methods are not sound anyone can forecast the result. Mr. Dunham, the writer of this article, is head of the QRV Radio Service in New York and writes from long experience. His article will be interesting to every man doing service work

—THE EDITOR.

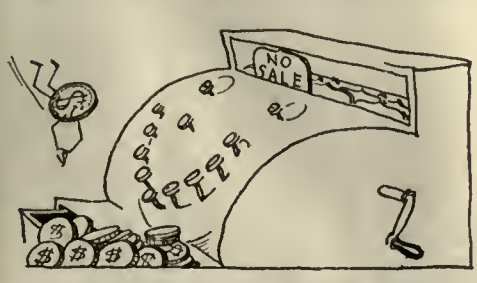
Policies of Procedure

NO SERVICE concern, whether it be composed of one man or of fifty men, can operate at optimum efficiency unless definite policies of procedure in all its activities have been clearly formulated and are rigorously followed. Changes of policy are, of course, necessary in any business with changing conditions, but when new policies are formed they must be carefully formed and steadfastly followed.

The first outstanding question of policy which must be answered definitely is: Shall we perform service only for the individual radio owner; shall we do only contract work—service for department stores and other radio dealers who do not desire to maintain their own service force; or shall we take all the work we can get of both individual and contract work? The advantages of dealing with the individual, over those of dealing with the store, are manifold. The average individual is more concerned about how efficient the service is than he is about how much it costs. He does not want to pay more than he has to but he *is* willing to expend whatever may be necessary in order to have his radio *properly* taken care of. The average store, on the other hand, while having a strong desire to satisfy its customers, wants primarily the cheapest service it can get. While they also want good service, they will not pay a reasonable price for good service. It is a strange, but nevertheless an actual fact, that it is seemingly impossible to convince the average merchandising man in a department store or the average radio dealer how much more economical it is and how much more it means in customer satisfaction to pay a labor charge of $2.50, for example, to have the troubles in a particular radio completely cured by a thoroughly competent serviceman in *one* call than it is to pay $1.00 per call for the three or four calls which are so often necessary when the work is being handled by incompetent poorly trained servicemen. In that respect, then, the advantage in favor of the individual is that he may be charged for labor at a rate which permits good service and a decent profit, both of which are impossible in contract work.

Another Difference

THE next important difference is that batteries, tubes, replacement parts, accessories, and other apparatus may be sold to the individual whereas none of those sources of income may be sold to the store, which is an obvious advantage in favor of the individual trade. The gross income which is normally obtained from dealing directly with the individual, as an average per call, is actually from two to four times greater than that which is obtained from contract work. While the overhead and the investment must be greater for individual work when computed *per call*, they are actually *less* when computed *per dollar of gross income*. In other words, if with a total investment of $1000.00 a serviceman could do a maximum annual contract business of $3000.00, then with the same investment he could do *at least* $5000.00 worth of individual business and at the same time keep his *percentage* of overhead expense approximately the same. The real advantage is that,



No-charge calls help to increase business.



Every service organization should be well equipped.

while in the first case a net profit of 5 per cent. on $3000.00 represents an actual gain of 15 per cent. on the investment of $1000.00, the same percentage of gain on a $5000.00 gross means a gain of 25 per cent. on the investment.

Another important difference between these two classes of service work is the difference of stability. If a serviceman is relying upon one store or even half a dozen stores for all or most of his income, and the one store, or two or three of the half dozen stores, should suddenly decide to farm out their service work to a competitor, who offered to do the same work cheaper, the business of the man who had been doing that work would be totally, or at the very least, badly crippled. On the other hand, if the serviceman is depending upon a comparatively large number of individuals, the loss of a few of them, while unfortunate, cannot ruin his business, a point which is extremely important and cannot be emphasized too strongly.

The only important advantage contract work has over individual work is that it may be built up with much greater rapidity. The acquisition by a serviceman of one radio store may give him that store's work for perhaps 500 individuals, whereas it may take him a year or more to build up a steady individual clientele of that number.

Sales vs. Service

THE next problem is that of how much relative emphasis to place upon service and upon sales. Shall we devote all of our energy to increasing the efficiency of our service, making only such sales as are necessary adjuncts to proper, complete service; shall we divide our energy equally between service and sales; or shall we devote the major portion of our energy to making sales, using service only as a gateway for sales and as a method of keeping in touch with the customers to whom we have made sales?

It seems to be a popular belief among servicemen that a greater percentage of profit may be had from selling tubes, batteries and apparatus, including parts, accessories, and complete sets, than may be had from the sale of service itself. That this belief, while popular, is a misconception, has been amply proven by the records of the organization of which the author is a member. The greatest gross profit which the average service concern can make from sales of whatever radio supplies may be sold, as an average of all of them over a period of a year, is about 35 per cent. and we believe that only a very small proportion of the service concerns in this country even closely approach that as an actual figure, if their accounting is properly done. An average gross profit of 40 per cent. on labor, however, is a practical possibility for the average service concern, and because that percentage of profit is not limited by fixed dealer discounts, 40 per cent. can be, and is, exceeded in actual practice. Other things being equal, there is, then, a decided advantage in keeping the income from service as large a proportion of the total income as possible.

It would be an ideal condition if one could do only service work and eliminate selling, but that condition cannot be attained. Even with no sales effort, the sales of those things which necessarily go with service will be large. In the author's organization, to give a concrete example, despite the facts that receiving sets are not sold at all and that no emphasis is placed or energy expended in attempting to sell parts or accessories, the actual gross sales to individual customers of tubes, batteries, replacement parts, accessories such as trickle chargers and relays, with an occasional good loud speaker, total *more* than the gross sales of service alone to those customers. So that every service concern, regardless of size, is a sales concern to a very considerable extent, whether or not they desire to be, which leads us to the germane observation that a service concern *can* devote its entire effort



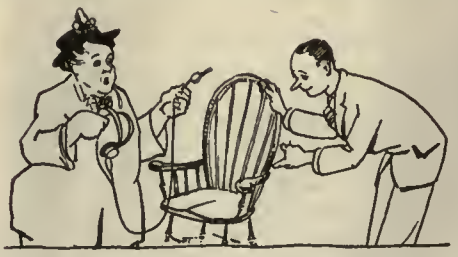
Service organizations may be located on the second floor in low-rent districts.

to the improvement of the efficiency of its service and still derive a very large proportion of its income from sales.

Large and Small Cities

WE BELIEVE that, in all of the larger cities of the country, the serviceman can obtain a larger number of steady customers within a given area, and build up a more permanent, profitable business by developing the most efficient service possible and letting the sales take care of themselves, than he can by dividing his energy between service and sales effort. One great advantage of this policy in large cities is that, with sales effort in the background, a location on a prominent street or even a ground floor location on any street, with its attendant high rent, is not at all necessary, thus permitting a much lower overhead expense than would otherwise be the case.

In smaller cities and towns, where the possible number of individual customers is not so great, the amount of income which must be derived per year from each customer is necessarily greater in order that a sufficient total income may be had. We believe that condition exists in fewer places than is the general belief among servicemen, but if it actually is the case, then it becomes necessary to devote more energy to sales, even to the extent of selling complete sets in order to avoid losing customers who would otherwise purchase them elsewhere and then have the service performed by the dealer from whom the set was bought.



The serviceman should be courteous first, last, and always.

No-Charge Calls

ONE other major problem which we shall discuss briefly is the question of just how far we shall go to satisfy our customers. Shall we keep our percentage of no-charge calls down to the absolute minimum by making only those which are necessary in order to collect money due us on a previous call; shall we make without question as many free calls as each customer would like without making any attempt to limit the percentage of such calls; or shall we adopt a middle course somewhere between those two extremes? The basic consideration is the well-known fact that a thoroughly satisfied customer means—in the vast majority of cases—not only a permanent customer but also the best possible advertising medium which exists. All organizations that have achieved a large and permanent success, no matter what they are selling, have done so because, first of all, they have satisfied each individual customer better than most of their competitors in the same field. Many highly successful concerns, especially in the retail field, have gone so far as to adopt the policy that "the customer is *always* right." That policy can be applied very advantageously in our own field of radio service, and we believe it needs to be applied more generally than it has been. It is fairly obvious that if, by making a no-charge call in order to satisfy a customer, we succeed in keeping him as a regular customer where he otherwise would go to some one of our competitors, we have then made an entirely justifiable sales expenditure, for by that free call we have secured future profitable business, from the customer himself and also from those friends of his to whom he will mention his satisfaction.

On the other hand, we cannot afford to give such a large percentage of free calls that our profit on chargeable calls will be eaten up by them. If, however, we find that we *are* giving too many free calls, the remedy for that condition is not to limit the number of free calls we *will* make, but to make our service so efficient and so pleasing to our customers that we will not *need* to make many free calls in order to give satisfactory service. The efficiency of the serviceman in the field, providing he is properly equipped, can be, and should be, kept over 95 per cent. In other words, the no-charge calls necessitated by the failure of a serviceman to cure properly the troubles in a radio, or by his failure to take with him the type and number of tubes and batteries or other supplies he may require need not exceed 5 per cent. of the total number of calls made. The percentage of no-charge calls of that nature made by the author's organization during the twelve months ending November 30th, 1928, was *under* 3 per cent. The exact figure was 2.68 per cent.

The percentage of no-charge calls made for other reasons, as a matter of policy to keep the good will of customers, automatically will remain low so long as the service efficiency is high and customers are handled fairly, courteously *and with a real desire to serve them* to the utmost of our ability. The total percentage of no-charge calls made, from all causes, should not exceed 15 per cent. and *can* be kept, as a matter of actual record in practice, *under* 10 per cent. Every service concern, even if it consists of only one man, should keep an accurate classified record of the no-charge calls made, to be tabulated monthly and analyzed along the lines which are suggested in this article.



STRAYS *from* THE LABORATORY

Regarding Power, Efficiency and Energy

MANY people, engineers included, speak indiscriminately of power, energy, and efficiency.

These words are technical terms and do not mean the same thing. Energy is the *ability to work*—whether that energy is being used or not. There are two kinds of energy, kinetic energy—the energy due to motion—and potential energy—the energy due to position. A bullet traveling at a high rate of speed hits a target. The target is heated and damaged. When the bullet hits, it gives up its kinetic energy. A ball on top a flag pole has potential energy, because if it falls it can do a lot of work—or damage, depending upon the way you look ar it.

Power is the *rate of doing work.* It requires the same amount of energy or work to raise a ton of coal one foot into the air whether it is done all at once by means of a steam shovel, or whether it is scooped into one's furnace a pound at a time. The difference is in the time required. The steam shovel is more powerful.

Efficiency is the *ratio between the useful work accomplished and the total amount of work expended* in getting a task done. An efficient man is not the one who gets the most work done, but the man who gets done whatever he is at with the least expenditure of effort.

As this is written a release is received from the General Electric Company which refers to a "powerful" optical system. What can a "powerful" optical system be? Is it one that consumes considerable power? Or does it have a high "resolving power"? This is but one example of the loose way in which one of these terms is used.

Let us consider a tube, such as a 171, feeding power into a load, a resistance, for example. The power in the plate circuit of that tube is used up in two ways, part of it on the plate of the tube, and part of it in the load. The sum of these two powers represents the total amount of power in the plate circuit.

Now, the conditions for maximum power output from the tube, and for maximum efficiency are not the same. That is, if we vary the load resistance, R, a value will be reached, which is numerically equal to Rp, the plate resistance of the tube, when the maximum power output will be delivered to the load. But the efficiency at this point will be only 50 per cent.; that is, as much a.c. power goes up in heat on the plate of the tube as appears in useful power in the load. If the load resistance is increased the power output goes down, the efficiency comes up. The curves in Figs. 1 and 2 illustrate this point. A 171 tube is assumed to be working into various load resistances and the power output and efficiency are plotted against this value of resistance.

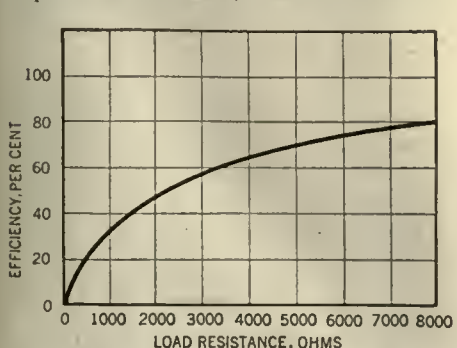


Fig. 1—Efficiency of 171-type tube versus load resistance.

The following are among the subjects discussed in "*Strays*" this month:

1. *Power, Efficiency and Energy*
2. *Power of Station Harmonics*
3. *New Pamphlets Available.*
4. *Importance of Tube Voltages*
5. *Impedance of Loud Speakers*
6. *A Test for 222-type Tubes*
7. *Duration of Engineering Jobs*
8. *How Useful is a Tube?*
9. *Accuracy of Variable Condensers*
10. *New Power Rectifying Tube*

Let us suppose we have a dynamo rated at 10 kilowatts. At maximum power output, half of this power, 5 kw. must be expended in the resistance of the generator winding—and as C. T. Burke would say, it is time to call out the fire department. To secure maximum power output it is necessary that the resistance of the apparatus to which the generator is attached shall have the same resistance as the generator.

Power of Station Harmonics

MANY fans who tune-in to short-wave broadcasting have listened to some more or less bad music which later is identified as a harmonic radiation from one of the broadcast-frequency-band transmiters. An operator in the laboratory of *Citizen's Radio Call Book* (Chicago) recently picked up the sixth harmonic of station WHAM (Rochester N. Y.) on a Silver-Marshall short-wave receiver. In this connection the following statement regarding the experimental transmitter at Whippany, N. J., 3XN, published in the *Bell Laboratories Record*, August, 1928, may be interesting:

"The transmitter has a power input into the antenna system of 50 kilowatts for the carrier wave alone, and the instantaneous peak power during the broadcasting of a program may reach 200 kilowatts. That is enough power to meet the lighting requirements of a village of over one hundred houses, and yet with all that power in the carrier wave, the amount of second harmonic allowed to escape would not light the tiniest incandescent lamp made. To be exact, it is less than .005 watt and represents about one-ten-millionth of the power of the carrier wave."

Three New Pamphlets Available

THE following pamphlets and publications have been received and will be found of interest to every experimenter and radio engineer.

1. *Design of Tuned Reed Course Indicators for Aircraft Radiobeacon*, by F. W. Dunmore, Research Paper No. 28, Bureau of Standards, price 5 cents.

2. *Methods for the Derivation and Expansion of Formulas for the Mutual Inductance of Coaxial Circles and for the Inductance of Single-layer Solenoids*, by Frederick W. Grover, Bureau of Standards, Research Paper No. 16, price 10 cents.

3. *Radio Acoustic Position Finding*, special publication of the Department of Commerce No. 146, price 20 cents.

All of the above papers may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Another interesting publication is the October, 1928, *Congressional Digest* which contains considerable material on the problems of radio reallocation. It includes articles by the Radio Commissioners whose names are seen frequently in print, a glossary of radio terms, and the new schedule of broadcasting stations, their powers, frequencies, locations, etc. It costs 50 cents.

Rated Voltages. Should Be Applied to Tubes

WE have spoken several times of the futility of running tubes at values of plate voltage or C bias not recommended by the manufacturer. It is true that initial performance obtained from a

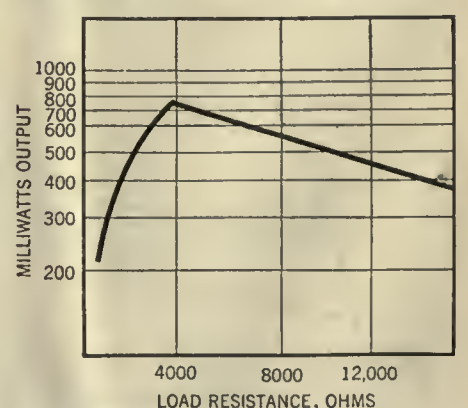


Fig. 2—Undistorted output of 171-type tube versus load resistance.

screen-grid tube by putting 180 volts on the plate and 1.0 volt C bias on its control grid may be somewhat startling and beyond the expectations of the hopeful user, but it is true, too, that he should have no come-back on the manufacturer when his tube fails prematurely.

Servicemen will do a favor for both the tube manufacturer and the user of tubes if they will insist on proper voltage values. A tube that gives fine initial performance and then fails long before its expected 1000 hours are obtained cannot but make the user skeptical of other products of the same tube manufacturer.

Within the last year we have had two manuscripts in the office in which the writers advised the use of values of plate voltage and C bias on screen-grid tubes that would limit their life to several months instead of a year or more. In one case the values of voltage were so excessive that the filament actually changed its brilliancy when the plate voltage was turned on.

Impedance of Standard Loud Speakers

MANY readers have inquired about the impedance of loud speakers. On this page is a curve made on the W.E. 540-AW loud speaker made by Frank C. Jones, of California, who has written several articles for RADIO BROADCAST. It shows that this loud speaker, long the standard laboratory loud speaker, has an impedance of 4000 ohms at 100 cycles, 13,050 ohms at 1000 cycles, etc. Here, too, is the impedance curve on the R.C.A. 104-A loud speaker—a moving-coil loud speaker.

A Test for Screen-Grid r.f. Tubes

A READER asks how to check his cx-322 tubes. The Cunningham engineering department states that a good emission test is to tie the grid, screen grid, and plate together and to apply 50 volts to these elements. Next, place 3.3 volts across the filament and measure the plate current. If the current is above 12 mA. the tube is good. Has every engineer, every serviceman, and every laboratician a copy of the *Cunningham Tube Data Book*? It has in it just this kind of data.

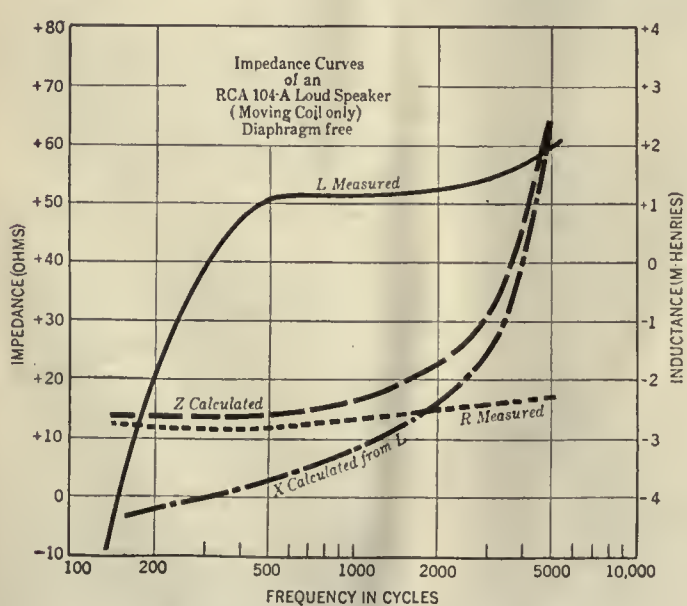


Fig. 3—Characteristic Curves of R.C.A. 104A loud speaker

How Long Will the Engineers' Job Last?

RADIO engineers often wonder how long it will be before their jobs are jobs of the past, with the progress now being made toward perfection. As an example let us look at the curves in Fig. 5 which are taken from *The Wireless Magazine* (England) of July 1928. They show the progress that has been made in the Columbia (English) phonograph records and reproducers since 1920. What will the engineers do next? There is no object in extending the frequency scale? Will they invent some new frequencies? Our suggestion is to drag out into the open those machines which will play for an hour or so without the bother of shifting records.

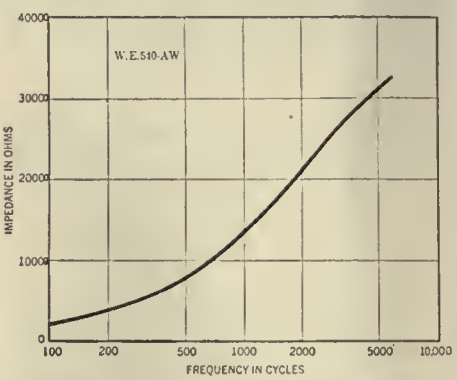


Fig. 4—Impedance curve of W.E. 540-AW loud speaker

How Useful is a Tube?

WE HAVE yet to find any figure in the radio industry who does not know George Lewis, vice-president of the Arcturus Radio Company. In a statement made recently Mr. Lewis suggests that a vacuum tube's usefulness has, in the past, increased with the square of the number of its elements. Thus the addition of the grid to Fleming's original two-element tube increased the tube's utility four times, then the isolated cathode, the heater, made possible the operation of tubes from raw a.c., and finally the word of Schottky and Hull in putting the second grid in the tube has again increased the value of the tube. Mr. Lewis believes that the a.c. screen-grid tube is the most satisfactory tube in the world.

We would agree with this belief except that no one seems to know how to make use of the tube's evident possibilities. Note that few of this year's manufactured receivers use tubes of this type. Is it possible that receiver manufacturers are waiting until the kit people have developed circuits to the point where set manufacturers can use them without any development cost?

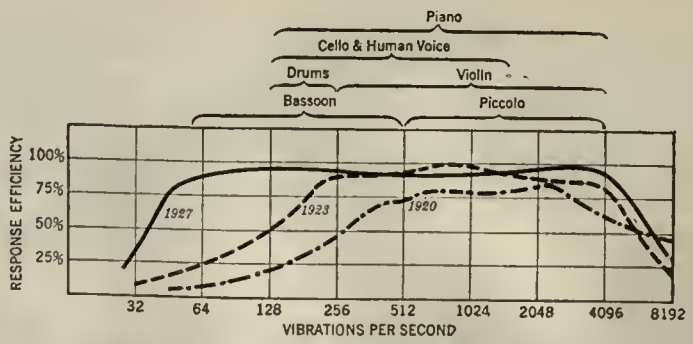


Fig. 5—Frequency characteristics of old- and new-type phonographs.

Accuracy of Variable Condensers

THE Hammarlund Manufacturing Company states that individual units of a Hammarlund three-gang condenser are accurate to within one quarter of one per cent. It is interesting to see what difference a discrepancy of this amount from the rated capacity will make in a tuned circuit. Suppose one condenser of the three is one quarter of one per cent. higher in capacity than the other two. By now many cycles at 1500 kc. will the circuit which this condenser tunes be out of resonance?

The capacity of the condenser compared with the others is C x 1.0025 and the frequency to which this circuit tunes, compared with the resonant frequency of the other circuits will be one half of one per cent. lower, or at 1500 kc., the circuit will actually tune to 1500 — 7.5 = 1492.5 kc. This is probably more accurate than commercial coils can be made—and so The Hammarlund Manufacturing Company has something to talk about in the accuracy of their production condensers.

New High Voltage Rectifier Tube

THE Raytheon company have announced a new rectifier, apparently a modern "S" tube whose demise was regretted by every transmitting amateur. This new tube will rectify 300 milliamperes of current at 3000 volts, and the voltage drop is only 10 or 12 volts. This is a lot of power as anyone who multiplies I = .3 by E = 3000 will find out. (It amounts to about one kilowatt). We are hoping to get some of these tubes in the Laboratory for our short-wave transmitters, w2GY and w2EJ. Incidentally, the Raytheon Company plans to manufacture all types of receiving and amplifying tubes of the filament type.

New Regulation of Radio Commission

GENERAL Order No. 55 of the Federal Radio Commission contains this paragraph, "No license shall be granted to any applicant for a fixed station, coastal station, or æronautical station who is unable to satisfy the Commission that he can maintain the assigned station frequency with an accuracy of 99.05 per cent. or better at all times."

At 6000 kc. this amounts to 3000 cycles. How is the applicant to satisfy the Commission on this point?—KEITH HENNEY.

AN EFFICIENT PUSH-PULL A. F. SYSTEM

By KENDALL CLOUGH

Engineering Dept., Silver-Marshall, Inc.

THE common concept of the advantage of push-pull amplification seems to be the possibility of providing an undistorted output greater than that which would be available from a single tube in the power stage. As a matter of fact, the available output from the push-pull stage is somewhat greater than is available from the same two tubes used in simple parallel relationship. The manner in which the signal impressed on the grid circuit of the push-pull arrangement is amplified in the plate circuit, while the harmonics generated (distortion) within the push-pull circuit cancel out in the plate circuit, has been so well discussed in texts on vacuum tubes (*Thermonic Vacuum Tubes* by Van der Bijl, page 261) that it would be superfluous to go over the matter here.

The writer has completed recently several designs of push-pull amplifiers using tuned transformers and it is felt that some expression of the performance of the combination of these two principles will be of interest to the readers of these columns.

Analysis of Circuit

TURNING to Fig. 3 we have two power tubes connected in push-pull to a divided choke coil. This coil may be the primary of either a transformer or an auto-transformer. In the use of the latter, however, resides several advantages of the push-pull system from a design standpoint. It is apparent that, when two well-matched tubes are used (passing the same plate current), the ends of the winding A and A^1, are at substantially the same d.c. potential. For this reason the speaker can be connected across these points without any danger of damaging current flowing through the speaker winding. This eliminates the expense of the blocking condenser which is ordinarily used with plate chokes. In the same way the two points, B and B^1, are at the same potential when placed equally distant from the center and may be used for speaker connection when a step-down ratio is desired for operation of low-impedance speakers. In addition, the simultaneous use of all or a portion of the winding as both primary and secondary results in a closer magnetic coupling between the tube and speaker circuits, with consequent improvement in efficiency and frequency characteristic. A further result is the economy of window area for the copper in the iron core. This results in either more liberal size of copper wire in a given lamination or a greater reduction in the overall size of the device than would result with the use of two separate windings.

We are grateful to Kendall Clough for explaining, in an engineering manner, the advantages of using more than one stage of push-pull in audio amplifiers. Several engineers have advocated such an unorthodox amplifier, but few seemed to have any good reason for it. In this article Mr. Clough states that there are distinct advantages and explains what they are. The amplifier he sent to prove his contentions made the entire Laboratory Staff discontented with their own personal equipment—which was not double push-pull!

—THE EDITOR.

In considering the more intimate details of the design, theory indicates that the inductance of the choke should be large compared with the impedance of the tubes out of which it operates. Of the four tubes available for power use, the 112, 210, 171 and 250, the first two are of about 5000 ohms impedance and the latter two of 2000 ohms. The 112-type tube has never enjoyed much favor because of its limited output, while the 210 is not as commonly used at present, probably because it requires as high a plate voltage for its operation as the larger and more capable 250-type tube. For these reasons only the 171 and the 250 will be considered. Fortunately, these are the two low-impedance tubes of the group which simplifies the problem of attaining a sufficiently high impedance for good operation at the low frequencies. Calculation and measurements indicated that a total inductance of 32 henries would be sufficient with a 4000-ohm output circuit (the plate impedances of the two tubes are in series) to give very good response at the low frequencies with several speakers that were at hand.

Another advantage inherent in the push-pull circuit made this value of inductance rather simple of attainment. In the ordinary single choke or transformer the iron is subjected to a continuous magnetizing force due to the direct current flowing through the winding to the plate. In order to prevent this force from magnetizing the core to or near the point of saturation, it is necessary to place a good size air gap in the magnetic circuit. This, in turn, increases the reluctance of the magnetic circuit making it necessary to use a much larger core (in order to secure the necessary inductance) than would be necessary if this magnetizing force did not exist. Even when the adequate inductance is attained in this manner, the core is subjected to a considerable magnetizing force, causing the signal to operate on an asymetrical magnetization curve which is as distinctly undesirable in an output transformer as in an interstage device. This type of distortion was pointed out in the author's previous article (July, 1928, RADIO BROADCAST) on the subject of audio amplifiers.

Advantage of Circuit

IT WILL be seen in Fig. 3 that, although the two halves of the choke are wound in the same direction, the plate currents flow in opposite directions to the plates; hence the magnetizing forces in the core, due to the two halves of the winding, cancel, and the resulting force in zero. [It will be noted that the author has indicated the direction of current as passing from plate to filament, thereby conforming to the convention that currents always travel from the point of positive potential to the point of negative potential. The actual electronic flow is of course in the opposite direction. *Editor.*] It should not be inferred, as many designers seem to have done, that this permits dispensing with the air gap altogether, although it does permit a smaller air gap, resulting in more economical use of the iron in securing the requisite inductance. A small air gap must be included in order that the original value of inductance, measured at small values of audio-frequency current, may be maintained at high signal levels.

Before proceeding with the design features of the input transformer that is to supply the two voltages, Cg, these voltages

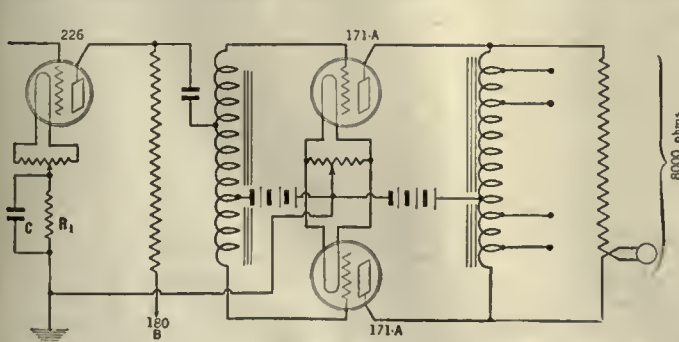


Fig. 1

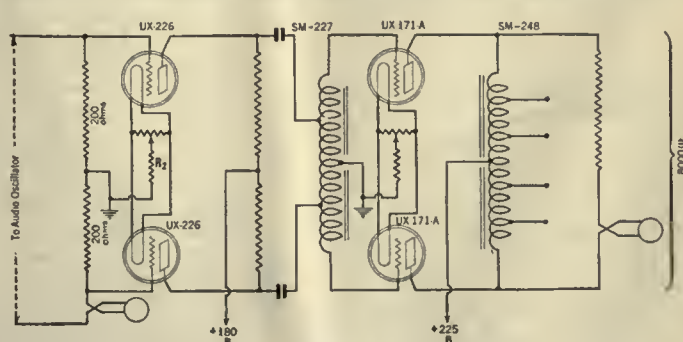


Fig. 2

were supplied from an oscillator as shown in Fig. 4, and the performance of the tube and output transformer circuit were examined for undistorted output at 500 cycles. The input voltage to the stage, as determined by the reading of the meter, M_1, and the equal resistors, R_1, was increased in small steps and the output power at each step computed as the product of the 8000-ohm resistor, R_2, and the square of the current through it. In this way the output in watts per volt input squared could be computed, and plotted as shown in Fig. 5. This curve was taken with two UX171A tubes operating with 180 volts on the plates, and the choke of Fig. 4. It will be noted that the output available before the gain falls appreciably is about two watts. The manufacturer's tables give an output of 0.7 watt for this tube which would permit of 1.4 watts output with the two tubes operated in simple parallel arrangement. The difference, 0.6 watt, in output is due to the push-pull arrangement. As a matter of fact, the ear does not notice the distortion until the output per volt squared has dropped about 2 DB, allowing the operation of this stage to 2.8 watts output. This output is sufficient to operate a dynamic loud speaker with sufficient undistorted volume for the home and for small halls and has the advantage over a 250 tube of employing low voltages that are available easily at low cost. Where larger outputs are required the 250 tubes will and can be used with the same choke.

The performance of this single stage with 250-type tubes was measured in the same way as the previous combination of 171's and the results are plotted in the curve of Fig. 6-A. It will be seen that this arrangement is suitable for operation where about 12 watts are required for coverage of considerable area. The impossibility of its operation for home use at full volume is indicated in the fact that none of the smaller dynamics on the market

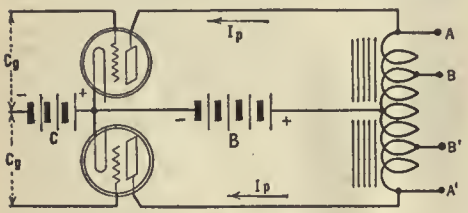


Fig. 3

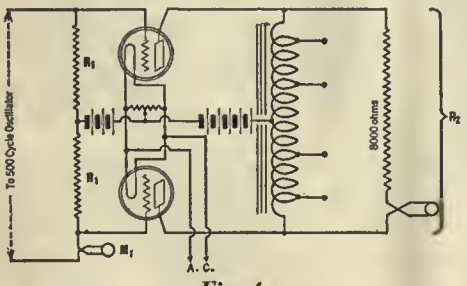


Fig. 4

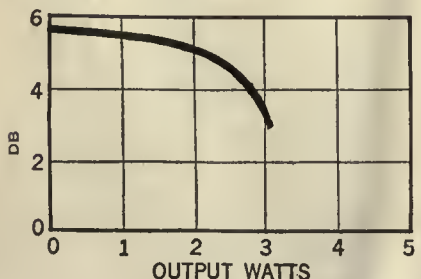


Fig. 5

will stand this output without rattling badly on the high frequencies.

Attention is called to the fact that both of the curves discussed were made with an 8000-ohm resistor in the output circuit. It has been shown many times that maximum undistorted volume (not maximum volume) is realized from a tube circuit when it is operating into a resistance of double its own plate resistance. The condition for maximum volume, neglecting distortion, is satisfied when the output resistance is equal to the tube's resistance. In order to illustrate the latter condition, the curve of Fig. 6-B was prepared using a 4000-ohm resistor in the output circuit. It will be seen that while the gain is somewhat greater than in curve A, the bend indicating distortion occurs at a much lower level. This illustrates a common malady in power amplifiers. In order to secure high volume the temptation is to operate the tubes into a low-impedance output circuit when properly the amplification should be increased in the preceding stages. As seen in the curves of Fig. 6, the *volume* is increased by this means, but the

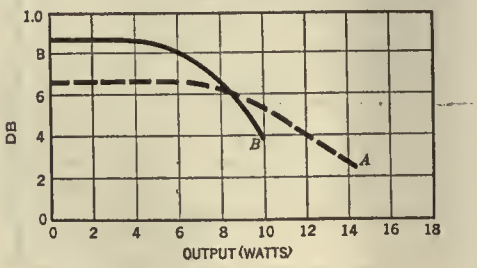


Fig. 6

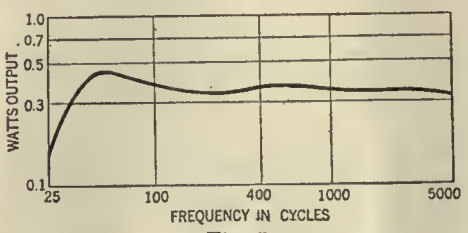


Fig. 7

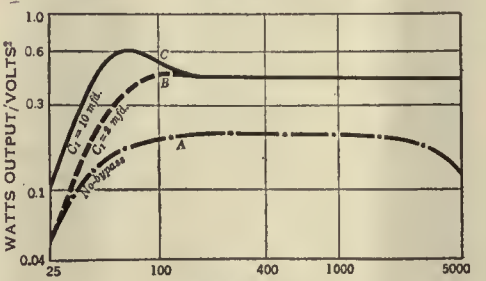


Fig. 8

undistorted output available is actually reduced.

In view of the fact that many loud speakers do not have sufficiently high impedances to permit operation under conditions similar to those of Curve A if the loud speakers are connected to the plate terminals of the power tubes (terminals A and A^1, Fig. 3), two other sets of taps have been directly provided on the choke for the loud speaker connection. These provide two available step-down ratios the use of which permit a low-impedance speaker to present the proper impedance to the tubes for attainment of the greatest possible undistorted power. The actual ratios available are 1:1 , 1:0.73, and 1:0.48. The first of these will be used when the low-frequency impedance of the speaker is 8000 ohms or greater;

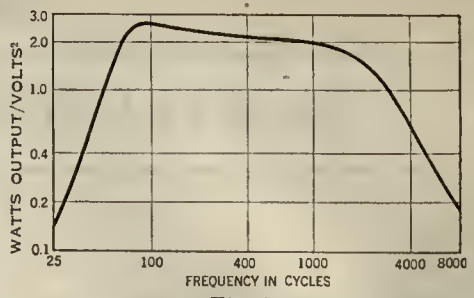


Fig. 9

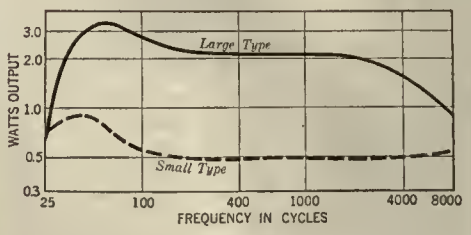


Fig. 10

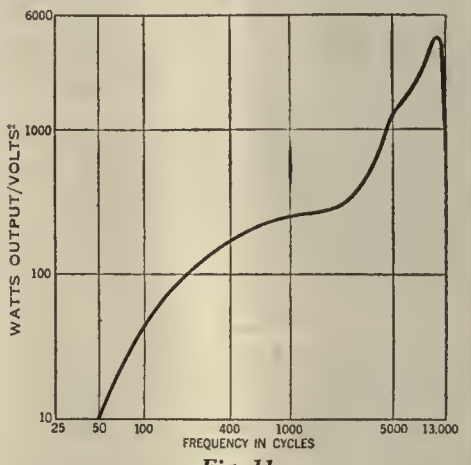


Fig. 11

the second for speakers of 4000 ohms or less, while the third tap is useful where several speakers are to be operated in parallel. Where the impedance of the speaker is not known, the best connection can be determined by trial by connecting a milliammeter in the plate supply lead and operating with that ratio which allows the greatest volume with a minimum of variation in the plate current.

A Further Advantage

A FURTHER advantage of the push-pull circuit was noted during this work. This was the possibility of obtaining the plate voltage from the output of the rectifier tubes as shown in Fig. 12 without the use of a filter other than the 4-6-mfd. condenser from the center of the choke to ground. This is of particular advantage in the operation of 250-type tubes for the size of the smoothing chokes is reduced to that necessary for handling the small currents of the preceding stages. In addition, the voltage divider can be inserted at the input, the filter as shown allowing the safe use of lower voltage condensers for the remainder of the filter, which is a distinct economy. It was found that with this arrangement the best of dynamic speakers with large baffle could be operated without objectionable hum from the power supply. In the same way the hum from the filament circuit was observed to be negligible. Changing the plate supply to batteries, temporarily, it was found that there was no increase in hum when the lead to the center tap of the filament resistor was

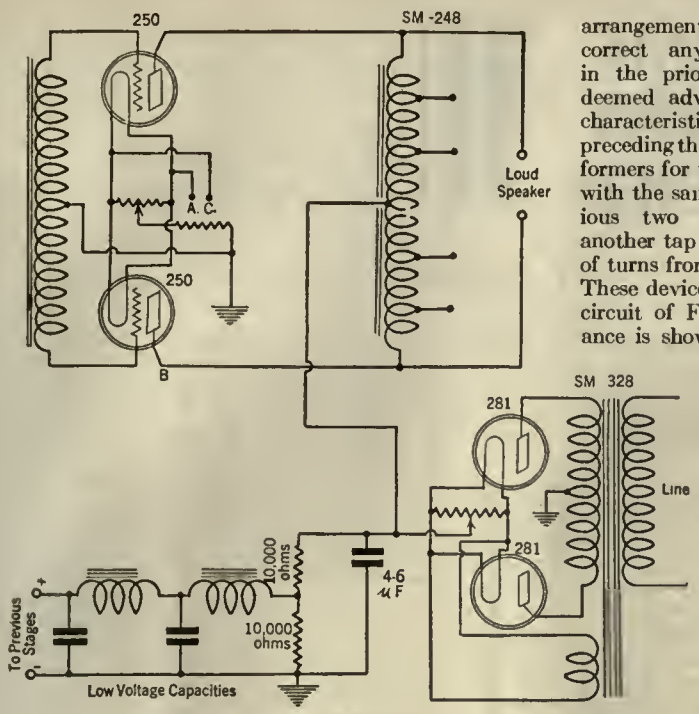


Fig. 12

returned to one side of the filament terminal. Every appearance was that this was a rather ideal power stage, and attention was turned to interstage transformers for its operation.

Two interstage devices were designed. The smaller of the two has an effective ratio of 1.8 when operating out of a 226-type tube. Characteristics on this unit are shown in Fig. 7, and the circuit used to make the measurements is given in Fig. 1. When this curve was taken a C battery was used for grid bias rather than the resistor R_1 of Fig. 1. When the resistor was used, as is the ordinary practice, an inferior charactersitic was obtained as shown in the curves of Fig. 8. The lower curve, A, shows the characteristic obtained when no bypass was used across the biasing resistor. Curve B indicates the operation with the usual bypass of 2 mfd. Not until this was increased to 10 mfd. did the operation approach the original curve of Fig. 6. The inferior performance without a large bypass is due to the signal current in the plate circuit setting up a voltage drop across the resistor, R_1, which is in opposite phase to the input voltage thus reducing the amplification. Curve B Fig. 8 indicates that a 2-mfd. capacity has a sufficiently low reactance to prevent this at the higher frequencies, while the low frequency amplification is still impaired.

The larger device has a ratio of 3.6 and its characteristic is shown in the curve of Fig. 9. It will be noted that a very definite high-frequency cut-off has been introduced due to the higher ratio and larger physical size of the windings. This is not at all undesirable, particularly for operation with phonograph records where a scratch filter is ordinarily inserted to accomplish the same thing. It should be noted that all of these curves were taken with the output circuit and the power tubes as in the circuit shown in Fig. 1.

Elimination of Harmonics

MOST advocates of the push-pull amplifier have dwelt at length upon the elimination of harmonics in the output stage and allowed distortion of that character in previous stages to go unmentioned. The push-pull arrangement of the output does not correct any distortion appearing in the prior stages, and it was deemed advisable to measure the characteristics of a push-pull stage preceding the power stage. The transformers for this purpose were made with the same windings as the previous two mentioned, but with another tap placed on equal number of turns from the center. See Fig. 2. These devices were measured in the circuit of Fig. 2 and the performance is shown in Fig. 10. The improved amplification on the low frequencies is due to the larger ratio of primary inductance to tube impedance. In changing from single to push-pull operation, the effective resistance of the plate circuit has been doubled (two tubes in series), while the total primary consists of twice as many turns and hence four times the inductance. (The inductance is substantially proportional to the square of the number of turns.)

As a definite advantage of the operation of this circuit, it is interesting to note that when the bias resistor, R_2 Fig. 2, was shunted by a 10-mfd. condenser, no measurable change in the characteristic occurred at any frequency, indicating that the degenerative effect of this resistor in the single tube arrangement had been completely eliminated by means of the push-pull feature.

As an example of the effect of small bypasses across C-bias resistors, the curve of Fig. 11 has been prepared. This curve was taken on a three-stage amplifier having two 250-type tubes in the output circuit. The interstage transformers when measured individually with batteries had very good characteristics due to the use of nickel-alloy in the cores. It will be noted in the curve, however, that due to the degenerative effect of inadequately bypassed C-bias resistors, the bass frequencies are almost entirely suppressed. In such cases as this it would be true economy to add two tubes to make the outfit push-pull all the way through and eliminate the bypasses entirely.

At the conclusion of the experiments on push-pull amplification, a complete phonograph amplifier was built up with the small transformers described in the above. The circuit of this amplifier is shown in the diagram of Fig. 13. It would be quite safe to say that the operation of a good dynamic loud speaker or an amplifier of this gain would be next to hopeless with single-circuit amplification due to the difficulty in eliminating the hum from the filament and plate circuits to a sufficient extent to insure a pleasant effect on the listener. It was found in the construction of this amplifier that, when the power supply was put in a separate sheet steel case from that which housed the amplifier, to prevent induction from the power supply to the transformers, the hum due to the filament circuit could be balanced out with the greatest ease and that the hum under the best conditions was so weak that it could not be heard more than two feet from a large baffle on which a dynamic loud speaker was mounted. The true significance of this statement will be appreciated by noting on the curves the high amplification produced at hum frequencies.

In the writer's previous article on tuned audio amplification, it was stated that the employment of the circuit advocated by him for interstage transformers eliminated the generation of even harmonics due to the asymmetrical magnetization characteristic of the iron when employed in circuits which allow the plate current of the tube to flow in the primary of the transformer. Obviously, no claim could be made for the elimination of the odd harmonics by the writer's method of connection. It will be obvious to those acquainted with the theory of push-pull amplification that these harmonics will be eliminated by the use of the circuit and that the combination of the two effects will practically assure freedom from wave form distortion.

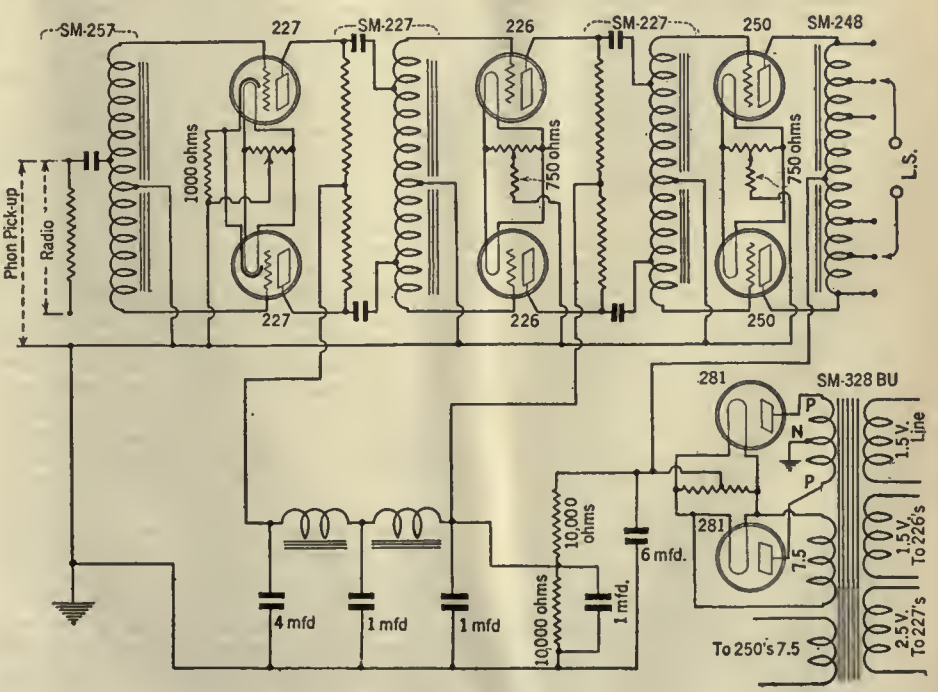


Fig. 13

TECHNICAL DATA

SOUND MOTION PICTURES

BY CARL DREHER

Further Data on Photo-Cell Characteristics

THE construction and general theory of operation of photo-electric cells has been discussed in a previous article (November, 1928, RADIO BROADCAST). The fundamental importance of the device makes it advisable to consider its properties further, however, and in more quantitative terms than formerly.

Dr. Herbert E. Ives in his paper "The Alkali Metal Photo-electric Cell," *Bell System Technical Journal*, April, 1926, gives curves showing the behavior of cells used in picture transmission. The characteristics here reproduced as Fig. 1 show the voltage-current relationship for vacuum cells with a small centrally placed anode within a concentric spherical cathode. That is, the positively charged plate or collecting member is placed within, and about at the center, of a considerably larger sphere, the inside of which is coated with the emitting material, and the cell contains no gas. The anode receiving a positive charge with respect to the cathode, the current for a given illumination increases with the voltage between the electrodes, at first rapidly, then more slowly, until a saturation point is reached. The shape of the curve depends somewhat on the wavelength of the light falling on the cell; at longer wavelengths the electrons given off by the cathode move more slowly and are collected more quickly by the anode. Now if a small quantity of gas is introduced into the cell, the curve changes remarkably, to the shape shown in Fig. 2. The wavelength of the incident light still plays a part, but now instead of saturating, so that increasing the voltage beyond a certain point no longer effects an increase in the space current, the cell has a critical potential at which the gas breaks down. With the addition of the gas (very little is introduced—a fraction of a millimeter of mercury being the pressure) the cell becomes more sensitive, and also somewhat more liable to variations in production and damage in use. The electrons liberated by the cathode collide with molecules of gas, producing ionization phenomena which increase the current. In both vacuum- and gas-type cells, if the voltage is held constant and the illumination is changed, a linear relationship between illumination and current

This is the second of a series of articles dealing with sound motion pictures. RADIO BROADCAST *was first and alone in its field to provide intelligent and authoritative articles on the engineering aspects of broadcasting and we are happy to be first now with authoritative articles on sound movies. The latter field is so close to broadcast engineering that it is proving of absorbing interest to almost everyone in radio. Pages in this magazine will regularly be devoted to this subject*

—THE EDITOR.

is found, provided some structural precautions are taken. If the window of the cell, through which the light enters, is made too large, it is likely to become charged and to cause a curved illumination-current characteristic.

Fig. 3, also taken from Ives, shows the current-voltage relationship in microamperes and volts for a potassium cell used in picture transmission, the illumination being 100 meter candles from a tungsten lamp, with an aperture area in the cell of 1.5 sq. cm. The luminous flux reaching the cathode is given as 0.015 lumen. The meaning of these photometric terms may as well be explained before the discussion is continued.

The *Handbook of Chemistry and Physics*, compiled by C. D. Hodgman and N. A. Lange, published by the Chemical Rubber Company at Cleveland, and now in its thirteenth edition, is useful in this connection. The principal definitions required are given on pages 1004–1005. Since light is radiated in all directions, we must first consider some solid geometry. The surface of a sphere of radius r is given by $4\pi r^2$. The unit of solid angle, called the *steradian*, is the angle which encloses a surface on a sphere equivalent to the square of the radius, that is, the total area divided by 4π. The *total luminous flux* from a light source is the total visible energy emitted in unit time. The unit, called the *lumen*, is the flux emitted in a unit solid angle as defined above, from a point source of one candle intensity. It follows that the total emission of one candle equals 4π lumens. *Luminous intensity* or *candle power* is the property of a source of emitting luminous flux; it is measured by the flux emitted per unit solid angle. The unit is the *international candle*, which is approximately the intensity of a standard English sperm candle (there are more constant and precise standards). *Illumination* on a surface is measured by the luminous flux incident on a unit of that area. The common units are the *lux*, one lumen per square meter, and the lumen per square foot. At unit distance from a point source of unit intensity the illumination is unity, hence such units of illumination as the *meter candle* (lux) and the *foot candle* (one lumen per square foot).

In slightly less technical language, we may summarize the above by saying that a light source emits luminous flux, measured in lumens, that the intensity of the source in candle power is measured by the flux or flow in a unit solid angle, and that the illumination is a matter of flux per unit area, and depends on the intensity of the source and the distance from it of the surface.

Applying these ideas to the cell cited by Dr. Ives, we note that the illumination given is 100 meter candles. This might come from a source having an intensity of 100 candles placed one meter from the cell. Such a source evidently emits 400π lumens over a sphere with a surface, at a distance of a meter, of $4\pi(1)^2$ square meters, or 4π square meters, or $40{,}000\pi$ square centimeters. We are also told that the area of the window of the cell is 1.5 square centimeters. Hence the flux in lumens reaching the interior of the cell will equal

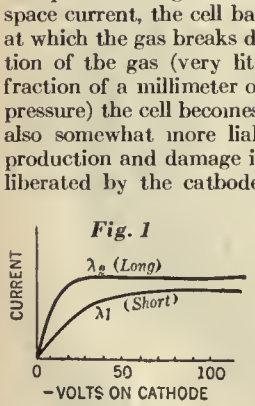
$$400\pi \frac{1.5}{40000\pi}$$

$$= 0.015 \text{ lumens}$$

This checks the figure given in the paper. If the calculation is not clear, the reader is referred to Fig. 4, which is not taken from Dr. Ives' paper, but has been added to clarify the present discussion. If the units are consistent, the flux entering the cell may be obtained by multiplying the illumination by the area of the window.

Current-voltages characteristics for another type of photo-cell are shown in Fig. 5. For convenience this cell, which is also of the gas-filled type, will be referred to as Cell No. 2. The window in this case is larger (about 8 square centimeters as compared to 1.5 square

Fig. 1



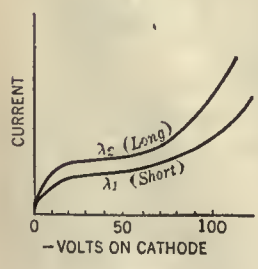


Fig. 2

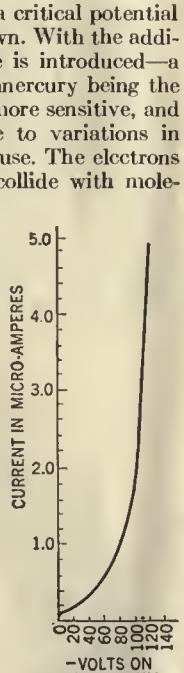


Fig. 3

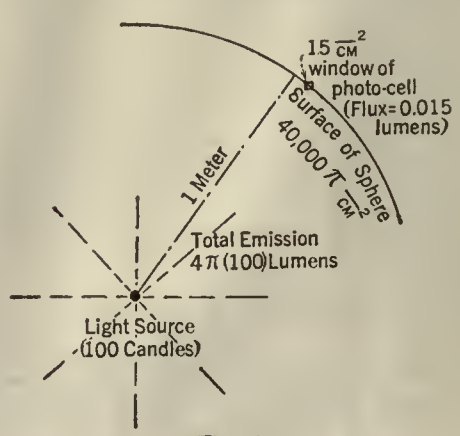


Fig. 4

centimeters for the cell shown by Ives) and the pick-up of light flux is greater. Four anode voltage-current characteristics are drawn in Fig. 5; these cover the range from 0.05 lumen to 0.5 lumen.

If, now, we take this family of curves and, with a fixed anode voltage, such as the cell would have in practice, find the currents corresponding to various illuminations, we secure the rectilinear graph of Fig. 6, which shows that within this range the photo-cell current is directly proportional to the light falling on the cell. The voltage in this case is 70. The slope of the line is a measure of the sensitivity of the cell under the conditions then existing. A steeper curve would show greater sensitivity. The cell under discussion, with a voltage of 70 between the cathode and the anode, has a sensitivity of about 10 microamperes per lumen. The sensitivity of photo-cells is normally expressed in terms of microamperes per lumen, the amount of light used in the measurement being of the order which the cell will receive in use—a value of 0.1 lumen would be about right for Cell No. 2.

As explained in the previous article on photo-cell circuits, the cell may be coupled to the associated vacuum-tube amplifier in any of the usual ways, as through a resistance or transformer. If a coupling resistance of 2 megohms is assumed, as in Fig. 7, an instructive calculation of the practical efficiency of the cell, the ratio, that is, of the electrical energy output to the light energy input, may be carried out. Light is known to have a mechanical equivalent, in the region of maximum visibility, of about 1.5 milliwatts per lumen. The sensitivity of the cell described above (No. 2) is about 10 microamperes per lumen in the circuit of Fig. 7. Assuming an input of 1 lumen, or 0.0015 watt, the electrical output energy is that corresponding to 10 microamperes through 2 megohms, which, by the application of I^2R, is found to be 0.0002 watt. The electrical light efficiency of the cell is then 0.0002 divided by 0.0015, or about 13 per cent. This demonstration, however, may be more interesting than rigorous.

Testing This and That

IN THE old days, when tubes did not oscillate as readily as they do now when you want them to the experimenter would frequently touch the grid terminal with his finger to find out whether the circuit was functioning or not. A dull thud in the phones as the finger was applied to the grid and again when it was removed indicated that oscillations were present. This is one of those simple tests which make laboratory work and trouble shooting less arduous, and it is still used in work on receiving sets. Of course, it is not applicable to transmitters, where the grid bias is often dangerously high.

Somewhat later, in broadcast stations, the operators would tap the microphones at the beginning of a transmitting period and listen to the noise in the monitoring speakers for a check on the air. Of course speech input to the microphone gave a better test along the line to the modulators, but one could not put it out on the air without attracting attention whereas the taps would mean nothing except to the insiders.

Now the finger method is used for test purposes in still another application. In sound-movie systems it is necessary to test the apparatus before each performance, in addition

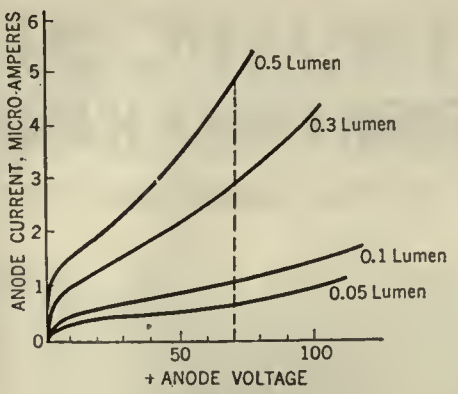


Fig. 5

to the usual meter checks, by some simple audio method which will only take a few seconds. Where disc reproduction is used this is accomplished by tapping the needle of the phonograph pick-up gently, with all the amplifiers on and the projection room speaker going, but the house speakers, preferably, cut off. The tapping, amplified, is heard in the speaker if everything is o.k. The proper loudness with the normal gain setting is soon learned. If the sound is taken off the film the finger method is equally useful, although the application is somewhat modified. Before film is put in the machine, but with the exciting lamp in the sound head and all the vacuum tubes lighted, the finger is moved up and down through the beam of light where it enters the photo-cell. As it shuts off the light and lets it through again characteristic clicks are heard in the speaker. The indication in that case is that there is nothing radically wrong between the film and the speakers. Of course if the test is made with the house speakers as

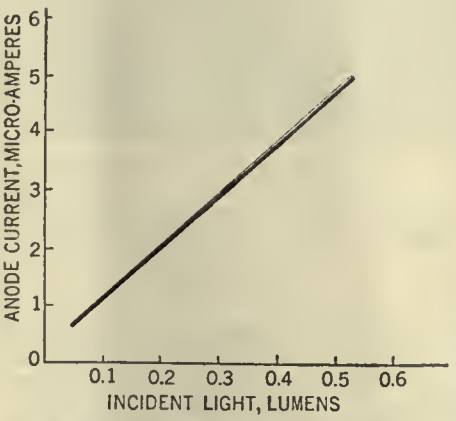


Fig. 6—This curve shows the light-current characteristics of gas-filled photo-electric cell No. 2. The diagrams below show methods of connecting a photo-cell with an amplifier

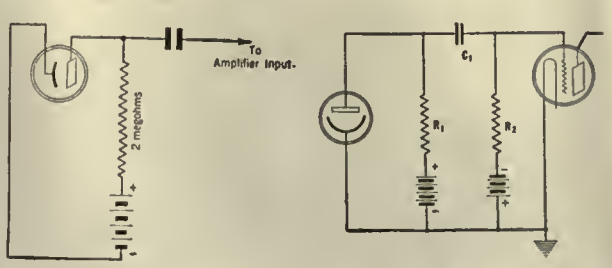


Fig. 7 *Fig. 8*

well the security is even greater, but the volume should be kept down.

When there is more time and scientific means are available, sound-movie machines are tested with special discs or films supplying tone at constant frequency and amplitude. Some of these provide a number of frequencies within the band which the system is expected to transmit. The overall frequency characteristic, as well as any periodic irregularities, such as flutter in the tones, caused by the gear system—a defect to which some film sound reproducers are liable—may thus be checked. The method corresponds to tone tests on a broadcast wire channel or amplifier system, except that the tone is supplied optically or mechanically instead of with an oscillating tube. But for everyday use nothing beats the finger tests.

Photo-Cell Connections

FIG. 3 on page 33 of November RADIO BROADCAST, showing the connection of a photo-cell to the first stage of an amplifier through a resistive coupling, is somewhat awkwardly drawn, and Fig. 8 in the present issue gives a more orthodox and complete picture. The circuit is the same, it will be noted, as a standard resistance-coupled amplifier. The polarizing voltage reaches the photo-cell anode through the resistance R_1, across which the audio voltage is taken off. C_1 is a blocking condenser to confine the transfer to this audio variation. R_2 is a leak for the first three-element tube, with the C-battery at its base. R_2 is usually several times as large as R_1, which may be of the order of 2 megohms.

Philology in the Movies

DR. DE FOREST, who got off the famous sneer about Græco-Schenectady designations when the terms "pliotron" and "kenotron" were first offered to the world, should have something to say about the present crop of names for sound devices in the movies. Leaving out the past nomenclature, in which the mortality is rather heavy as the promotors go back to playing the horses, the following synthetics were discovered in a cursory search of two moving picture trade papers:

Phototone, Orchestraphone, Orchestrola, Duotone, Electrograph, Duplex-o-phone, Dramaphone, Cortellaphone, Bristolphone, Sonoratone, Phonofilm, RCA Photophone, Movietone, Vitaphone, Vocafilm, Synchraphone, Theatrephone, Moviephone, Tonefilm, Biophone, Cinephone.

This leaves out the foreign legion as well as a considerable number of American devices which were not advertising in those issues. A few are big, synchronized outfits, but most of them are theatre photographs intended for use in the smaller houses as an unsynchronized accompaniment to the pictures—simply a twin turntable, switches, a volume control, amplifier, and a cone loud speaker or two.

After extended calculation, in which I consulted the works of Poincaré, Bertrand Russell, Lobatchevski, and Weierstrass, I find that 1.363×10^{18} possible combinations of *phone*, *tone*, and *film* with various other words in the English language remain on tap, so that no alarm need be felt by those interested in the continuance of this educational activity.

BROADCAST ENGINEERING

BY CARL DREHER

Pertinent Information on Broadcast Monitoring

BROADCAST monitoring generally consists in putting some sort of loud speaker in a control room and leaving the rest in the hands of an ex-wireless operator who has got tired of going to sea. This gives sufficiently satisfactory results in some cases, but as the programs get bigger and costlier, corresponding to a similar progression in the advertisers who pay for them, and as receiving sets improve and field strengths go up, judgment of what leaves the station becomes more critical. Some of the scientific aspects of the problem are worth considering.

Two papers by Irving Wolff and Abraham Ringel, primarily on the subject of loud speakers, should be read by the up-to-date broadcaster in this connection. These articles ("Loud Speaker Testing Methods," *Proceedings* I. R. E., Vol. 15, No. 5, May, 1927, and "Sound Measurements and Loud Speaker Characteristics," *Proceedings* I.R.E., Vol. 16, No. 12, Dec., 1928.)throw considerable light on problems of sound reproduction in general.

One possible defect in acoustic judgment, which is not mentioned by these authors, is that of anomalies in hearing. Naturally anyone who has anything to do with judging the output of a broadcasting station should have normal ears, with adequate response within the usual frequency limits of human audition. I mention this because I am told that at one station the technical staff has an unhappy time with a very elderly orchestra leader whose ears have become insensitive to high notes. He comes out into the control room and listens to the orchestra, with an assistant conducting, and insists on getting a better balance in the higher octaves. Nobody wants to tell him that the trouble is in his own head, and he remains an unsolved problem.

Monitoring should be done in a quiet room with average acoustic properties. Noise from motors or other sources is very objectionable. It leads to auditory fatigue and carelessness, and may mask defects in transmission. The best plan is to put the gain control into a small, acoustically treated room within sight of the studio through a double glass window and well isolated acoustically, with a good loud speaker near the operator, and a musician to advise him. The room should be free from unusual resonances and the period of reverberation should be low. Wolff and Ringel point out this pertinent fact: "A person who has been in a room, which is not average, for a rather long time, becomes accustomed to it. and is no longer struck by its acoustic peculiarities." A monitoring chamber about 12 by 9 by 8 feet, with a hard floor, but the walls and ceiling lined with material absorbing about 25 per cent. at 512 cycles and free from extraordinary absorption at any frequency, is a good compromise. Such a room will have a period of 0.4 second and will not show the striking resonance effects of small rooms finished in hard plaster and not treated for acoustic improvement.

SELECTION OF LOUD SPEAKER

The differences between loud speakers are such that the selection of one for a monitoring room is a moot problem. The old horn types, with their single high-resonance peaks and a rapid fall to nothing on either side, may be left out of consideration. One solution is to use a moving-iron loud speaker and a moving-coil type, or several moving-coil speakers in different sized baffles, and to set up the orchestra and the performers on a basis of compromise between them. A more practical procedure is to select one speaker which is fairly typical for the period and to judge on the basis of its output. It should be a good loud speaker in the interest of the progress of the art generally, and because it is hopeless to try to adapt transmission to the defects of all kinds of receivers in the homes of listeners. Ringel and Wolff found, in this connection, that "the loud speaker which has the best looking characteristic (most free from peaks) will, in spite of the defects of existing broadcasting transmitters and receivers, generally sound best when tried on radio."

Where conditions favor it, radio monitoring as a supplement to audio is desirable. When a relatively noise-free signal is available from the air a good radio receiver to which the loud speaker can be switched from the audio amplifier output of the station should be provided. If there were enough difference it would be worth while to simulate radio transmission during rehearsals by modulating a baby transmitter with the same characteristics as the radio plant of the station.

On important programs the preparation of a cue sheet is worth while. This may include the gain settings for various portions of the program, as determined during rehearsals.

ANOTHER SYSTEM

It is quite possible that more elaborate methods of broadcast monitoring will be developed in the future as standards of performance rise. The sound movies may be pointing the way in this field. Some of the large producers have gone to the trouble of placing the microphone mixing and gain controls on a "bridge" or platform in one corner of a room about fifty feet on a side, otherwise empty except for a few men and pieces of apparatus, and with monitoring loud speakers of the theatre projection type, operating at theatre volume, in the diagonal corner. The speakers are about 70 feet from the operators. The room is acoustically treated and gives a good imitation of theatre conditions during the recording. There is nothing else in the place; this volume of 125,000 cubic feet is entirely turned over to the monitoring staff. The actual recording on film or disc takes place elsewhere, and the studio where the action is photographed and picked up acoustically is on the other side of a soundproof wall, although it is within sight through double windows. Interphone connections are of course provided between the separate units. This scheme may not improve the quality of the product enough to justify the expense; if a cheaper system will give almost equally good results, it will naturally prevail. It is, however, a bold attempt to fit the means to the end, and the attitude, if not the mechanism, is worthy of imitation.

The Truth is Mighty and Must Prevail

THE lament is frequently raised that once an error is spread abroad it is impossible for the truth to catch up with it. This is a sad fact, even in engineering circles. Specialization adds to the confusion. The highly skilled technicians in some little corner of applied science can't be fooled when it comes to their own specialty, but they take more or less on hearsay material from other fields, and thus they learn many things which are not so.

The fallacy about remedying defective acoustics in auditoriums by the use of stretched cords and wires is known to all acoustic engineers. Its absurdity was first exposed by Wallace Clement Sabine. It can be shown theoretically that the scheme cannot work, and practice bears out the theory. When it seems to work the usual reason is that a large audience has been crowded into the hall, and the resulting increase in acoustic absorption has partially remedied the trouble. To an acoustic engineer, or any university student in the physics of sound, or to broadcasters who know the elements of their business, all this is well known, but among other learned men the romantic device of stretching wires for acoustic correction still holds its own. I present in evidence an excerpt from the discussion on Prof. F. R. Watson's "Acoustics of Motion Picture Theatres," taken from the *Transactions of the Society of Motion Picture Engineers*, Vol. XI, No. 32, 1927, p. 650:

MR. S.: You probably remember when the Century Theatre in New York was opened. The acoustics made it almost impossible to give a play, so they intermeshed the ceiling with fine wire and it made a great improvement.

Mr. R.: I should like to add that I know a case in Chicago where a plain wall building gave a bad echo. They stretched wires across the hall and kept adding them until they broke up the echo.

MR. C.: I believe that is a common method. I know the Denver Auditorium suffered that way and the cross wires corrected the effect, but of course they are unsightly.

MR. WATSON (*communicated*): Wires in an auditorium are practically useless. If an auditorium with wires has good acoustics, this must be due to other features—carpet, upholstered seats, or other absorbents. The Denver Civic Auditorium, for example, had a considerable amount of absorbent installed.

TRANSMITTING AMATEUR TELEVISION

By BOYD PHELPS

A GREAT deal of eredit for tbe development of short waves bas been given to the amateurs but only a handful of their large numbers did any degree of pionccring, as Mr. Kruse has pointed out in previous artieles in this magazine. Jenkins, Maxim, the Secretary of tbe Navy, and a host of others are looking to the amateurs for tbe development of television. Television, however, bas been with us for some time but somehow tbe amateurs, like proverhial mules, bave been backward about coming forward in tbe field. A few experimenters have set up receiving apparatus to satisfy their euriosity, but transmitting seems to be considered out of the question.

Knowing that amateurs like particularly hard problems, tbe Federal Radio Commission took the recommendations verbatim of a group of amateurs interested primarily in two-way telegraphie-code communication and assigned the worst and least usable of amatcur ehannels to amateurs for television purposes. The 5.00 to 5.35 meter (60 to 56 megaeycle) band is highly experimental witb only spasmodie distant reception and the lone two-way contaet of tbe writer and former 2NZ to its eredit. It is suspected of being a daylight wave for very long distanees under eertain eonditions, or rather a whole flock of conditions, but little is known of this band for telegraphy, let alone television.

Tbe remaining legal amateur television band, whieh is from 150 to 175 meters (2,000–1715 kc.), is praetieally deserted because most amateurs wish to take advantage of the much better earrying power of the shorter waves over great distanees on low power. The inability to ereet a large enough antenna in the average baek yard to permit efficient sub-fundamental operation eonstitutes a serious disadvantage to some. Also, the hand is largely occupied hy illegal but never-the-less present harmonics of practieally evcry broadcasting station from one to a tbousand miles distant. Other conditions sueh as static and distanee to power ratios are not unlike the so-called "graveyard" broadeast waves around 200 meters. In other words, amateur television must not be expected to cover every continent witb a few watts of power for it will take considerable power and good conditions to cover a few hundred miles.

Before any of us drift too far apart we ougbt to think of some standardization of the many optional methods of produeing and reproducing the images so that we may all use the same type of receiver for many transmitting stations. As reeeiving docs not require learning the code and taking a license examination it is quite probable that the non-transmitting experimenters "looking-in" will outnumber the television transmitters many times over, and it is for these that standardization sbould be especially helpful, so that it will not be necessary to use different discs, different spccds, different arrangement of boles, and different directions of seanning to receive eacb transmitter.

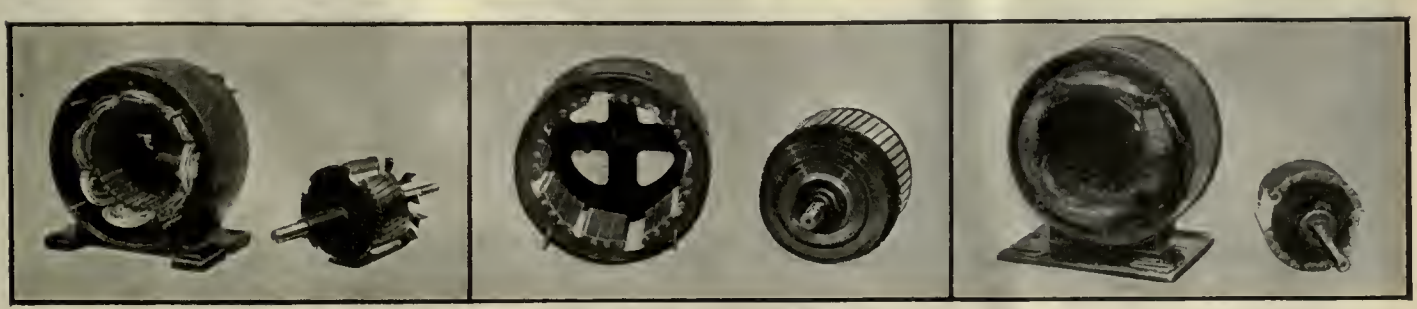


A victim posing in front of Phelps' televisor

Rules of Standardization

TO START things along the same path, let us adopt some simple rules of standardization, based on bow the resultant signals must be "unscrambled" at the receiver. The first rule I propose is to make all transmitters sueb tbat the reeeiving dise holes will scan the image from left to right and tlie spiral more slowly progress from top to bottom, *exactly as we read a printed page.* Random design of a trans-

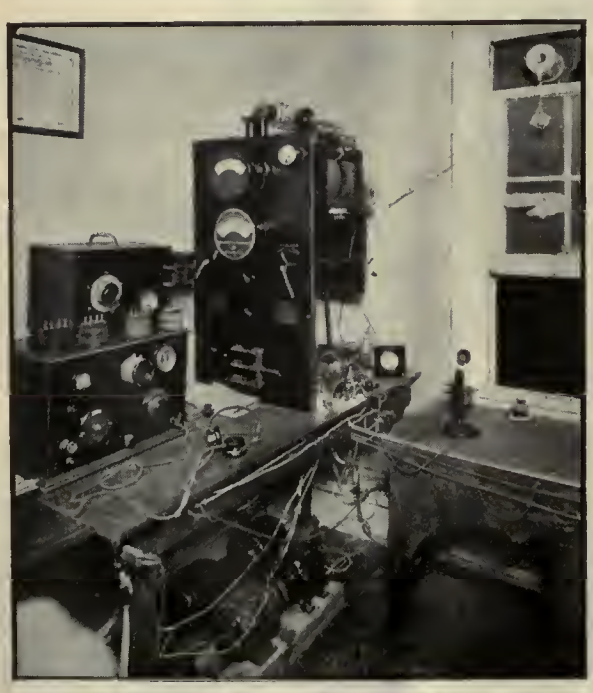
The pictures below show three induction motors which have been converted for synchronous operation



mitter, however, may cause the "lefts" and "rights" to he reversed, or the picture upside down, or hoth.

We next need to standardize the speed of the disc. a speed of 450 r.p.m. or 7½ pictures per second is very slow, causes a bad flicker, and requires a synchronous motor with a large number of poles. One broadcasting station uses this speed, mainly to keep its modulated frequencies within 5 kc. required limits, and one uses a speed of 1200 r.p.m. or 20 pictures per second, but the majority use a speed of 900 r.p.m. or 15 pictures per second. which seems a wise choice from many standpoints and might as well be ours.

The easiest way to secure very constant speed is hy the use of a synchronous motor. Such a motor may he made hy the amateur without much trouble or expense hy cutting out eight slots in an 875 r.p.m. squirrel-cage motor of about ¼ h.p. The illustrations show several types of non-synchronous motors that have been slotted and rewound to run synchronously at 900 or 1800 r.p.m. In some cases the rotor is slotted and in some cases the stator gets divided up, depending upon which has the copper-har squirrel-cage construction. There seems to he no data as to how much metal should be cut away. The writer has varied the width of the cut from 10 to 30 per cent. with little effect. The 1750 r.p.m. motor shown at the right was slotted at two places and assembled; it runs synchronously at 1800, although it should have four slots for more power at synchronous speed. Similarly one 1725 motor illustrated on the left was rewound to have eight poles of the same total number of turns as before on four poles hut only four slotted places instead of eight and it runs nicely at 900 r.p.m. synchronously on the transmitter. The other motor illustrated in this group shows the 900 r.p.m. "sink" motor used at W2BUO for reception. With all of these motors the power is about 40 per cent. of its former rating which is adequate for television purposes if a ¼ h.p. motor frame is employed and a small direct-mounted disc is used. With too great a load the motor gets out of step and throhs or "hunts" with grunting noises at the rate of two or three per second. A small type G-10 neon lamp held behind the scanning disc will show four black bars moving towards or away from the center if the motor is not running synchronously, otherwise the hars appear to stand stationary. If more power is desired, or if the motor does not keep in step, a winding may be put in the slots cut out and fed with direct current. Each pole so wound should he wound in the opposite direction so as to produce alternate north and south poles and greatly increase the power delivered before falling hack out of step.



A view of Phelps short-wave transmitter

The Remaining Question

THE remaining question to he decided is the number of holes we are to use in the disc and this may not be so easily settled. Scanning discs of 24, 30, 48, and 60 holes are now in use among the broadcasters and experimental stations of the big laboratories, but the tendency is to standardize on 48 holes. The greater the number of holes in the disc the finer grained the picture will be and the better detail it will show, but the difficulties in realization mount up rapidly as the number of holes is increased. For the same size picture, the 48-hole disc will have holes of half the diameter of the 24-hole disc, and these holes will let through only one-quarter the amount of already weak light that the larger holes pass. Therefore, expensive and very sensitive photo-electric cells are necessary for a 48-hole transmitter; intense illumination, unusual amplifier shielding, and supply filtering also add to the difficulties immensely as compared to 24-hole systems. Mr. Kruse points out that the optics with 24 holes is far simpler and I am inclined to agree that with so many new problems for the experimenter in this new field that the 24-hole disc should be the standard for a while. Possibly later we may tackle 48 holes, but hy that time the broadcasters may develop some new agreement which we may use as a standard. Decently recognizable faces *can be obtained* with 24-hole discs and many other factors and misadjustments may easily produce worse quality with 48-hole systems, especially when considering the number of things that can go wrong. Then, to do justice to 48-hole discs the efficiency and amplification through a total of eight to eighteen stages must he uniform up to about 50,000 cycles whereas with a 24-hole disc picture quality crosswise equal to that vertically may he had without going above 9000 cycles, and even 5000 cycles as the upper limit does not give an entirely hopeless result. This makes possible the use of iron-core audio transformers with their immense gain over the usual resistance-coupled stages.

While not wishing to appear dogmatic in proposing the above rules, I believe the beginner will find them helpful as much is to be learned and will he learned in developing 24-hole television to a high degree. A possible future transition respecting an increase in holes does not mean throwing away equipment and starting in all over again. The experience gained with 24-hole television will result in a saving in time, tools, material and temper. None of the recommendations above will hamper future development for a long time. They permit either of the two basic methods of scanning and great latitude for individual ingenuity along many lines, and best of all they promote coöperation and close friendship amongst experimenters. In the old 200-meter spark days amateur conventions were meeting places for acquaintances made over the air and nightly maintained to get together. Nowadays the appeal of great DX so easily gotten with low power, together with the fact short waves skip over much of one's own state so that the closest friends over the air are the farthest away, conventions have not increased in interest as they otherwise might. As a result conventions are used for one amateur to boastingly acclaim how many foreign countries he communicated with the evening before or to display his choice cards reporting his signals as "loudest in America,"—an often used expression. Television on 150–175 meters may bring back the good old days, not the crashing spark, but the fellowship, which is easily half of the game.

Late Wednesday afternoon November 28, 1928, the writer transmitted his first television schedule to Werner Olpe, W2BUO, about two miles away, and Robert S. Kruse, W1OA, West Hartford, Conn., about a hundred miles distant. Mr. Kruse did not have his scanning disc finished at the time so he was only able to report on the signal strength, fading, interference, etc., but Mr. Olpe succeeded in reproducing the images excellently before his whole family. Easily recognizable shadowgraphs were produced and the hammer used to tack up some test charts was recognized and described. Incidentally, it was not realized that the hammer was in the field of vision at the transmitter—pulling down the shades is soon not going to he sufficient in the modern home. On subsequent tests a few days later Mr. Kruse got fleeting glimpses of moving images under combinations of most all the difficulties mentioned at the first of this article,—fading, low signal level and broadcast harmonics. One broadcast harmonic was so bad that a transmitter retune was necessary.

The First Amateur Television

AFTER the manner of proclaiming world champions in various new athletic classifications in which they have not yet contested, and consequently are unbeaten. the writer follows suit in calling the above the first amateur television.

A sufficiently detailed description of the transmitter to permit it being copied hy the layman would take considerable space. Some parts of the construction would not he ethical or convenient to try to copy as parts on hand were used wherever possible. However, some idea of the equipment necessary may he gained from a description of what was used for these tests although the apparatus is almost daily "subject to change without notice."

To start with, two 500-watt Mazda bulbs with tin reflectors produce the light source, flood-lighting the subject or victim at close range, not unlike a doctor's baking lamp in action. A few sittings and one should he immune from rheumatism of the face for at least 200 years! Plug-in victims with plenty of spares and an ashpit beneath might be just the ticket. Because of this and because the writer's experiments have been largely one-man affairs, test charts and drawings have been substituted, one devilish horned figure being particularly able to stand the heat is

dubbed the "Spirit of Television." Charts with various checkerboard meshes give amplifier characteristics at a glance but a cross or plus sign is usually used as a preliminary test to facilitate synchronizing receivers.

The optical system continues through either a lens from an old post-card projection lantern or a reading glass, the latter being preferable as it has a somewhat shorter focus. With this lens the image is projected directly on the transmitting scanning disc upside down and with its lefts and rights reversed. Therefore, it is projected on the bottom of the disc which scans in a counter clockwise direction with the spiral progressing upward or inward to conform with the rules given for standardizing television receiver disc scanning. While the $1\frac{1}{2}$ inches square surface at the bottom edge of the disc acts like a projection curtain, somewhere in the picture area there is a hole moving across this projected image and letting light through to the light-sensitive photo-electric cell mounted directly behind, that is, when the hole is in a part of the picture that is bright. For every turn of the disc each part of the image is analized by the scan holes and the resistance of the photo-electric cell is varied in accordance with the intensity of light reaching it.

The Scanning Disc

THE scanning disc used for the receiver is the same as for the transmitter except that holes are drilled with a size 40 drill in the transmitter disc and a size 44 drill for the receiver. The disc may be made from a flat brass plate 0.05" or more thick, or of somewhat thicker aluminum. From the center of the brass plate a 6-inch radius circle is drawn and sub-divided into 24 equal parts from which points lines are scratched to the center. Starting about $\frac{3}{8}$ inch in from the edge of the one-foot diameter circle a scratch is made on each radius line $\frac{1}{16}$ inch nearer the center for each radius line until the 24 radii have been scratched. The points located in this manner determine the positions of the holes of the spiral. In order to increase the initial electrical signal energy above the noise level a considerable degree of overlap in the track of adjacent holes seems permissible in the transmitter disc, but the same overlap in a receiving disc would give a streaked picture, hence the different drill sizes. The holes in the disc shown in the picture are nearly a tenth of an inch in diameter, and a gain equivalent to considerable amplification is the result.

While silhouettes are comparatively easy to transmit because the intense light shining directly into the photo cell, working with reflected rays, from the face at a distance, the light is so weak in its indirect reflected path as to produce only a very minute current in the cell. The signal in the first few stages of amplification may be easily buried under noises such as filament emission, vibration from the scanning motor, noisy B, C, or A batteries or connections, stray feedbacks, audio regeneration, a.c. induction, noisy grid leaks, plate resistors or grid blocking condensers, etc. Too much emphasis can not be put on using good parts in the first few stages at the same time obtaining a rapid gain in signal level above stray pick-up noise. In order to gain this end one of the first amplifiers built by the writer for this purpose used transformer coupling in the first two stages and between the cell and first tube input, but in spite of considerable shielding enough a.c. was induced from the motor into the windings of the transformers to spoil the pictures. Therefore, resistance coupling was resorted to and finally the advantages of the screen-grid tube were used in a resistance-coupled amplifier with surprising improvement. A theoretical voltage amplification of sixty per stage is obtained, which compares well with transformer coupling, and better quality results. The disadvantages of stray induction coupling, even with only moderate shielding, are done away with and the only new difficulty introduced seems to be that only small signal potentials can be handled by this type of tube because the maximum grid swing is only about a volt and a half. However, for amplifying the very weak photo cell currents up to a moderate workable volume where one can be sure of their existance, the screen-grid tube seems admirably well fitted. Two stages are shown in the diagram although three have been used where the reflected light iatensity was unusually weak. However, when three stages are used considerable isolation of battery circuits and shielding is necessary in order to realize anywhere near maximum gain. Indeed, even with the diagram shown, considerable juggling was necessary to get rid of assorted howls and squeals. In this connection it must be remembered in placing and shielding the amplifier that the resistance-coupled stages may pick up, amplify, and overload on radio frequency from the transmitter. Also, it should be mentioned that there seems to be a scarcity of amplifying transformers that will handle heavy plate current and volume (such as between a $7\frac{1}{2}$-watt amplifier and a 50-watt modulator) with good response up to 9000 cycles.

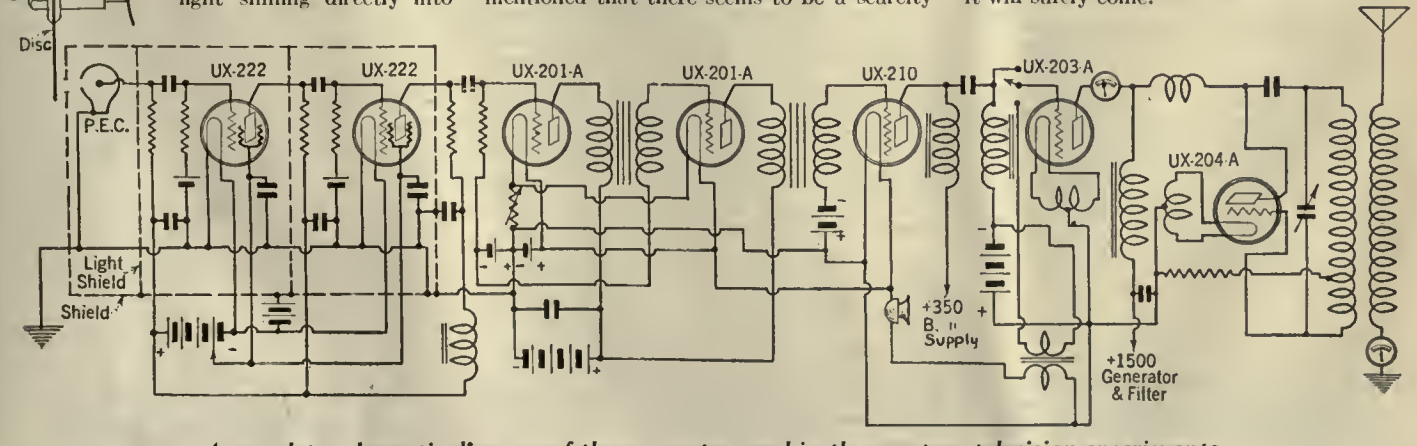


A close-up view of the transmitting scanner and television amplifier

Transmitting Circuits

IN THE matter of oscillatory circuits, any of them work but those that shift wave with different plate voltages should be avoided as they do this in modulation. Consideration should also be given the degree of cutting off of the side bands farthest from the carrier, representing the best image detail, by sharp tuning in amplifier stages as well as degree of modulation efficiency. The diagram on this page shows the complete transmitting circuit used by the writer in his experiments with amateur television.

The television experimenter will at times, no doubt, loose patience with his results, or lack of results, and may even tend towards profanity. The Bible is often a great soother of sorrow and the television experimenter has not been forgotten therein and may get comfort from Habakkuk II, 3, which reads, "For the vision is yet for an appointed time, but at the end it shall speak, and not lie; though it tarry, wait for it; because it will surely come."



A complete schematic diagram of the apparatus used in the amateur television experiments

ARE FILTERS NEEDED IN A. F. AMPLIFIERS?

By KEITH HENNEY
Director of the Laboratory

OSTENSIBLY, a two-stage transformer-coupled audio amplifier is a perfectly simple assemhly of apparatus for the set-builder to put together and operate. All that it is necessary to do is to mount the transformers, sockets, binding posts, and C-hias resistors, if a.c. opcrated, on a base-board, and wire them up. But, is it as simplc as this? Suppose you have the manufacturers' curve on a single transformer, giving its frequency characteristic, have you any assurance that the complcte amplifier will have such a curve, or will it have additional humps and hollows in it, and will it tend to sing at some bigh frequency, or will it "motorhoat" if you try to run it on a none-too-good B supply?

For years George Crom of Amcrtran bas been trying to educate experimenters up to the point where they will "filter" their amplifiers. The use of such filters kceps the a.c. where it belongs, and prevents it from roaming through the B-supply unit where it would become mixed witb a.c. from other circuits. According to Mr. Crom, the characteristic of a two-stage amplifier will be that of a single stage squarcd provided—and only provided—it is wcll filtered. Just what does this mean?

The circuit of a well-filtered Amertran De-Luxe amplifier is shown in Fig. 3 and a picture of the unit will he found in Fig. 4. A list of parts used in constructing it in the Laboratory will he found at the end of this article. To determine the value of Mr. Crom's suggestions regarding filtering, we took this amplifier into the Lahoratory and measured its characteristic by putting constant voltages on the input through 12,000 ohms—to simulate the detector out of which it ordinarily works—at various frequencies, and measuring the current into a non-inductive output resistor of 4000 ohms. According to tube experts, the greatest amount of undistorted power output from a 2000-ohm tube (CX-301A) will be secured when the load into which it works is equal to 4000 ohms, and while the loud speaker into whicb the amplifier works will not bave a constant impedance equal to 4000 ohms at all frequencies, we cannot hopc to simulate it

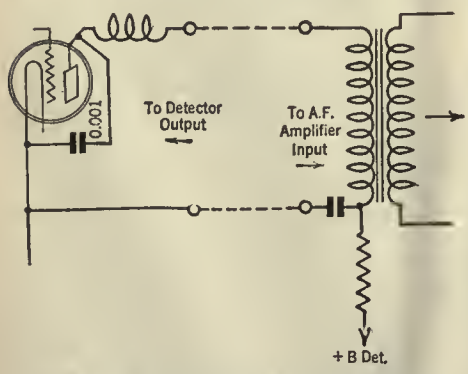


Fig. 1—When filtering is employed in the detector plate circuit, two wires are needed to connect the detector with the amplifier input

George Crom of the Amertran Company has maintained for a long time—he first stated his position in an article in RADIO BROADCAST *for October, 1925—that audio amplifiers and their filter circuits could not be considered separately. It is fair to say that his thoughts have not been as generally appreciated as they might have been. We went into our Laboratory and this interesting article, with accurate and quantitative data is the result. It all means simply this: it is not enough to build your amplifier from the best of units, you must also use proper filtering. From the information given here, everyone can go over his own amplifier and apply the suggestions given. With audio amplifiers and reproducers now covering a really satisfactory scope, real fidelity can be attained, where it was not possible several years ago. This article is the first to give, we believe, any considerable quantitative data on this important subject.*

—THE EDITOR.

better than this. If the amplificr itself has a good characteristic when operated into a resistance load of the proper value, the problem is then up to the loud speaker designers to make a unit that will give equal results.

In thesc tests we were not concerned with overall amplification nor with the power output, hut for simplicity of measurcment we calibrated our output current meter—a Weston thermocouple—in DB (TU) up and down from 5 mA. which, into 4000 obms, is equal to an output of 100 milliwatts.

How Tests Were Made

THE source of tones was a heat-frequency oscillator which would function down to 60 cycles easily; its output was impressed across 10,000 ohms and 500 ohms in series, and the voltage drop across the 500 ohms (General Radio resistance box) was impressed on the amplifier. The B supply was a Majestic power unit which used a gaseous rectifier tube, and which had heen found to havc an output impedance respresentative of all such devices. To obtain plate potentials lower than 180 volts—which was applied to the 171 tube—we used resistors of 25,000 and 50,000 ohms, respectively, at R_4 and R_1. Since 12,000 ohms is much lower than the d.c. resistance of a detector, we placed only 22.5 volts on this tube so the current through the primary of the first DeLuxe transformer was about 1.0 milliampere. Thc 227 tubc (a deForest) was supplied with 90 volts on the plate and about 5 volts on the grid. The 171 tube (a Raytheon) had 180 and 40.5 volts on its plate and grid, respcctively.

To prevent any of thc a.c. in the primary of the first transformer from entering into the B supply we placed a 1.0-mfd. condenser, C_1, as shown which provided a low-impedance path as compared with the 50,000-ohm resistor. The grid circuit of the first tuhe was filtered by means of a high series resistancc, R_1, and a low-reactance condenser, C_2. A.C. voltages appearing across the 2000-ohm resistor, R_3, were not able to enter the grid circuit, first hecause of the high resistance in series with it and secondly hccause the lower end of the audio transformer secondary is practically short circuited to the filament, so far as a.c. is concerned, hy the condenser C_2.

Similarly, a.c. currents in the 227 tube circuit were kept out of the B supply hy filtering the plate circuit of the first audio tube by means of the condensor C_3 and the resistor R_4. This means that the a.c. voltages across R_3 were very small. The grid circuit of the power tube was filtercd in the same manner as the 227, and to keep the a.c. currents of the last tube from wandering around through the B supply the loud speaker was connected directly to the center-tap of the filament of the 171. All the a.c. currents that entered the B supply from the last tuhe, were those which passed through the choke L_1, and these were very small as compared with the currents going through the loud speaker. That was the purpose of the choke, to keep the a.c. currents going through the loud speaker and not through the choke. The purpose of the condenser, C_5, was to keep the d.c. flowing through thc choke, and not through the loud speaker.

The above paragraphs dcscribe how our apparatus was arranged. Now what happened when we placed tones on the input, and measured them in the output? The amplifier was flat from 100 to 8000 cycles (curve A, Fig. 5), it went down ahout 1.0 DB at 60 cycles, and up about 8.6 DB at 10,000 cycles where the capacity across the secondary resonated with

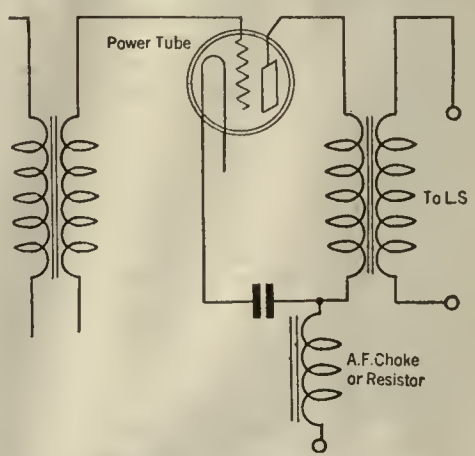


Fig. 2—When an output transformer is employed the filter system illustrated above should be used in the plate circuit of the power tube

the transformer leakage reactance. Since the transformers employed high-permeability cores (about five times the permeability of silicon steel cores) the leakage reactance was low, and the resonant frequency was high—well above the usual range of frequencies transmitted by broadcast stations. This is a very good characteristic.

After completing this test there were a number of experiments which we had to perform. "How much filtering can we remove before the characteristic goes bad?" "Or will it go bad?" These were questions which we had to answer. First, we removed R_1, and connected the 22.5 volts directly from the B supply to the lower end of the primary of T_1. This left 1.0 mfd. across the 22.5-volt tap. At 60 cycles (C) of Fig. 5 the amplifier went down 6.6 DB from its 1000-cycle level, and the entire amplifier was down 1.0 DB. Why?

Those who read the "Armchair Engineer" (March, 1928, RADIO BROADCAST) will remember we calculated the amount of a.c. current that flowed through a 40-henry choke (which is a good big choke) when the loud speaker was connected as in this test. This a.c. current, although small, flows through the B supply, sets up an a.c. voltage there, and part of this voltage appears across the 22.5-volt tap. This voltage is fed into the input of the amplifier and, of course, is amplified. Since the amplifier was now down at 60 cycles, it means that the transformers were so "poled" that this a.c. voltage impressed on the input from the B supply, returned to the 4000-ohm output resistor out of phase with the original voltage, and hence was subtracted from it.

It is worth while, then, to filter the detector. In this case, despite the 1.0-mfd. condenser across the 22.5-volt tap, the amplifier was down, indicating that this capacity (which has a reactance of 2650 ohms at 60 cycles) was too small to give any bypassing effect. When the resistor, R_1, of 50,000 ohms, was in the circuit, however, the condenser was relatively much more effective and kept these a.c. voltages from entering the primary of the first a.f. transformer.

Other Experiments

IN THE next experiment we increased the a.c. current through the B supply by connecting the output resistor directly across output choke, thereby reducing its impedance to approximately 4000 ohms and increasing the a.c. through the B supply by the amount that previously went directly to the filament. Now



Fig. 4—Top view of completed amplifier shows exact arrangement of apparatus on baseboard

the amplifier (D) in Fig. 5 was down 14.8 DB at 60 cycles, and down 7.0 DB at 1000 cycles. Placing 8 mfd. across the Majestic unit increased the 60-cycle response to 12.8 DB—a gain of 2 DB—but this was not worth while. Since this is analogous to operating the amplifier with an output transformer, it is absolutely essential that the detector supply be well filtered and as near (physically) the first a.f. transformer as possible. This necessitates two wires from the detector to the amplifier as in Fig. 1.

Filtering the 22.5-volt circuit (the detector plate-voltage supply), as in Fig. 1, and removing all filtering from the first a.f. tube, provided a good characteristic, almost as good as with the filtering in the circuit.

Taking out all the filtering, even the by-pass condensers across the C-bias resistors, gives the characteristic shown at (B) in the curve. With this arrangement the amplifier suffered badly at both low and high frequencies. Placing the loud speaker across the choke and removing all filtering gave the characteristic at (E)—which in our estimation is pretty terrible. Replacing the condenser across the C bias to the last tube increased the 1000-cycle response to normal but improved the 60- and 100-cycle response only 4 DB, showing that this capacity is far too small to do much good compared with the 2000-ohm resistor which it bypasses. In other words, at low frequencies its reactance is too great to be of much good as a bypassing agent. It is only when the circuit beyond this condenser (toward the B supply) is *increased* in impedance (one-half megohm, R_6) that the condenser gets in its good licks.

Now with all the filtering in place, a 1000-ohm resistor placed in the B-supply lead caused no change in the characteristic at either low or high frequencies, proving that if the amplifier is properly constructed, it is independent of the source of plate or grid voltages.

Conclusive Proof

HERE, then, is conclusive proof that Mr. Crom is correct. The audio amplifier must be filtered if the good characteristic of a single transformer is to be preserved when a two-stage affair is constructed. Here is an amplifier operating entirely from a.c., that gives a flat frequency characteristic from 100 to 8000 cycles and a power output of roughly 100 milliwatts for an input r.m.s. signal of 0.1 volt, or to put it another way, an amplifier that requires an input r.m.s. signal of 0.31 volts to produce a one-watt output. This is true providing the 171-type tube with a mu of 3 is used and providing it works into twice its own internal plate resistance. It is a beautiful amplifier, since it has not only a good characteristic but plenty of overall gain as well.

Now how much of this filtering is necessary? So far as this particular amplifier and particular B supply are concerned, we can do away with the filtering in the grid and plate circuits of the first audio tube—but it is highly questionable whether such an economy would be a true saving. The filtering in the detector plate lead and the shunt condenser and series resistance in the grid circuit of the power tube are both absolutely essential. But so far as a general amplifier and a general B supply are concerned, we need every bit of filtering there is in this present assembly of apparatus as shown in Fig. 3.

While it is true that the ear will not detect differences of perhaps 10 DB at the two extremes of the audio band, it is not safe to say that we can eliminate such filtering as is only effective in bringing up these frequencies. If, by accident, one of the transformer primaries

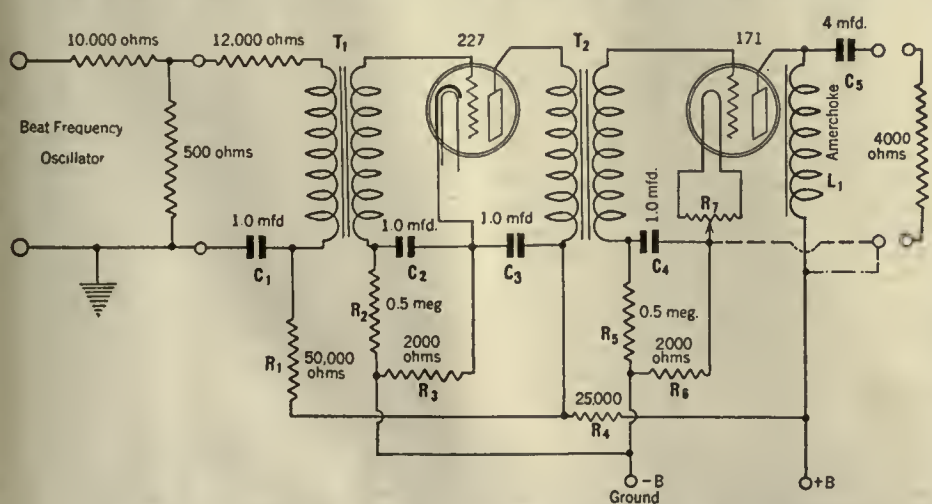


Fig. 3—Schematic diagram of a well-filtered two-stage transformer-coupled a.f. amplifier

bad been poled differently, the chances are that the entire amplifier would sing at some frequency with the removal of any part of the filtering. The only safe way to get a good characteristic out of good transformers is completely to isolate all a.c. circuits. The best place to do this, physically, is in the amplifier itself, for with this arrangement the amplifier circuit is entirely independent of the B supply.

It will be noted that the series filter resistor must pass the plate current required for the tubes on the side furthest from the plate supply unit. Thus, in the circuit diagram, Fig. 3, the 50,000-ohm resistor must be able to carry the plate current of the detector or about 2 mA, and the 25,000-ohm resistor must pass not only the plate current of the first a.f. tube, or about 3 mA., but the current taken by the detector as well, or about 5 mA. in all. The resistors should be able to handle at least one watt.

The series resistors in the grid circuit do not handle any steady current at all since there should be no current flowing in this part of the circuit. Mr. Crom, however, states that these resistors should be able to handle considerable current which is taken by the charging of the shunt condensers. It is his experience that small grid leak type resistors frequently go bad in this kind of filter circuit within a few months after the apparatus is put into use, probably due to the momentary high currents passed through them. Noisy resistors, of course, should always be avoided as a never ending source of embarrassment and bother.

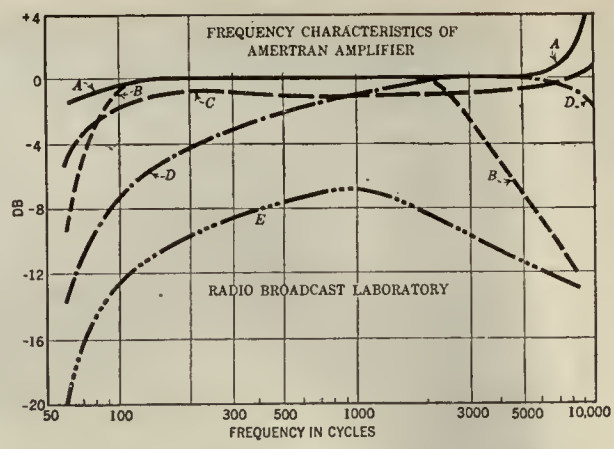


Fig. 5—These curves show the frequency response characteristics of the amplifier with various filter combinations

The voltages which the condensers must handle are not very great, and ordinary 150- or 200-volt units of the paper-dielectric type will prove satisfactory. If the tubes are taken from their sockets while the power is turned on, however, the full voltage output of the plate supply unit will be impressed on the condensers, and if such conditions ever exist, it is well to use condensers that will stand up under the added strain. Although the filter condenser in the plate circuit of the first a.f. tube is required to stand up under a voltage of not much over 90 volts with the tube in the socket, if the tube does not draw plate current, or is taken from its socket, the voltage across the condenser may rise to the full 180 volts supplied to the power tube.

List of Parts

THE list of parts indicates what was actually used in the Laboratory. Equivalent apparatus may be used, of course. The complete list follows:

C_1, C_2, C_3, C_4—Faradon condensers, 1-mfd., type WS3810-A;
C_5 Acme condenser, 4-mfd., Series A;
L_1 Amerchoke, type 874;
R_1 Durham Powerohm resistor, 50,000-ohm;
R_2 Daven Hi-duty Glastor resistor, 0.5-megohms;
R_3 Aerovox Pyrohm resistor, 2000-ohm; type 992;
R_4 Durham Powerohm resistor, 25,000-ohm;
R_5 Daven Hi-duty Glastor resistor, 0.5-megohm;
R_6 Aerovox Pyrohm resistor, 2000-ohm; type 992;
R_7 Electrad center-tapped resistor, 20-ohm;
T_1, T_2 Amertran DeLuxe Transformers;
Fourteen Eby Binding Posts.

BOOK REVIEWS

THE B. B. C. HANDBOOK, 1929. The British Broadcasting Corporation. Published in September, 1928. 480 pages, including advertising.

The British Broadcasting Company's Handbook, issued for the second time, illustrates an underlying difference between the British and American forms of broadcasting. In the United States the large broadcasting chains content themselves with getting what newspaper publicity they can, and satisfying their listeners and advertisers. In its *Handbook*, which of course is also a publicity medium, the B. B. C. assumes the rôle of a British institution, somewhat on the order of the House of Lords, the Royal Institute, and the Church of England.

In the advertisements which are included with the text we note that the British radio manufacturers, like their American prototypes, build perfect radio sets which will, however, be less than perfect when the next model comes out.

The articles cover a wide range. There are recapitulations of important programs and a discussion of program plans for the future. Sports, the opera, educational material, and orchestral broadcasts receive considerable space. There are miscellaneous articles indirectly connected with broadcasting, such as the one on "Bands, Orchestras, and Instruments." Artists who have broadcast extensively give their views on the best technique. The listeners are even told how to listen. The drama and religious broadcasting are not neglected. The press, poetry, and copyright limitations are other miscellaneous heads picked out at random from the text. Like the radio itself, the *Handbook* evidently aims to present a number of things of interest to its variegated group of patrons.

The "Technical Section" contains a summary of progress in transmitter design, in which low-power transmitter modulation is favored, although not enthusiastically. The radiation pattern of the Daventry station is shown. There is quite an informative article on broadcast acoustics, including a disclosure of the "artificial echo" scheme. The output of the microphone amplifier is split, one channel going directly to the transmitter, while the other, through a re-inforcing amplifier, actuates a loud speaker in an echo room with bare walls and a consequently high period of reverberation. The sounds emitted by the loud speaker are picked up by a microphone in the room, and mixed with the straight studio output in any desired proportion. The method is an ingenious one and should give good results in selected cases where the distortion involved in repeating through a loud speaker is not objectionable.

The article on microphones discloses the fact that in the British stations the moving-coil type of microphone which was standard at one time has been largely superseded by a carbon transmitter apparently of the Reisz type, in which the sound affects a layer of carbon granules through a rubber membrane, and by American condenser transmitters. Considerable material on receiver problems also appears in the technical section of the *Handbook*.

The illustrations are interesting and some of them refute the idea which has proved so useful in American vaudeville shows, that the British generically lack a sense of humor.

CARL DREHER

RADIO, By Elmer E. Burns, D. Van Nostrand Co., New York, 1928, 255 pages, price $2.00.

The sub-title of *Radio* is "A Study of First Principles"; it is intended for "Schools, Evening Classes, and Home Study." The author is an instructor in physics in the Chicago high schools. The treatment, probably as a result, is more thorough in setting forth the theoretical basis of the art than most elementary books, and there is correspondingly less "How to Make" material. Graphs are used liberally but there is some application of simple mathematics, and here and there a vector diagram. At the same time Mr. Burns' text never becomes abstract or merely verbal. His first chapter, in fact, plunges abruptly into "Simple Receiving Circuits," without the preliminary wooing of the principles of electricity to which we have become accustomed. However, the author then retraces his steps, starting with electric batteries, and going through electric circuits and Ohm's Law, electron tubes, alternating currents, detectors and amplifiers, fundamentals of receiving circuits, oscillators and transmitting circuits, and radio measurements. In an appendix some of the common mathematical relations are brought together, and there are lists of graphic, mathematical, and code symbols. An index is provided.

Radio—"First Principles" provides an excellent course of study for students with high-school preparation in physics and mathematics. It might serve as an effective introduction to an advanced text like Morecroft's, for, in its restricted sphere, it shows some of the same care in preparation and choice of material.

CARL DREHER.

Radio Broadcast's Home-Study Sheets

The Transmission Unit

WHEN comparing the voltage amplification or the power output of two or more amplifiers, it is convenient to use a unit of comparison that bears some relation to the sensitivity of the ear. For example, the difference in volume output between a full orchestra playing very loud and playing very softly is about one million times. And yet to the ear the difference is only about 60 times; that is, between these two extremes in level, there are about 60 steps which the ear can detect by which the volume may be increased.

As another example, one amplifier may deliver 600 milliwatts of power into a loud speaker while another is capable of turning out one watt, or 1000 milliwatts. Off hand one would say that the second is a great deal better, but is it? Of two amplifiers having voltage gains of 50 and 60, the second is better, of course, but if it costs a great deal more, is it worth it? As a matter of fact the differences between these two amplifiers would be scarcely audible to the average ear.

A convenient unit of comparison has been known as the Transmission Unit of Loss or Gain, and is now called the Decibel, abbreviated to DB. It has been called the TU, for want of a better name, up to the present time. The DB is one tenth of the internationally used unit, the Bel, named in honor of Dr. Alexander Graham Bell, the inventor of the telephone. The transmission unit of loss or gain was originated in the telephone industry which deals almost exclusively with differences in volume in which the ear plays a part, and so such a unit, which had some connection with the manner in which the ear hears, was necessary.

The DB is defined as "Ten times the common logarithm of the ratio between any two powers."

$$N_{DB} = 10 \log_{10} P_1/P_2 \ldots\ldots\ldots (1)$$

in which N is the number of DB by which the two powers P_1 and P_2 differ. The DB is such a unit that the trained ear can just distinguish the differences between two powers which differ by one DB, or one unit of loss or gain.

The table below gives some easily remembered values of DB and the corresponding power and voltage or current ratios.

NDB	APPROX. POWER RATIO	APPROX. VOLTAGE OR CURRENT RATIO
3	2.0	1.4
4	2.5	1.58
6	4.0	2.00
7	5.0	2.24
9	8.0	2.8
10	10	3.16
20	100	10.0
23	200	14.0
30	1000	31.6

The second advantage in the use of such a unit, which is a logarithmic unit, will be apparent in glancing at the above table. Every time the power is doubled, we add 3 DB, and every time the power is multiplied by 10, we add 10 DB. Thus a ratio of 2 gives 3 DB, a ratio of 4 gives 6 DB, a ratio of 8 gives 9 DB, etc. All power ratios between 100 and 1000 are included between 20 and 30 DB. DB are to be added when power ratios are multiplied, and subtracted when power ratios are divided. Thus, if one amplifier has a gain of 25 and is to be used after another similar amplifier, the total voltage gain is 25^2 or 625, which is awkward. But if the gain of each amplifier is 25 DB, the total gain is 50 DB.

In other words the DB is a compressed unit, and neglects differences of power the ear cannot detect. Thus, when an engineer speaks of the superior power output of his amplifier as compared with another, one must be careful to translate the power ratios into DB before taking him too seriously.

Example: Let us consider an amplifier that is capable of turning out 100 milliwatts of power. By how much must we increase its output before the ear can just tell the difference?

Solution: A table of DB, or a logarithm table, tells us that 1.0 DB corresponds to a power ratio of 1.25. Thus the power output to which 100 milliwatts must be increased before the difference is audible to the ear is,

$$\text{DB} = 1.0 \text{ when } P_1/P_2 = 1.25$$
$$\text{or} \quad P_1/100 = 1.25$$
$$\text{or} \quad P_1 = 125$$

and so the power output must be increased to 125 milliwatts before the ear can tell the difference.

Strictly speaking, the unit of loss or gain deals with power ratios only, but with a little juggling of our mathematics we can use it to express ratios of current or voltage. It is only necessary to convert these voltages and resistances to powers, get the ratio and convert to DB, or to use the following formula when voltage ratios are involved:

$$N_{DB} = 20 \log \frac{E_1/\sqrt{R_1}}{E_2/\sqrt{R_2}} \ldots\ldots (2)$$

or (when current ratios are involved)

$$N_{DB} = 20 \log \frac{(I_1)^2 R_1}{(I_2)^2 R_2} = 20 \log \frac{I_1\sqrt{R_1}}{I_2\sqrt{R_2}} \ldots\ldots (2)$$

in which the factor 20 appears because of the fact that the voltages in the above equation are squared. (When you square a number, you double its logarithm.) If the impedances into which two currents flow, or across which two voltages appear, are equal, the expression for DB becomes,

$$N_{DB} = 20 \log \frac{E_1}{E_2} \text{ or } 20 \log \frac{I_1}{I_2} \ldots\ldots (3)$$

How to Use DB

To convert power ratios to DB look up the logarithm of the ratio and multiply it by TEN. To convert current or voltage ratios to DB, look up the logarithm and, if the impedances are equal, multiply this logarithm by 20. If the impedances are not equal, use formula (2). When looking up logarithms, remember that all numbers up to 10 have logs between 0 and 1, all numbers between 10 and 100 have logs between 1.0 and 2.0, all numbers between 100 and 1000 have logs between 2.0 and 3.0, etc. In other words the first figure of the log of all numbers between 100 and 1000 will be 2 and the next number tells us exactly where, between 100 and 1000, the number is. Thus, the power gain corresponding to 100 is 20 DB and corresponding to 200 is 23 DB—adding 3 DB every time the power is doubled—and for 400 is 26 DB.

When converting DB to power ratios, follow this example. What is the power ratio corresponding to 18 DB? Dividing by 10 gives 1.8. The figure 1 tells us that the number lies somewhere between 10 and 100, and the figure 0.8, when looked up in a log table, is the log of 6.32. The ratio is, then, 63.2. If it were 28 DB the figure 2 indicates that the number lies between 100 and 1000 and the "antilog" of 0.8 is 6.32 so the ratio is 632.

Example: An amplifier has one volt applied to its input resistance of 10,000 ohms. Across its output resistance of 4000 ohms appears a potential of 40 volts. What is the power gain in DB, the voltage gain in DB, and the voltage gain expressed as a ratio? Would it be worth while to increase the amplification so that 50 volts appeared across the output?

Solution:

$$\text{Power input} = P_i = \frac{(E_i)^2}{R_i} = \frac{1^2}{10000} = 10^{-4} \text{ watts}$$

$$\text{Power output} = P_o = \frac{(E_o)^2}{R_o} = \frac{40^2}{4000} = \frac{1600}{4000} = 0.4 \text{ watts}$$

$$\text{Power ratio} = \frac{P_o}{P_i} = \frac{0.4}{10^{-4}} = .4 \times 10^4 = 4000$$

Power gain = 10 log 4000 = 36 DB (because the log of 4 is 0.6 and because the first figure of the logs of all numbers between 1000 and 10,000 is 3 and the power gain in DB is 10 times the log of 4000)

$$\text{Voltage gain} = 36 \text{ DB} = 20 \log \frac{E_o/\sqrt{R_o}}{E_i/\sqrt{R_i}}$$

$$\log \frac{E_o/\sqrt{R_o}}{E_i/\sqrt{R_i}} = \frac{36}{20} = 1.8$$

Voltage gain = 63

If E_o becomes 50, gain (between $E_o = 50$ and $E_o = 40$) $= 20 \log \frac{50}{40} = 2.0$ DB. And so the difference between an output voltage of 50 and one of 40 would be hardly worth any trouble to get it. The solution to this example is characteristic of all such problems.

The easiest way to learn to use the DB chart in Fig. 1 is to look along the horizontal axis for the DB corresponding to a power ratio of 100 which is along the right vertical axis. This we know is 20 DB. A power gain ratio of 20 corresponds to 13 DB. A voltage gain ratio of 6 corresponds to 15.6 DB. A power loss ratio of 0.2 corresponds to 7 DB, a voltage loss ratio of 0.06 corresponds to 24.5 DB, etc.

Problems

Problem 1. What in DB corresponds to a voltage ratio of 100? Power ratio of 100? What voltage ratio corresponds to 100? What power ratio?

Problem 2. A current of 0.006 amperes flows through a resistance of 1000 ohms. A switch reduces this current to 1.0 milliampere. How much is the current reduced in DB?

Problem 3. An amplifier has a normal output of 1 watt. A switch is provided so that its output can be reduced in 5 DB steps. What is the output in watts when it is reduced by 5, 10, 20, and 25 DB?

Problem 4. A radio receiver has a voltage gain in its radio-frequency amplifier of 50 DB. Express this in voltage ratio, and in power amplification provided that the same impedance closes the input and output of the amplifier.

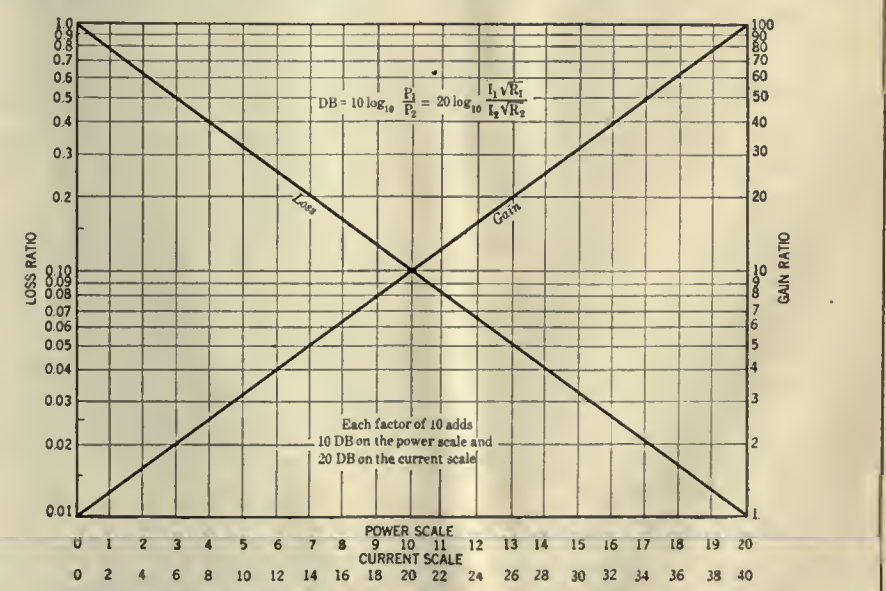


Fig. 1—Chart of transmission units (DB)

Radio Broadcast's Home-Study Sheets

Experiments With a Wavemeter

METHODS of calibrating a wavemeter were discussed in Home-Study Sheet No. 13. If the experimenter provides himself with a heterodyna wavemeter, that is an oscillating vacuum tube with n grid-current meter and a series of coils and a tuning condenser, he has, in his own laboratory, the most important item of equipment for a whole series of interesting, instructive, and useful experiments. The heterodyne wavemeter can be avoided if an oscillating detector is used with a pair of telephones in its plate circuit according to Fig. 1. The circuit will have to be calibrated, but this can be accomplished as indicated in Home-Study Sheet No. 13. With this system, instead of using a grid-current meter to indicate resonance with another circuit, a click in the telephones serves the samo purpose.

Properties of Coils and Condensers

A. Wind up on n form approximately 2.0 inches in diamcter about 60 turns of rather large insulated wire, say about No. 20, so that the distributed capacity will be large. Connect the ends of the coil across a variable condenser whose capacity at seveml settings is known—a calibrated condenser, in other words. A 500-mmfd. condenser will have about tha maximum capacity needed. Starting at the maximum condenser capacity, "click," the coil-condenser combination into the oscillating detector, or into tbe heterodyne wavemeter. Note down the wavelength or frequency, and then change the setting of the variable condenser and get a new wavelength or frequency setting. Continue until three or four points have been secured, for example, if a 500-mmfd. condenser is used, get the wavelength at 500, 400, 300, 200, and 100 mmfd.

Make a table, as in Tablo 1, showing the condenser capacity, tha wavelength, and the wavelength squared. Plot, as in Fig. 2, the wavelength squared against capacity. A straight line should result, because of the equation,

$$(\text{wavelength})^2 = 3.54 \times L \times C$$

where L = microhenries
C = mmfd.

This equation states that the wavelength squared is proportional to the capacity. Tha "proportionality factor," that is, the factor which connects tha wavelength squared and the capacity is L, the inductance.

The slope of the line divided by 3.54 then, is tho value of L, that is,

$$L = \frac{1}{3.54} \times \frac{(\text{wavelength})^2}{\text{capacity}}$$

It will be noted that the lina crosses the vertical axis (the wavelength-squared axis) at some distance above the zero point. In other words, if thero were no additional capacity present, except what the coil inherently possesses, thc wavelength squared would be given by this value. This point on the curve gives us the natural wavelength of tha coil, determined by its inductance and its distributed capacity. To check this valne, remove the condenser end click the coil alone into the wavemeter.

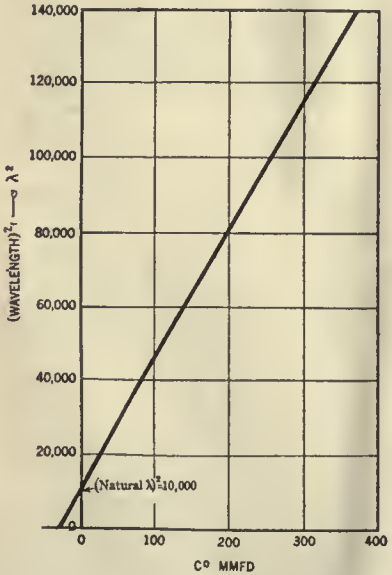


Fig. 2

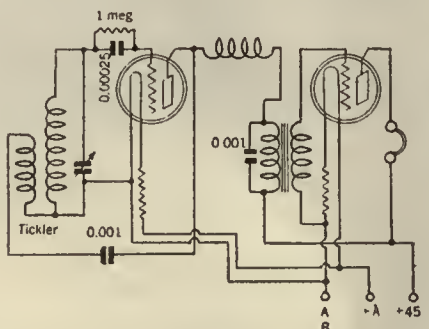


Fig. 1

The point where the line crosses the capacity axis gives us a value for the distributed capacity of the coil. This valne when multiplied by the proper value of L gives us tha LC product which, when fitted into the formula above, gives us the natural wavelcugth of tha coil.

Thus one experiment not only gives us tlie inductance of a coil, but its distributed eapacity and its natural wavelength as well. Tbe greater the distributed capacity of the coil, the more accurately it can be measured by this method.

As a check on this method of determining the inductance of a coil, calculate the inductance from the following formula,

$$L = \frac{d^2 N^2}{9\ d + 10\ b}$$

where d is the diameter in inches
N is tha number of turns
b is tha length of winding in inches

Measuring Capacity

B. The product of L and C in a circuit determines the wavelength or tha frequency to which that circuit will tune. When the circuit is near by a source of energy of this frequency, tha circuit begins to absorb energy and n large current will flow in the coil and tha condcnser. This phenomenon is tbe basis of all tuning in radio circuits, and has been described in Home-Study Sheets 11 and 12. It can be used for measuring purposes as well as for receiving radio signals as the following experimcnt will prove.

Connect a condenser whose capacity is known across a coil so that the combination will "click" into the range of frequencies over which the wavemeter or oscillating detector will cover. Adjust the circuit to resonnnce. Connect across tha condenser a capacity whose value is unknown but which is desired. Adjust the variable standard capacity until resonance is again obtained. Wbat has happened?

We have increased the total capacity in the circuit by adding the unknown condenser to the standard. We must, therefore, reduce the setting of the standard until the total capacity in the circuit is as it was before.

For example, if the condenser were set at 400 mmfd. when resonance occurred without the unknown capacity, and at 320 mmfd. with the capacity, the difference, 400 — 320, or 80 mmfd., gives the capacity of the unknown.

Such a mcthod enables the experimenter to disregard the capacity of the coil and of the leads since they are in the circuit at all times and do not affect the difference of capacity produced by adding another condenser to the circuit.

If a large condenser is to be measured, it may be necessary to put it in series with the standard condenser to obtain resonance. Tbe experimenter must remember that when two condeusers are put in parallel thc resultant capacity is the sum of the individual capacities—this is tha basis of the experiment just described; but that when two condensers are put in series, the resultant capacity is the product of the individual capacities divided by thc sum, or the resultant capacity, C_0, of adding C_1 iu series with C_2 is

$$C_0 = \frac{C_1 \times C_2}{C_1 + C} \text{ or } \frac{1}{C_0} = \frac{1}{C_1} + \frac{1}{C_2}$$

If the capacities of small paper or mica condensers ara measured by these mcthods, i.e., determining their capacity at high frequencies, some strange results will occur. The capacities will differ rather widely from the rated values. Air condensers will give true readings, however. The variation in capacity at different frequencies seems to bo a kiud of electronic disturbance in thc dielectric at high frequencies so that the dielectric constant is not what it is at low frequencies. Snch discrepancies are not important whcre the units are used as bypass condensers but when they nre to be used for tuning circuits, one cannot rely on their markings. The experimenter should make a list of the rated capacities, tha measured capacities, and the percentage accurate of a serics of small fixed condeusers.

Measuring Antenna Capacity

C. Connect a coil in series with the antenna and ground and "click" into the wavemeter or the detector. Then removc the antenna and ground wires and connect across the coil a variable coudenser whose capacity is known, or can be obtained. Tune the condenser until resonance is obtained. Then the capacity of the condenser is the same as the capacity of the antenna.

Measuring Antenna Inductance

D. Connect a known inductance in series with the antenna and ground and measure the wavelength of the system. Then connect another inductance, different in value from the first, and get a new valua of wavelength. Then the two wavelengths are related as below:

$$(\text{wavelength})_1 = 1.884\ \sqrt{(L + L_a)\ C_a} = \lambda_1$$
$$(\text{wavelength})_2 = 1.884\ \sqrt{(L_1 + L_a)\ C_a} = \lambda_2$$

where L_a = antenna inductance
C_a = antenna capacity

Eliminating C_a from these two equations, gives

$$L_a = \frac{L_1 \lambda_2^2 - L_2 \lambda_1^2}{\lambda_1^2 - \lambda_2^2}$$

Problems

1. Two condensers whose capacities nrc 400 mmfd. and 500 mmfd., respectively, are across two inductances. Both combinations tune to the same frequency. What is the ratio of inductances? If the inductance across the 400-mmfd condenser is 300 microhenries, what is the inductance across the other?

2. What is the inductance of the coil used in the experiment which produced Fig. 2?. What is its distributed capacity? What is its natural wavelength?

3. If the wavelength of a circuit varies as the square root of the capacity, what must be done to the capacity in a circuit to double the wavelength? If the wavelength vnries as the square root of the inductance, and if the inductance varies as tha square of the number of turns, how is the wavelength related to the number of turns on a coil? That is, if a coil has 30 turns and tunes to 300 meters, how mauy turns are necessary to tune to 600 meters?

4. A coil to tune over the broadcast band has 75 turns. It is used with n 0.00035-mfd. condenser. How many turns, approximately, will be needed if the condenser is 0.0005 mfd.?

5. A coil-condenser combination tunes to 450 kc. when the capacity is 600 mmfd. When an unknowu condenser is placed in series with tho coudenser, the circuit tunes to 600 kc. What is the valua of tha unknown capacity?

6. An antenna tunes to 300 meters when 200 microhenries are in series with it, and to 400 meters when the inductance is increased to 300 microhenries. What is the inductance of the antenna? Remembering that the antenna inductance is in series with the "loading" inductance, and that the total inductance in the circuit can be calculated hy adding the individual inductances, what is tho capacity of thc antenna? What is its uatural wavelength?

7. An antenna bas a natural wavelength of 400 meters and a capacity of 0.0003 mfd. How would you rcduce tha natural wavelength to 200 meters?

8. The LC product of a coil and condenser to tune to 220 meters is 0.01362 mfd. If the distributed capacity of the coil to be used plus tha miuimum capacity of the variable condenser amounts to 50 mmfd. what is the necessary inductance? What will be the tuning range if the maximum capacity of the condenser is 0.00035 mfd?

Table 1

C_0 MMFD	WAVELENGTH	(WAVELENGTH)²
100	212	45000
200	283	80000
300	340	115000
350	364	132000



THE SERVICEMAN'S CORNER

SERVICEMEN have not been slow to write us of their unqualified approval of "The Serviceman's Corner." And what is more, they have sent us a great number of excellent contributions, many of which appear in the paragraphs below. We welcome contributions, all of which, if accepted, will be paid for at space rates.

Melvin L. Shook, of Shook & Jones, Akron, Ohio, writes that a large proportion of their service calls are on old sets. "So far, our experience on the a.c. sets has largely been the replacement of tubes. One of our greatest difficulties is in securing circuit diagrams of standard receivers which we are called upon to service. It eliminates a lot of work when you have the diagram with the constants to go by. As practising servicemen we are constantly called upon to service all types of sets. Consequently, we greatly appreciate your 'Service Data Sheets on Manufactured Receivers.'"

It is doubtless true that a large amount of service work is not done by the dealer from whom the set was purchased. Service organizations and individuals doing service work will be wise to collect systematically all the data on all types of sets which turns up from any reliable source.

How to Tell Failing Rectifier Tubes: Failure of the rectifier tube is best indicated by a decrease in the plate voltage supplied to all tubes in the receiver. It may be distinguished from failure in the last audio tube by comparing the voltage readings obtained on the remaining tubes with the plate voltage reading on the power tube. When the rectifier tube is at fault, all readings will be low; when the power tube has failed, all readings will be high. E. T. Cunningham Inc., inform us that the average life of the cx-381 is 1000 hours or more when the transformer voltage does not exceed 700 volts and the plate current is limited to 85 mA. maximum. Tubes of this type operated from transformers not made recently may be operating out of 750 volts, with a resulting lessening of tube life. Another important precaution is operating the filament at its rated voltage. The tolerance here is not greater than plus or minus 5 per cent. (see RADIO BROADCAST for January, 1929, page 181.)

Replacing a Fixed Condenser in A. K. Sets: "I have had considerable difficulty in procuring a condenser of proper physical dimension to replace the fixed by-pass condenser in Atwater Kent sets," writes G. A. Thurling of Springfield, Massachusetts. "This condenser breaks down, shorting the B-power circuit and making reception very weak, or altogether impossible.

"The fixed condenser used in a Ford ignition spark coil makes an excellent substitute. Discarded Ford coils may be purchased for as little as twenty-five cents at most Ford service stations. This condenser fits snugly in place of the usual condenser in Atwater Kent models."

These pages mark the third appearance of our special section for the practising serviceman. To say that this department has been enthusiastically received would be putting it mildly. Scarcely any innovation in RADIO BROADCAST *in the last five years has attracted so much favorable comment. We are welcoming carefully considered contributions which, if accepted, will be paid for at our regular rates. A number of contributions describing set testers have been received and we are not at present interested in others unless they are designs of great originality and especial merit. Contributions are especially desired which describe the solution of especially baffling problems encountered which service manuals do not cover and similar items calculated to be of the widest interest to others working in the field. Typewrite your contributions and address them to the Editor, Serviceman's Corner,* RADIO BROADCAST, *Garden City, New York.*

—THE EDITOR.

Testing a.c. plate voltage: Servicemen testing the plate voltage on tubes operated from a.c. often make the mistake of placing their voltmeters across the B supply just as they would in a d.c.-operated amplifier, for example. This does not give the true plate voltage, but the plate plus the grid voltage. In order to read the true plate voltage of an a.c.-operated tube, especially where the tube gets its C bias by the plate-current drop through a resistor, the meter must be connected between the plate terminal of the tube's socket and the filament terminal of this tube. It does not matter which of the two filament terminals is used. See Fig. 1.

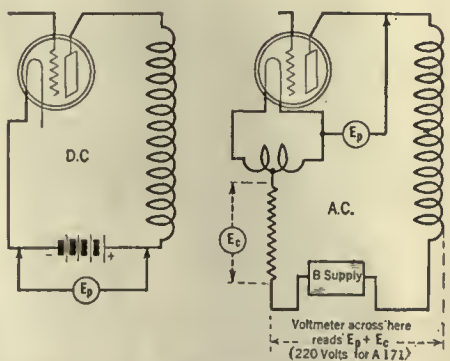


Fig. 1—These diagrams show how to measure accurately the plate and grid voltages in a.c.-operated receivers

Increasing Response on the Longer Wavelengths: My contribution is on the subject of boosting volume on the long-wave end of the dial on sets employing a resistor across the grid and ground as an untuned coupler for preventing the length of the antenna used from affecting the gang control of the radio-frequency stages following. Such sets as the Aero Seven, Graybar 310, R. C. A. Models 16, 17, 18, Knight 6-7, Monroe 8-9, and many others can be improved with this simple kink. Take any solenoid coil such as is used to cover the broadcast band in conjunction with a 0.00035-mfd. condenser and connect one end of the coil to the antenna post of the set and the other end to the ground post. Coils having a diameter greater than two inches seemed to work best. Some old Lorentz wound coils out of an ancient Freshman Masterpiece set worked excellently. The primary coil was ignored, but care was taken that the ends did not short. The results were not so good on two Atwater-Kent sets the coils were tried on, probably because A.K. uses a choke instead of a resistor across the antenna and ground. The most effect of the coil in all cases was on the long waves, just where most one-dial sets need a little more energy.

—J. P. KENNEDY, South Bend, Indiana.

Interference Elimination: In one locality a great deal of motor noise was picked up by a Radiola 18 and it was found that by removing the ground the trouble was reduced to such an extent that it was not objectionable, while in another case with the same type of receiver the trouble seemed to be due to a faulty ground. When a wire was shunted across the water meter the interference practically vanished and the volume picked up at least 50 per cent.

—K. R. TANTLINGER, Cumberland, Md.

Trouble in a Radiola 17: Operation would be normal for about twenty minutes then a tremendous noise would drown out the signal. This noise would continue and then normal operation would obtain. Tubes were tested and proved in good condition, but as an additional precaution were tested in another set. Routine tests for continuity were made, showing proper results. The trouble was finally remedied by replacing the grid condenser. The condenser after removal was tested for a short circuit with 250 volts, but it showed no current passage. As I was unable to disassemble it without injury, I do not know what the trouble was. [The test made would indicate a short circuit, but not an "open." It is just possible that the mica grid condenser in question had an open cir-

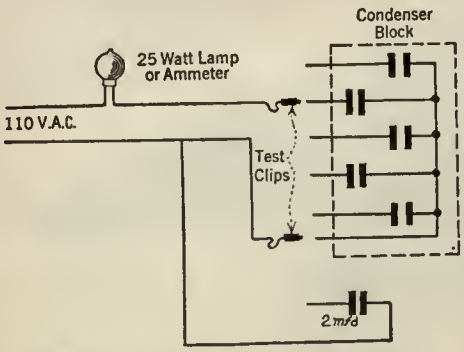


Fig. 2—Method of determining approximate capacities of various units in a condenser block.

cuit which could not be shown by 250-volt test.—*Editor.*]

—W. C. Roemer, New Haven, Connecticut

Testing Condensers: Several days ago in building up a power amplifier, I tore down an old power unit in order to salvage the condensers. I lost track of the various leads on the condenser bank and was faced with the problem of finding a quick and easy method of determinining the common ground and the various capacity leads. I finally hit upon this scheme: The two leads from the 110-volt a.c. main are connected in series with a 15- or 25-watt lamp and the condenser to be tested. See Fig. 2. Since a.c. is employed, some current will flow. The amount which flows depends on the capacity of the condenser. The glow of each section was compared with the glow using a standard 2-mfd. condenser. In this way I could determine not only the ground lead or common lead, but also the approximate capacity of each section. If an a.c. ammeter is available, a much more accurate check can be made. For an ordinary condenser bank, however, the lamp method is quite satisfactory.

—Karl F. Oerlein, Philadelphia, Pa.

Common A.C. Receiver Troubles: The simple chart below lists some of the most frequently encountered troubles in a.c. receivers. The chart is not exhaustive by any means, but may suggest to others ways of organizing service information which they have or may gather in the course of their work. The use of this chart in conjunction with a good set tester, such as Jewell, Weston, Supreme, will enable the serviceman to locate quickly the defective part or condition.

Symptoms:	For causes refer below to:
No Filament Voltage	No. 1
No Grid Voltage	No. 2
No Plate Voltage	No. 3, 4, 5, 6, 7
Voltage with little or no current in Plate Circuit	No. 8, 9
Excessive Plate Current	No. 10

Causes:

1—Loose terminals, poor soldering, open or shorted power transformer winding.
2—Open grid suppressor, open divider resistor, open a.f. or r.f. transformer secondary.
3—Open divider resistor.
4—Open r.f. primary.
5—Open a.f. primary.
6—Shorted by-pass or filter condensers.
7—High-resistance connections, open leads, or loose terminals.
8—Low-emission tube.
9—Defective socket, dirty contacts.
10—Open a.f. or r.f. grid circuit, no bias, excessive plate voltage, defective tubes.

Carlton W. Croteau, Mount Carmel, Conn.

Shooting Trouble on Atwater Kent No. 20: Having made many service calls on Atwater Kent model 20 sets, two main sources of trouble stand out: blown out by-pass condensers, and blown resistors. To test properly for these troubles, a regular set tester is desirable, but if none is available, a high-resistance voltmeter (1000 ohms per volt) should be used. Test the plate voltage on each of the r.f. sockets. If there is no plate voltage, remove the set from its cabinet and make a circuit tester from a high-resistance voltmeter. See Fig. 3. If the condenser passes a steady voltage, it should be replaced. To test the resistors, the set must be removed from the cabinet and tested with the meter arrangement suggested. My experience has shown that in nine out of every ten service calls on this set these two tests made in this way will locate the trouble.—F. D. Mitchell, Collingdale, Pennsylvania.

Hum in Moving-Coil Loud Speakers: "I have had two a.c. Peerless dynamic speakers which hummed badly, due apparently to feedback on the 8-volt a.c. links," writes L. A. Moss of Los Angeles, California. "A 4000-mfd. dry "A" condenser stopped it, so that there is now no hum at all. Fig. 4 shows the method of connection. [The suggestion is excellent, but the reason for the hum is not correct. Hum in a.c.-operated moving-coil

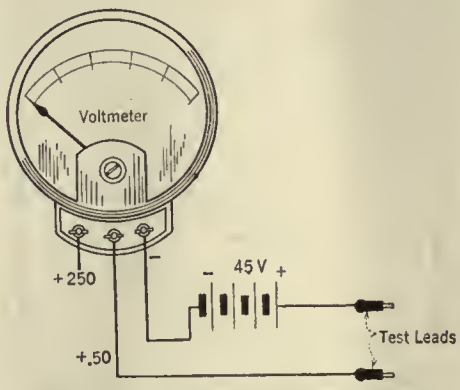


Fig. 3—A high-resistance voltmeter and battery provide an efficient circuit tester

speakers is due to the fact that the rectifiers employed do not supply pure d.c., but a pulsating direct current. Placing a condenser across the field cuts out much of the ripple and the field is therefore supplied with current more nearly pure d.c.—*Editor.*]

Items of Interest

MANY servicemen are called upon to remedy interference due to oil burners, mechanical refrigerators, leaky power lines, door bells or the neighbor's pet dog. We have answered many requests from men in the field as to what printed matter is available on the solution of interference problems. These are the references:

"Suppressing Radio Interference," by A. T. Lawton Radio Broadcast, September, November, 1927; January and March, 1928. 35 cents each. Circuits and methods for solving every kind of interference problem. Order copies from subscription department, Doubleday Doran & Co., Inc., Garden City, New York.

Radio Interference Problems, a bulletin. National Electric Light Ass'n., 420 Lexington avenue, New York City, 60 cents each.

Radio Interference, Casey. Distributed by Radio Manufacturers Ass'n, 32 West Randolph Street, Chicago, Price 25 cents.

The information from each of these sources does not differ greatly. In our opinion, the Radio Broadcast articles by Lawton are the most complete, with the National Electric Light Association pamphlet a close second. The RMA pamphlet is also good.

¶ The bound volume of Radio Broadcast's Laboratory Data Sheets contains a great deal of useful information for radio servicemen. Many have written us ordering extra copies for use in the field, and, even though the book has been on sale for little more than a month, thousands of orders have been filled from servicemen. If your newsdealer does not have the *Sheets* orders can be sent directly to the Circulation Department, Doubleday Doran & Co., Inc., Garden City. Price, one dollar.

¶ In a recent article in this magazine by B. B. Alcorn, the use of test prods was discussed. While made-up prods can be had, Mr. Alcorn advises that those he used were made in his shop. He bought fibre tubing with an inside diameter about the size of the average pin jack. The Weston Electric Instrument Company, Newark, N. J., supply with some of their meters a long-pointed prong. Extra prongs can be had from Weston. These were slipped inside the tubing and flexible leads soldered to the far end. And so you have perfectly satisfactory prods which are really invaluable for service work in the field or on the shop bench.

¶ The Tobe Deutschmann Company, Canton, Massachusetts, have been supplying for some time devices for interference reduction and elimination. Mr. Deutschmann writes that in addition to the apparatus they have for sale, the engineering department of the company is glad to lend its aid in helping to solve immediate interference problems which present themselves. Inquiries should be sent direct to Mr. Deutschmann at Canton.

Tobe Deutschmann now make the following devices for interference work: radio interference filter No. 1 (large capacity condensers connecting across the supply line), filterette No. 22 (metal box containing fuses, condensers, etc.,), filterette No. 31 (for sign flashers).

¶ A dealer in Manhattan, Kansas, the Kolster Radio Company informs us, got good radio reception where it seemed almost impossible in a downtown building. A motion-picture theatre wanted to receive a particular broadcast and reproduce it in the auditorium through Kolster moving-coil reproducers. A special telephone line was secured, connecting the theatre and the home of G. W. Livingston, the local Kolster representative. A Kolster K-20 set was installed and its output transmitted over the telephone line to the theatre where the reproducers were connected. This bit of initiative brought credit to the dealer, the set, the theatre, and unquestionably made some set sales.

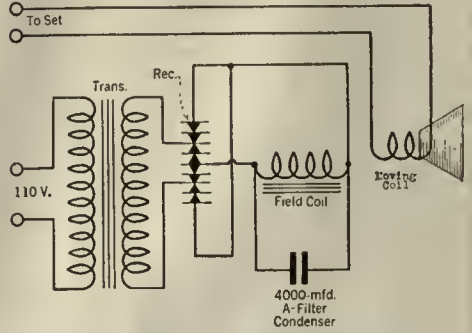


Fig. 4—Hum in a.c.-operated dynamic loud speakers may be reduced by use of a 4000-mfd "A" condenser.

Interesting Design Data on

AN ECONOMICAL BATTERY-OPERATED SET

By HOWARD E. RHODES
Technical Editor

AN INEXPENSIVE receiver with a plate-current consumption low enough to permit economical operation from dry-cell batteries should appeal to those living in districts so remote from power lines that light-socket-operated receivers cannot be used. Those who would like to build this type of receiver also require that it provide good quality, sensitive, and selective enough for ordinary reception, and that it cost not more than about $40, exclusive of tubes, batteries and loud speaker.

Such a set has been built up in RADIO BROADCAST'S Laboratory and is illustrated and described in this article. The feature, which more than anything else contributes to the low current consumption of the receiver, is the resistance-coupled audio amplifier, since the plate current drawn by the high-mu tubes is not more than about 0.2 milliamperes per tube. The power tube is a 112A and the r.f. amplifier and detector tubes are 201A's. The plate-current consumption of the entire receiver is 10 milliamperes, and with this load the three heavy-duty B batteries required for the operation of the set should have a life of about 500 hours, the equivalent to about a year's operation if the set is used a couple of hours each day. The total drain of 10 milliamperes required for the operation of the set is divided between the various tubes as indicated below.

TUBE	PLATE CURRENT
201A r.f. amplifier	2.0 mA.
201A detector	0.5 mA.
240 first a.f. amplifier	0.2 mA.
240 second a.f. amplifier	0.2 mA.
112A power tube	7.0 mA.
Total.....	9.9 mA.

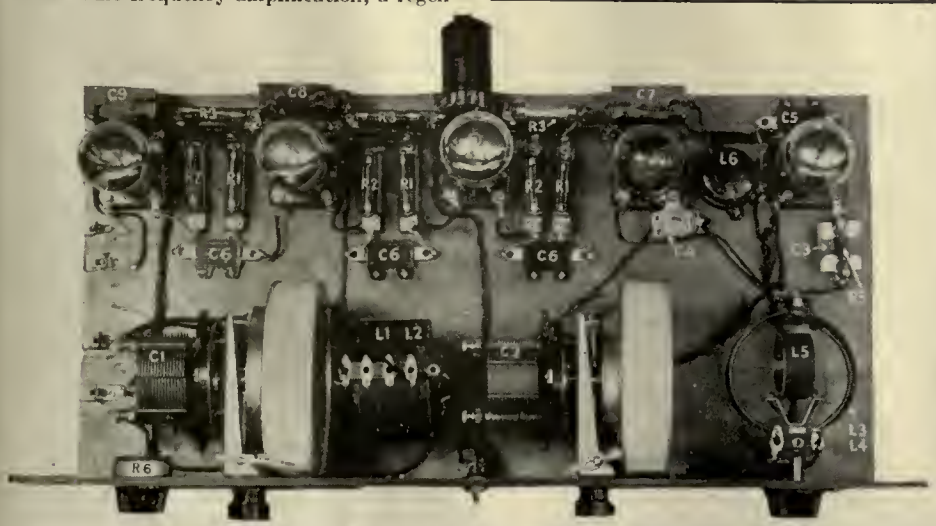
The circuit diagram of the receiver is given in Fig. 1. The set consists of a stage of tuned radio-frequency amplification, a regenerative detector, and a three-stage resistance-coupled amplifier. The two tuning condensers are C_1 and C_2, and C_4 is the neutralizing condenser. Regeneration is controlled by the tickler coil, L_6. Coil specifications, which will enable those who so desire to build their own coils, are given in Fig. 2.



View of receiver installed in an attractive walnut cabinet

This receiver, which has more to recommend it than neat appearance, should interest those who are unable to use the power lines as a source of A and B potential. The A potential must be supplied from a storage battery, and with this design it is really economical to operate this outfit from B batteries. The total current consumption is not more than 10 mA. With average use this means that a set of B batteries should last about a year, The cost of the essential parts does not exceed $40 which should make this set even more interesting!

—THE EDITOR.



Top view shows arrangement of parts on baseboard

The circuit of the resistance-coupled amplifier is perhaps somewhat unusual. Such amplifiers frequently have a tendency to "motorboat" and to prevent this filter circuits have been placed in the plate circuits of the detector tube and the first- and second-audio tubes of this receiver. In the detector plate circuit the filter consists of C_7 and R_3, in the first audio-amplifier circuit the filter is C_8 and R_3, and in the second amplifier circuit, C_9 and R_3 comprise the filter. In these filter systems, the condensers C_7, C_8, and C_9 provide low-impedance paths directly from the plate circuits to the filaments, so that all the currents flow through these condensers, rather than through the resistors R_3 and into the B batteries where they might cause common coupling which would result in oscillations or "motorboating." These filter systems will prove especially advantageous when the B batteries become old and their resistance increases as this tends ordinarily to produce "motorboating." In the Laboratory it was found possible to place a resistor of 1000 ohms in series with the negative B lead before the amplifier began to "motorboat." This value of resistance would correspond to a resistance of about 333 ohms per battery and when the resistance reaches this value the batteries have long since passed the end of their useful life.

The plate resistors, R_1, used in the amplifier each have a value of 250,000 ohms and the grid resistors, R_2, all have a value of 2 megohms. The coupling condensers, C_6, have a value of 0.005 mfd. These values of resistance and capacity yield a satisfactory frequency response. However, those who feel that the decrease in response at 60 cycles is too great may improve the response at this frequency by using larger coupling condensers.

When a detector is followed by a resistance-coupled amplifier it is quite important that

none of the r.f. currents in the plate circuit of the detector tube are permitted to pass into the audio amplifier. For this reason there is included in the plate circuit of the detector the r.f. choke coil, L_6, and the small 0.0002-mfd. by-pass condenser, C_5. These two units comprise a filter system which causes the r.f. currents to pass directly back to the filament of the detector tube but which does not prevent any of the audio-frequency currents from passing into the audio amplifier.

The receiver contains two tuned circuits, L_2C_1 and L_4C_2. Were it not for the fact that regeneration was incorporated in the detector these two tuned circuits would not give sufficient selectivity. By means of the regeneration control, however, it is possible, when necessary, to bring up the selectivity to a point where satisfactory discrimination between different stations is obtained readily. The various taps are placed on the antenna coil, L_1, so that when the set is first placed in operation reception may be checked with the antenna connected to the different taps and the lead can be soldered finally to that tap giving the most satisfactory combination of sensitivity and selectivity. The volume control consists of a variable resistor, R_6, connected in the filament circuit of the r.f. tube.

Output Arrangement

THIS receiver has been operated in the Laboratory with a 112A-type output tube feeding into a good moving-coil loud speaker. and excellent quality was obtained at moderate volume. If more volume is desired a 171A-type tube may be used with 135 volts on the plate and a 27-volt C bias. Under these conditions the latter tube will deliver about 330 milliwatts of undistorted power as compared with about 120 milliwatts which is obtained from a 112A tube with 135 volts on the plate and a C bias of minus 9 volts. The only disadvantage of using a 171A-type tube rather than a 112A is the increased plate current drain which will raise the total load on the B batteries from 10 mA. with a 112A-type tube to 19 mA. with a 171A-type tube. With the latter tube the batteries will, therefore, have a life of about 250 hours. We feel that in most cases the 112A-type tube will prove satisfactory although, if sufficient volume is to be supplied for dancing, for example, then it will probably be necessary to make use of a 171A-type tube.

In operating this set in the Laboratory it was interesting to note how clearly defined is the overloading point of the resistance-coupled amplifier. When using transformer-coupled amplifiers a certain small amount of overloading may exist on peaks without experiencing serious distortion, but with a resistance-coupled amplifier even slight overloading tends to make the tubes block so that reception is practically ruined. All this simply means that in operating the set the volume control must be kept at a point low enough to prevent overloading. Incidentally, the plate and grid voltages supplied to the first- and second-audio tubes are such that these tubes will not overload if called upon to supply a peak potential of about 50 volts to the grid of the power tube. It follows, therefore, that the amplifier has more capacity than necessary to supply either a 112A- or a 171A-type tube, since the latter tube (with a C bias of 27 volts) doesn't require a peak potential of more than 27 volts on its grid.

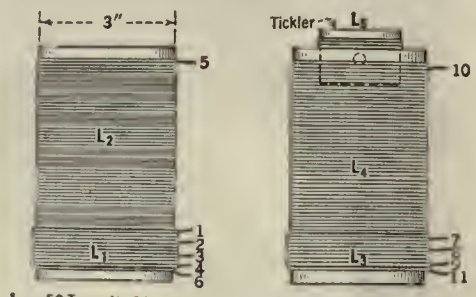


Fig. 2—Coil Specifications for battery set

The model of this receiver which was constructed is illustrated in the various pictures. The baseboard is 10 inches deep and 20 inches long and the panel is 7 inches high and 21 inches long so the set will fit in any of the standard cabinets which are generally 21 inches long and about 12 inches deep. The various parts which make up the set are lettered on the circuit diagram, Fig. 1, to correspond with the lettering in the pictures and in the list of parts. With these data it will not be difficult to locate the various units on the baseboard and to lay out the panel. The drilling templates supplied with the Remler drum dials are used in locating the various holes on the panel. The volume-control rheostat, R_5, the on-and-off switch, and the regeneration control may be placed as indicated in the pictures. In starting the construction of the receiver, the coils and condensers should be placed on the baseboard first, their corresponding position relative to the panel determined, and the latter drilled as indicated above. The various sockets, resistor mounts, and condensers are then mounted on the baseboard. The cable connector is located along the rear edge of the baseboard.

The tuning of this receiver should not be difficult. To tune-in a station regeneration should be increased until the detector circuit oscillates, the carrier wave should be tuned-in by locating a heterodyne squeal, and then the first condenser may be tuned to resonance. Maximum selectivity will be obtained when considerable regeneration is used in the detector circuit; therefore, in those locations where great selectivity is required it is advisable to operate the set with some regeneration, reducing the volume if necessary by means of the volume control.

Parts Required

THE parts used in the model illustrated in this article are named below. Other parts electrically equivalent may, of course, be substituted if desired. The complete list follows:

C_1, C_2 Two Remler condensers, 0.0005-mfd.;
C_3 One Polymet grid condenser, 0.00015-mfd;.
C_4 One Hammarlund neutralizing condenser;
C_5 One Frost fixed condenser, 0.0002-mfd.;
C_6 Three Frost fixed condensers, 0.005-mfd.;
C_7, C_8, C_9 Three Polymet by-pass condensers, 1-mfd.;
L_1, L_2 One Hammarlund antenna coil.;
L_3, L_4, L_5 One Hammarlund coil, type TCT-23;
L_6 One Hammarlund r.f. choke, type R.F.C. 250;
R_1 Three Daven Glastors, 0.25-megohm;
R_2 Three Daven Glastors, 2-megohm;
R_3 Three Daven Glastors, 0.1-megohm;
R_4 One Frost fixed resistance, 0.8-ohm;
R_5 One Daven Glastor, 2-megohm;
R_6 One Yaxley filament rheostat, 15-ohm;
S One Frost Filament switch;
Five Frost sockets;
One Frost cable, type 780;
One Frost cable connector, type 781;
One coil Frost hook-up wire;
One Micarta panel, 7 x 21-inch;
One Baseboard, 10 x 20-inch;
Two Remler drum dials, type 40;
Four Fahnestock clips.

The total cost of the parts listed above is not more than $40.00.

The following accessories are required:

Two 201A-type tubes;
Two 240-type tubes;
One 112A-type tube;
Three Eveready heavy-duty B batteries;
Two Eveready C batteries, 4½-volt;
One Storage battery, 6-volt;
One Loud speaker.

The set described in the preceding paragraphs was constructed as a result of requests from many readers for data on a receiver that might be operated economically from B batteries. Those who desire such a receiver but who, perhaps, do not want to go to the trouble of constructing one will be interested in the Eveready receiver. This set contains six tubes, is single controlled, and uses 240-type high-mu tubes throughout, except in the power stage where a 112A- or a 171A-type tube is recommended. This Eveready receiver contains three stages of r.f. amplification, each stage of which is neutralized and shielded. The detector is followed by a resistance-coupled amplifier. The set lists at $85, without tubes or batteries.

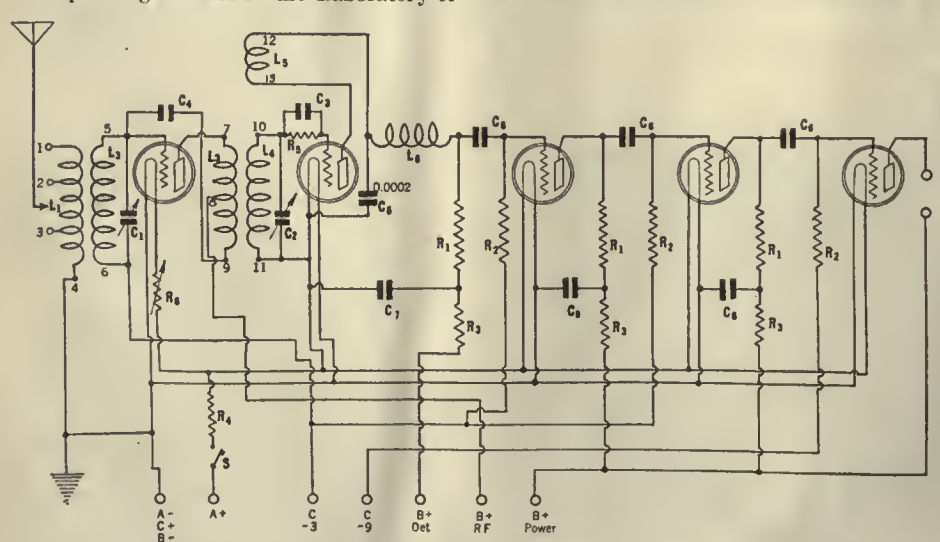


Fig 1—Complete schematic diagram of the low current consuming receiver developed in the Laboratory

VOLUME CONTROL SYSTEMS

THE modern radio receiver has three controls on the panel—the tuning dial, the on-and-off switch, and the volume control. The electrical position of the first two controls is fixed—the on-and-off switch always is connected in the power circuit and the tuning dial always controls to the tuning condensers. The volume control, however, may be located at many different points in the circuit.

From the standpoint of volume control a radio receiver might be divided into two main sections. In one section we place all the apparatus between the antenna and the input to the detector and the other section includes the circuits from the output of the detector to the loud speaker. Let us consider first the former section and determine at what points a volume control might be located.

The First Section

THE first section mentioned above, consisting of that apparatus between the antenna and the input to the detector, is actually the r.f. amplifier and so discussion now centers around where the volume control might be located in such an amplifier. In Fig. 1 we show seven diagrams of different parts of an r.f. amplifier system and each drawing indicates a different location for the volume control. Diagram A shows the volume-control resistor connected between antenna and ground. Sketch B shows the volume control connected across the primary of one of the r.f. transformers, in C the volume control is connected in series with the ground lead, and in D it is across the secondary of an r.f. transformer. In E the volume control is across the secondary of the r.f. transformer feeding the detector tube, and in F the volume control is a rheostat in the filament circuit. Diagram G shows a variable resistor, R, in series with the plate circuit of an r.f. tube and this provides another method of controlling volume. The characteristics of these various arrangements are briefly given below.

Arrangement A: This control is used in many receivers and is considered quite satisfactory. Its one disadvantage is that when the control is adjusted to a point where its resistance is quite small (to obtain a low output from the loud speaker) the shunting effect of this resistor may lower the selectivity of the first r.f. transformer. Since, however, the volume is cut down when listening to powerful local stations, selectivity is not especially important and this is not a serious drawback. This volume control arrangement may be considered satisfactory.

Arrangement B: This arrangement is practically the same as A except that the resistor is connected across the primary of one of the interstage r.f. transformers. This control may also be considered satisfactory.

Arrangement C: With the volume-control resistor connected in series with the antenna-ground circuit, as in this arrangement, minimum volume is obtained when the volume control has a maximum value of resistance. This control will not tend to decrease the selectivity, but in many cases it has the disadvantage of making it impossible to bring the volume to absolute zero.

Arrangement D: Connecting a resistor across the secondary of a tuned circuit is essentially similar to connecting a smaller low-value resistor across the primary, as was done in arrangement A, and both controls have essentially the same characteristics.

Arrangement E: The input circuit to a leak-condenser-type detector tube is generally of much lower resistance than that of a tube used as an r.f. amplifier; for this reason the selectivity of the tuned detector grid circuit is lower than the r.f. stages. Therefore, a volume control may be connected across this tuned circuit without materially impairing the selectivity of the receiver.

Arrangement F: A rheostat in the filament circuits of the r.f. tubes has long been a standard type of volume control in battery-operated sets. However, it cannot be used with a.c. receivers, since it is not practical to control the volume by varying the filament currents of a.c. tubes. With the 226-type tubes varying the filament current would tend to increase the hum and in the case of the 227-type tube the electron emission from the cathode does not follow instantaneously the variations in current through the heater.

Arrangement G: This type of volume control, consisting of a resistor in series with the B supply to the r.f. tubes, has been used very satisfactorily in battery-operated sets but cannot be considered a good control for receivers operated from a B-power unit. As the resistance is increased to reduce the volume the current drain of the r.f. tubes also decreases and, as a result, the voltage on the other tubes in the receiver is increased.

In summary we would classify arrangements A, B, D, and E as satisfactory volume controls for any receiver, arrangements A and E being, in general, preferable. F is a satisfactory control for a battery-operated set. C and G are unsatisfactory.

Table I

Arrangement	Resistance Required	Manufacturers
A	5000 ohms	Carter type TP-5M, Frost type 1897
B	10,000 ohms	Carter type TP-10M, Frost type 1898
D	100,000 ohms	Bradleyohm type E, Carter type 11, Centralab type 100M, Frost type 1891, Clarostat Universal type, Electrad Tonatrol
E	100,000 ohms	Bradleyohm type E, Carter type 11, Centralab type 100M, Frost type 1891, Clarostat Universal type, Electrad Tonatrol
F	15 ohms	Carter type IR-15, Frost type 1815, Yaxley type 515, Clarostat Universal type, Electrad Tonatrol

The Second Section

VOLUME controls in any part of the circuit following the detector are generally unsatisfactory, for they do not prevent overloading of the detector tube when receiving strong local signals and detector overloading can produce serious distortion. A safe rule is always to locate the volume control at some point in the r.f. amplifier.

In Table 1 we have listed resistors made by various manufacturers which can be used satisfactorily as volume controls.

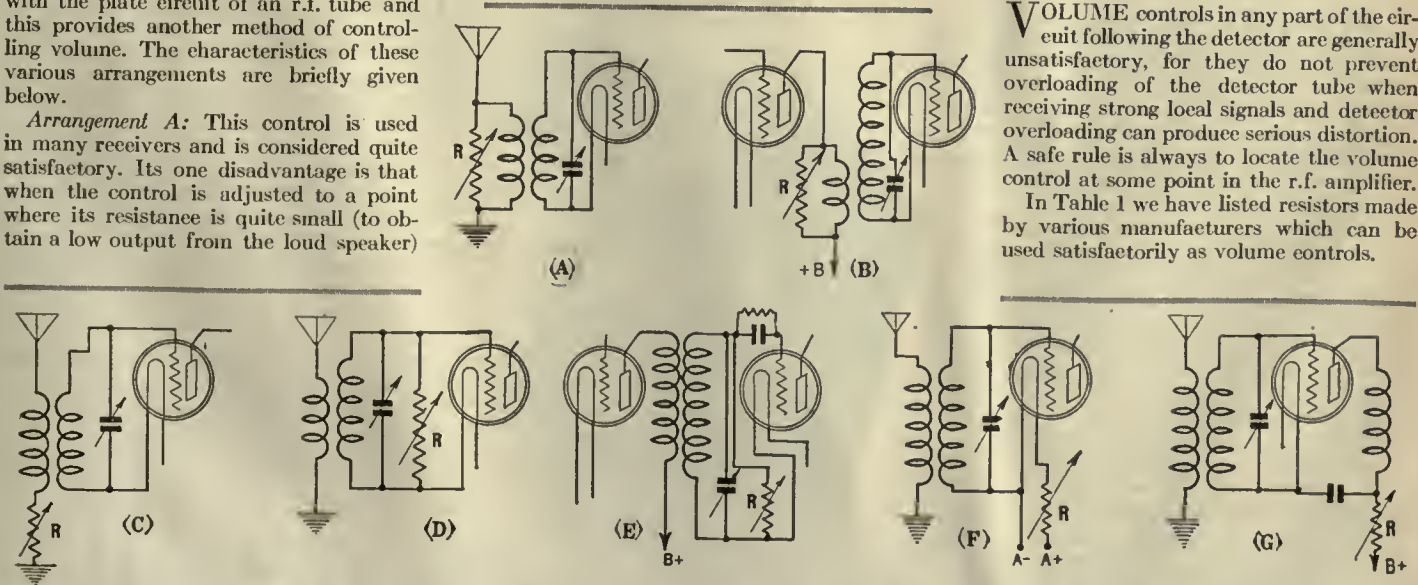


Fig. 1.—The volume of a radio receiver may be controlled in many different ways. The above diagrams illustrate seven different systems which are used frequently

our readers suggest . .

This department of RADIO BROADCAST *is utilized each month for the presentation of miscellaneous short radio articles which are received from readers. These abbreviated manuscripts describe "kinks," radio short cuts, and economies that the experimenter runs across from time to time and that can be made clear in a concise exposition. Although some of these notes have been submitted by engineers and professional writers, the editors particularly solicit contributions from the average reader. All material accepted, including photographs, will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas*

—THE EDITOR.

Uses for Damaged Meters

THE writer recently had on hand two Weston model 425 thermo-ammeters, reading up to 1.5 amperes, that had been used as antenna ammeters. Accidental overloads destroyed the thermo-junction but left the galvanometer movements undamaged. Test showed that the movement gave a full-scale deflection with a current of about 2 milliamps. The meters were accordingly taken apart, the thermo-junctions discarded, and the leads from the moving coils attached to the external connecting posts of the meters. One of the meters was then employed as the grid-current meter in the modulated oscillator described in June, 1924, RADIO BROADCAST, a nichrome shunt of about ten ohms being connected across the meter to provide a little damping. Otherwise the meter would be working practically on open circuit, and the needle would oscillate freely owing to the absence of electromagnetic damping, making the observation of readings difficult.

The remaining meter was used as resonance indicator in an absorption wavemeter for transmitting work, the circuit of which is shown in Fig. 2. A "low-loss" coil and condenser form the tuned circuit. The meter in series with a carborundum crystal, is tapped across about one-eighth of the coil. Carborundum is used for two important reasons: it is robust, holding its adjustment indefinitely, and not being liable to burn out on accidental overload; and it usually has a high resistance of the order of thousands of ohms, so that it does not unduly damp the tuned circuit, which would make the point of maximum response very broad and indefinite. For the same reason, the crystal and meter are shunted across only a small portion of the tuned circuit, and in practice the instrument tunes so sharply, especially on the shorter waves, as to make a slow-motion control necessary for comfortable working. It is quite sensitive, giving a good deflection at 80 meters when excited by the modulated oscillator at a distance of a foot. A shunt of ten ohms or so, wound on a match-stick with fine nichrome wire, is needed to steady up the needle, the best value for which should be found experimentally.

A picture of the instrument is shown in Fig. 1. The writer used a crystal of carborundum set in solder in a cup, with a steel phonograph needle attached to a stiff spring as the "cat-whisker" (use plenty of pressure), but no doubt the commercial carborundum detector cartridge would be quite satisfactory. The connections to the meter may have to be reversed to get the polarity right. No attempt was made to calibrate this instrument in wavelengths, in view of the possibility of a fresh point in the crystal being needed occasionally which might affect the calibration. The point of maximum response to the transmitter is found, and the actual wavelength is then obtained by removing the instrument without disturbing its setting, and coupling it to a modulated oscillator, which has been carefully calibrated, and is kept as a standard wavemeter.

F. G. CANNINE, Melbourne, Australia.

High-Frequency Tuning

I HAVE read in RADIO BROADCAST numerous excellent articles on short-wave reception and transmission. In most receivers the tuning condensers specified are usually of 0.00014 mfd. capacity, or thereabouts. For easy tuning, especially on the very short wavelengths, a small capacity condenser is to be preferred. In my receiver I use a 50-mmfd. General Radio midget condenser cut down to 4 plates (about 12 mmfd.), and I find this sufficient for all bands from 18 meters up to above 85. A hair-splitting vernier isn't necessary, and with an ordinary 4–1 vernier the tuning is not in the least critical.

HARRY F. WASHBURN, Jr., New York City.

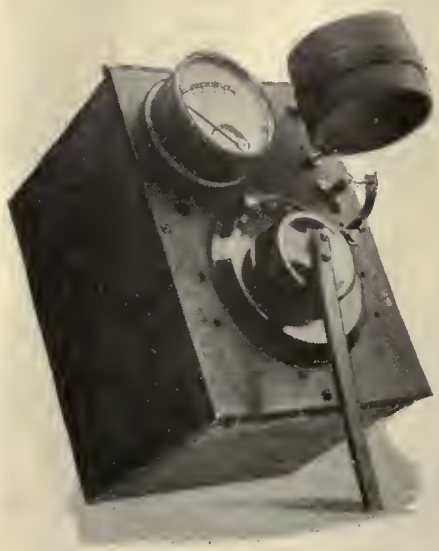


Fig. 1—External view of home-made wavemeter. The resonance indicator is a d.c. milliammeter.

A Handy Connector

OFTEN the experimenter finds it desirable to connect several pairs of headphones in series, or to make other temporary connections. It usually takes considerable time to connect the phone tips, and I have hit upon a plan which greatly simplifies the process.

I carefully removed the clips from several discarded B batteries and placed them in my tool box. Whenever it is necessary to connect two phone cords or wires all that is necessary to make a tight connection is to insert the tips into the clip from opposite sides, and the connection is tight until you are ready to release it.

IRMEL N. BROWN, McAfee, Ky.

Increasing Charging Rates

A TUNGAR or Rectigon two-ampere charger can be made to charge up to three amperes simply by removing the outer cover or shield. This metal shield around the transformer absorbs considerable energy, particularly the old-type cast-iron cover on the Rectigon.

To give the battery a quicker charge, simply remove the cover.

R. B. BARROWS, Portland, Me.

STAFF COMMENT

The same applies to six-ampere chargers. The charging rate may be still further increased (apparently without damage to the tube) by remounting the elements of the charger on a wooden base. This will also eliminate most of the noise associated with many commercial types of tube rectifiers.

Home Broadcasting

HERE is a surprisingly simple and inexpensive way of converting your present radio set into a speech amplifier or public-address system. Such an outfit is not only amusing for use in the home but has many valuable applications for special events, large gatherings, etc.

A single open-circuit jack is wired across the grid and negative filament terminals of the detector tube socket, into which the leads from the microphone transformer are plugged. In this way the detector tube functions as the additional stage of audio-frequency amplification desirable for best results with a microphone.

The microphone in this case is a standard telephone transmitter and the transformer is a Jefferson No. 1603 bellringing transformer. The 110-volt primary leads from the transformer are connected to a regulation loud-speaker plug and inserted into the jack connected to the grid circuit of the detector tubes. The telephone transmitter, with 3 standard dry-cell batteries in series, is connected across the two outside binding posts on the transformer (the terminals of the 18-volt secondary winding).

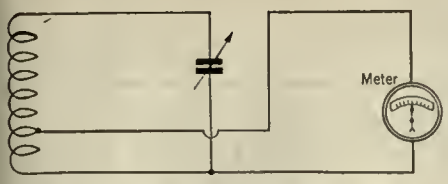


Fig. 2—Circuit diagram of absorption wavemeter

This arrangement will be found to have excellent voice-frequency characteristics and the output will be very lifelike and natural, depending of course upon the quality of your audio amplifier. As the microphone is very sensitive it must be placed some distance from the loud speaker, preferably in another room if used indoors, to prevent mechanical feedback and squealing. A volume control in the audio amplifier will be found helpful in controlling the output as well as any tendency to squeal due to proximity of microphone and loud speaker.

T. F. McDonough, Los Angeles, Cal.

STAFF COMMENT

Mr. McDonough is perhaps a little tolerant of the quality in the arrangement he describes—which by the way, works nicely. However, the standard telephone microphone, aside from being the property of the Bell Telephone Company, is hardly partial to the frequency requirements of good loud-speaker speech reproduction. Much better quality will be secured by plugging the winding of a horn-type loud speaker into the jack provided in the detector circuit—without a transformer of any kind. The loud speaker is used as the microphone. You may speak into the horn, or the horn can be removed and a small mouthpiece substituted. No batteries are used. The loud-speaker unit functions as a magnetic microphone, and will output excellent quality.

A Simple Wire Shield

"Our Readers Suggest—" for last November contains a contribution on reducing hum in a.c. sets by running the a.c. leads in grounded BX cable. Another and perhaps easier way of securing the same results, is to wrap the leads in "talking tape," and grounding as usual.

"Talking tape" is the familiar indoor antenna tape.

H. Cranston Jones, Brooklyn, N. Y.

A Simple Lightning Arrester

AN EFFICIENT lightning arrester may be made from old phonograph needles. Obtain a small piece of bakelite and mount on it two strips of brass copper or other metal. The strips may be held in place by two terminals, as shown in Fig. 3. The phonograph needles are soldered on to each strip, towards each other, with a gap of $\frac{1}{20}$" between them. The leads from the antenna and the ground are connected to the terminals on the strip. A heavy discharge of lightning will jump the gap and will not injure the receiver.

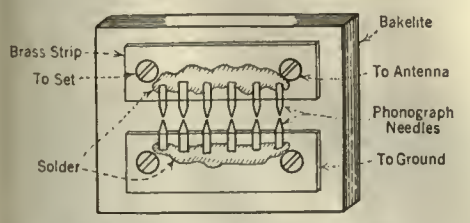


Fig. 3—Old phonograph needles may be used in the construction of a practicable lightning arrester.

Edward Piranian, Philadelphia, Pa.

An Emergency Output Circuit

A SIMPLE emergency repair of a set in which the primary of the output transformer had burned out was accomplished as illustrated in Fig. 4. The secondary of the transformer was connected as a choke coil and the loud speaker fed through a 2-mfd. condenser. The primary was left unconnected.

Break connections at points marked "X" and make the new connections indicated by dotted lines.

As the repair was an emergency one, and some doubt was felt about the particular condenser at hand standing up under the voltage applied to the last audio tube, the return from the loud speaker was connected to the B-plus side of the choke, so that the B supply would not be short-circuited if the condenser did blow.

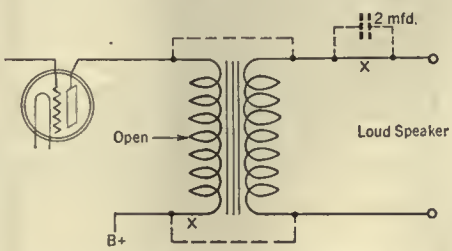


Fig. 4—Diagram shows method of using burnt-out transformer as an output choke.

If a condenser of proper voltage rating is used, the return may be connected to the negative filament or to the center-tap connection of the filament transformer secondary if the tube is lighted from a.c.

John O'Donnell, The Bronx, N. Y. C.

STAFF COMMENT

This department receives more suggestions on output arrangements than on any other phase of receiving technique. The editor considers that this is indicative of unusual interest in the subject, and so will continue to publish the majority of such contributions, even with the possibility of an occasional duplication.

High-Resistance Voltmeter

THE high-resistance voltmeter is second only to output devices in contributions to this department. The following suggestion is submitted by D. J. Valentine, of Bangor, Me.

The average radio fan or set-builder seldom can afford the price of a high-resistance voltmeter, although there are many occasions where the use of such an instrument is practically a necessity. For best results the B voltage applied to the plate circuits from a power-supply system should be adjusted carefully with a high-resistance meter, instead of by guess work, as the average fan must do. The voltmeter described below was made by the writer at a cost of less than $10.00, and it has a resistance of 1000 ohms per volt, which means that only 1 mA. is drawn for full-scale deflection. The parts were mounted on a small piece of rubber panel, with the necessary binding posts, and the whole enclosed in a cigar box which was covered with artificial leather.

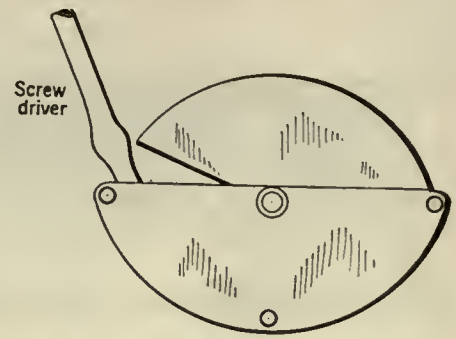


Fig. 5—Bending the plates at the right-hand side of the condenser affects tuning on both long and short waves, while bending them at the left-hand side will affect only the long waves.

The meter is a milliameter with a range of 0-1 milliampere and the resistors are Daven "Davohms" of 200,000 and 500,000 ohms. The resistors are guaranteed accurate within plus or minus 1 per cent. By throwing the single-pole, double-throw switch (such as a Yaxley Antenna Switch No. 11), either the 200,000-ohm unit or both units are thrown in series with the meter (Fig. 6), and the range becomes 0–200 or 0–700 volts accordingly. Of course, other values of resistances may be used, and the range of the instrument extended to 1000 volts or more. The accuracy depends on the accuracy of the meter and of the resistors. If desired it may be calibrated with a standard although the one built by the writer proved to give sufficiently true readings for all ordinary uses.

STAFF COMMENT

The voltage will always equal the reading on the meter divided by 1000 times the resistance in series with it.

Balancing Gang Condensers

THERE are many instances, particularly in factory receiver construction, where trimmers are not provided to compensate tuning discrepancies in tandem-tuned circuits. The proper adjustment of such circuits may be effected by inserting a screw driver between the plates, close to where they are attached to the frame, and prying one stator plate nearer to an adjacent rotor, thus raising the capacity of the section without materially altering the tuning characteristic (an advantage over the trimmer system). It is also possible, by means of this method, to compensate tuning on the long wavelengths without affecting tuning on the short wavelengths, as suggested in the drawing of Fig. 5.

A. T. Lequear, Erie, Pa.

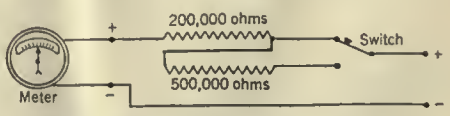


Fig. 6—Circuit of home-made high-resistance voltmeter.

A SHORT-WAVE SUPER-HETERODYNE

By ROBERT S. KRUSE

IT WILL be rcealled that Armstrong's form of double-deteetion receivcr was devised to meet an emergency. The French army owned a large number of long-wave amplifiers but desired short-wave amplification. Depending on the gullibility of the amplifiers, Armstrong devised a converter which would conneet in the antenna circuit, hastily turning short-wave signals into long-wave signals and passing them on to the amplifier. The amplifier trustingly accepted them as genuine long-wavc signals and amplified them into something of presumable military value. In the enthusiasm of the moment, one assumes, there was invented the name "super-hcterodyne" which has itself been amplified into something of unmistakable commercial valuc.

This bit of radio history naturally brings double-detection to mind whenever one has a short-wave amplification problem on hand. In the broadeast band the problem no longer exists, other means of scemingly equal merit being universally known and somewhat less universally available. In the region below 150 meters, and in fact to some degree between 150 and 200 meters, the problem of satisfactory amplification is still present and one is somewhat amazed that the double-detection receiver does not have a larger foothold.

The situation is probably historical. Until very recently the sub-200 meter region was almost wholly telegraphic; even the radiophone experimenters used the key to supplement their microphones. The commercial men who worked in the region were all message handlers. Naturally, therefore, the receivers were suited to telegraphie reception and for that purpose the double-detection prineiple has no alarming advantage between 25 and 200 meters; one can do nearly as well with a simple oscillating deteetor and audio amplifier.

As soon as telephony and television invaded the shorter waves the story beeame different. The *oscillating* detector became merely *regenerative* and in that act lost most of its sensitivity and all of its selectivity. The result is a receiver as primitive in principle (though not in circuit) as the infamous "single eircuit" of a few years ago.

Given a short-wave receiver of the conventional regenerative detector type, how can it be improved? Mr. Kruse turns it into a double-detection receiver, which is the "high hat" way of saying super-heterodyne. He adds a frequency changer, and an amplifier working at the frequency to which the desired signal is changed. This amplifier may be specially built or it may be one's broadcast frequency receiver used as an amplifier, second detector, and audio amplifier. Mr. Kruse has another article on this double-detection business in the office, and it will appear in a forthcoming issue of RADIO BROADCAST.

—THE EDITOR.

One may turn to tuned r.f. stages, using the 222-type tube, but for several reasons this is not as simple as tuned r.f. in the 200-550 meter region. The best of these reasons is that one is trying to cover the huge territory between 14 and 200 meters and this is equivalent to 20,000 kilocycles! It is a troublesome task to cause a set of plug-in coils with gang tuning to "run together" with the cramped scales that result. One must either drop down to a single r.f. stage and two controls or else convert the signals to some more normal wavelength where they will be more amenable to amplification. The second scheme makes necessary the use of a double-detection system.

In this article the writer describes a double-detection (super-heterodyne) receiver. It is made by adding a beating oscillator to an already existant short-wave receiver. The beat frequencies from this oscillator and receiver are amplified at a lower frequency, detected again, and then amplified.

The Detector-audio Adapter

THE particular kit shown in the illustrations is chain-store distributed and, therefore, an excellent subject for manipulation since additional parts may be obtained easily. It happens also that the coils used are especially suited to the adaptation, although a "dodge" to make others perform similarly is also given.

Referring to Fig. 1 we have the normal diagram of the set which is, for some mysterious, reason called the "Wasp"! It employs the usual regenerative detector, VT_1, plus two stages of audio. Regeneration is controlled by means of a variable bypass condenser, C_2. The tickler, T, and primary, P, are on the same plug-in form with the tuned secondary, S.

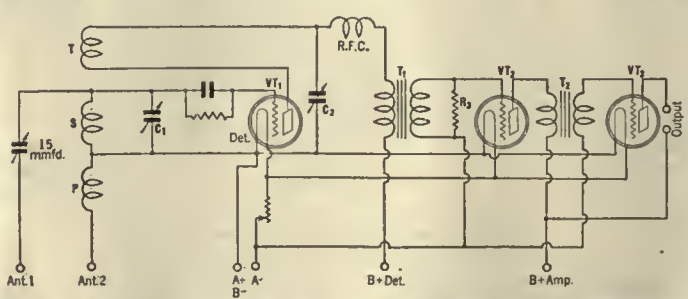


Fig. 1—The normal circuit of the "Wasp" receiver

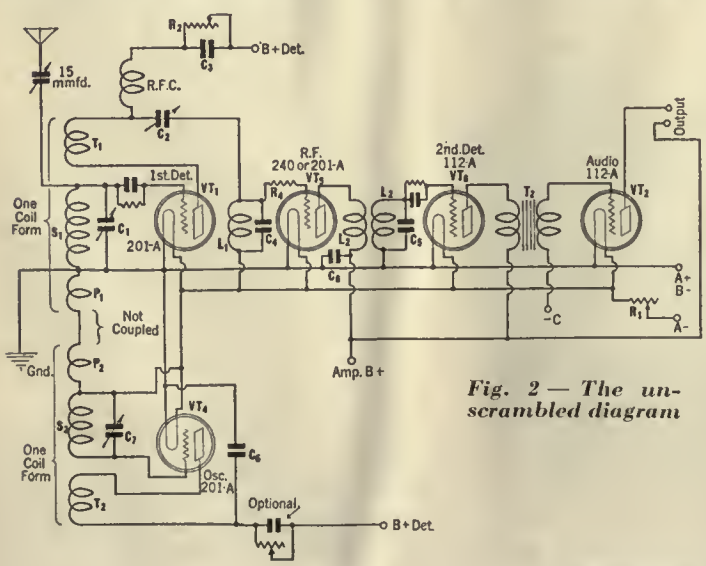


Fig. 2 — The unscrambled diagram

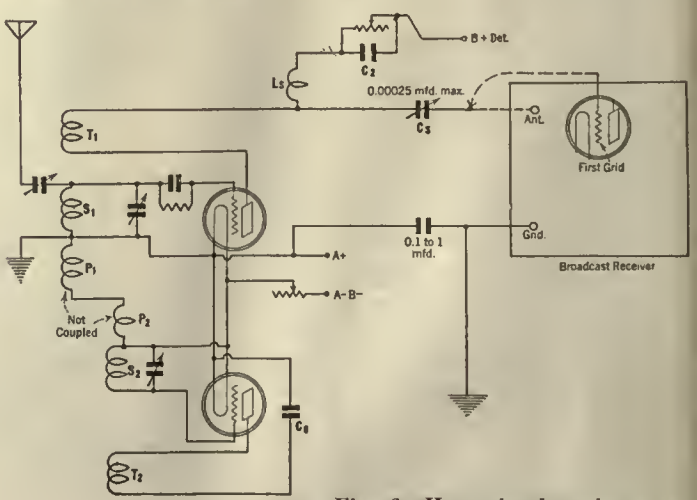
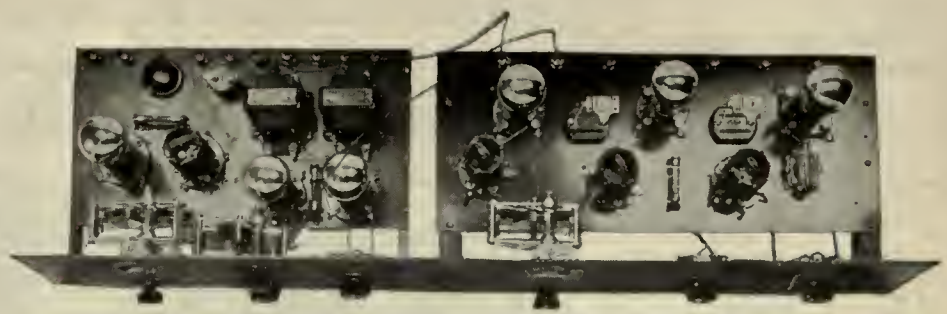


Fig. 3—How the broadcast set is connected with the detector-oscillator



Top view of "Wasp" receiver and amplifier

In Fig. 4 we have the circuit converted into a double-detection affair by the addition of an oscillator, VT_4, one stage of r.f., VT_5, and a second detector, VT_6 In the unscrambled diagram of Fig. 2 T_1, S_1, and P_1 are the coils on the plug-in form feeding the first detector. The coil P_1 was originally intended for use in the antenna circuit, as in Fig. 1, but an alternative method of antenna coupling has been provided through terminal A_1 and the 15-mmfd. condenser. This alternative method is used in the set when adapted, the coil P_1 acting as an oscillator pick-up in conjunction with the extra coil P_2 on the oscillator plug-in coil form. Such an arrangement has the advantage that as the coils are changed the pick-up coils change with them and the pick-up from the oscillator remains more uniform than is the case with a set-and-leave arrangement. This is a considerable advantage when going over so wide a range as these tuners cover. It will be seen that P_1 and P_2 in series with the filament leads form an untuned "link" transfer circuit. The rotor of the regeneration-control condenser, C_2, is disconnected from the filament and through a clipcord is run to the top of the tuned circuit L_1C_4 which feeds the r.f. tube, VT_5, (See. Fig. 4). This tube may be a 201A, 240 or 222 without causing any change in the system up to this point. The clipcord should be reasonably short and kept tolerably clear of things. Since the condenser C_2 is now a sort of coupling control between the first detector, VT_1, and the circuit L_1C_4 it cannot be used to control detector regeneration. This regeneration is too valuable to lose, and it is accordingly suggested that C_2 be set rather high and oscillation in VT_1 controlled by the addition of the 500,000-ohm Frost rheostat, R_2, with a 0.1-mfd. shunt condenser, C_3. This is not essential and one can get along very nicely without these devices by simply reducing C_2, which may in fact be a "postage-stamp" mica condenser. The first audio transformer primary has been disconnected and the wires connected together, also the first a.f. tube, VT_2, has been removed from the socket.

The oscillator is tuned by the condenser C_7, which is a duplicate of C_1. The condenser C_6 is merely a bypass and may have a capacity of 0.001 mfd. If it happens that the oscillator tends to squeal (audio-frequency blocking) it may be necessary to introduce at X a combination of rheostat and condenser like that shown at R_2 and C_3.

The description above is general rather than applying to the particular unit shown in the illustrations.

Having put the converted short-wave signal into the tuned circuit L_1C_4 we naturally would like to know something of that circuit. L_1 is a common broadcast r.f., coil shunted by a fixed condenser which tunes the circuit to a point above the broadcast band; 0.0005 mfd. is a convenient capacity obtainable in the small "postage-stamp" mica condensers. The output of the r.f. tube is fed into transformer coil L_2,L_3. The latter is another ordinary broadcast tuner coil shunted by a .0005-mfd. mica condenser. Since the condensers C_5 and C_4 will not have exactly the same capacity one of them must be shunted by a midget condenser of some sort that can be adjusted while the set is in operation. Any one of the various "screwdriver" condensers on the market will do, provided the range is adequate. It is, of course, possible to use regular tuning condensers at C_4 and C_5 or to use condensers of the mica-compression type with capacities high enough to make sure of resonance at some point. This whole thing can be done much more easily than it can be described.

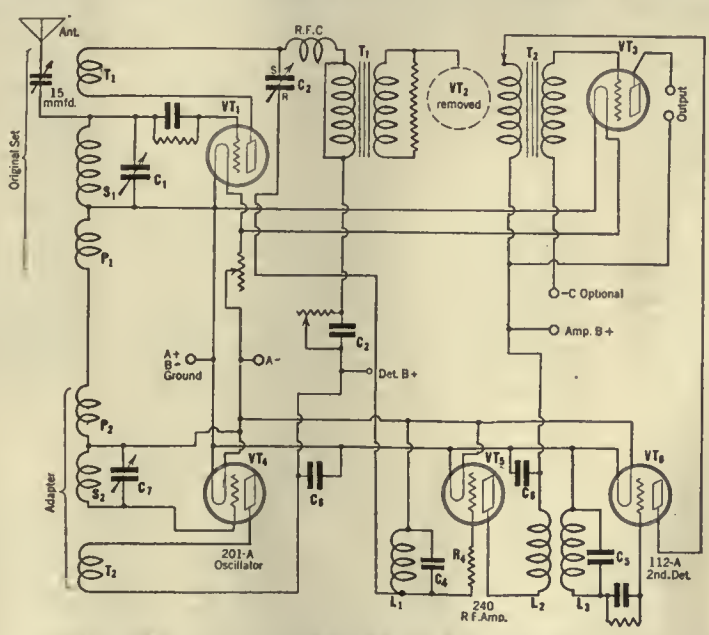


Fig. 4—Method of connecting amplifier and oscillator to receiver

The winding L_2 depends on the tube used ahead of it. If a 201A-type tube is used the usual primary found on the coil will serve. A 240-type tube will call for about double the number of turns used by the 201A, while the 222 tube should have a winding with a number of turns equal to about ½ the number of L_3. The 222-type tube will require a tube-shield and on the whole it is less painful to use the 240 or the 201A. If this tube desires to oscillate use an ordinary "grid suppressor" at R_4. Two stages may be used as they are not much more troublesome when worked in this manner. Obviously these two stages, the second detector and the audio system may all be found in the broadcast receiver with which the unit it used. Diagrams differ so greatly in these that the reader will find it safer to devise his own diagram of connection rather than to rely on Fig. 3 which may overlook some of the possible causes of trouble when used on a strange receiver. The points to remember are simply that the output of the first detector is to be applied either to the antenna post or to the grid of the tube in the first tuned circuit in the r.f. system of the receiver, at the same time making sure that the detector plate voltage does *not* get into the input to the receiver. A stopping condenser, C_5, of adjustable nature and a choke, L_5, will do the trick. The choke must, of course, be good over the broadcast range as well as the range in which the short-wave tuner is to work. The chokes furnished with short-wave tuners usually fulfil this requirement.

A list of the apparatus used by the writer in the construction of his short-wave superheterodyne receiver is given below. However, the experimenter may substitute electrically equivalent parts, if desired. The complete list follows:

One Pilot "Wasp" tuner;
Two Frost resistors, 500,000-ohm;
One tuning condenser, 140-mmfd.;
One vernier dial;
One tube socket, UY-type (for oscillator coil);
Two tube sockets UY-type (for coils L_1 and L_{2-3});
Three tube sockets, UX-type;
One extra set of Pilot "Wasp" coils (Two coils of a kind are used in the set and oscillator, respectively, while the 200-500 meter coil of each set is used for L_4 and L_{2-3}. The tickler serves as L_2);
One grid leak, 1.5-megohm;
One grid condenser, 0.00025-mfd.;
One grid suppressor, 300-ohm (R_4);
Assorted by-pass condensers, 0.001-mfd. and larger (C_6);
Combination of fixed and adjustable condensers with maximum capacity of 0.0005 mfd. in each case. In the writer's set C_4 is a Sangamo unit and C_5 is a Sangamo unit plus an XL adjustable condenser);
One panel, 7" x 10" or 7" x 14";
One baseboard;
Two brackets;
Binding posts, wire, solder, usual small hardware, etc.



Front view of "Wasp" receiver and amplifier

TROUBLE SHOOTING IN THE POWER UNIT

By B. B. ALCORN

IN THE first three installments of this series of articles discussing the problems encountered in the servicing of radio receivers, the writer devoted considerable space in describing the symptoms, methods of detection, and rectification of troubles experienced with the usual types of factory- and home-made sets, and also accessories such as tubes, batteries, cable connectors, etc. However, similar difficulties which are found in power-supply units as yet have not received their share of consideration. This month, therefore, the eccentricities of power devices are the chief subject of discussion.

In the repair of the receiving set proper, the three most frequent causes of trouble, in the order of their importance, are open circuits, short circuits, and defective parts, respectively. On the other hand, the chief cause of breakdown in power-supply circuits are short circuits, although defective parts and open circuits are also major considerations.

Concrete Examples

IN ORDER to provide concrete examples of the problems encountered in the servicing of power units, a few of the writer's most recent experiences will be recounted. The first concerns an unusual short circuit which was found in the Radiola 104 loud speaker. In the power supply of this unit the usual trouble is shorted filter condensers, and this condition is manifest by the plates of the 216B-type rectifier tubes becoming red hot, due to the heating effect of the extra current which passes as a result of the short circuit. In the case under discussion, however, the plates of the rectifier tubes did not overheat, although the power unit was inoperative. In this instance, in performing the manufacturer's continuity test, it was found that sparks could be drawn from all parts of the chassis when the power was turned on. The trouble was located finally in the secondary winding of the power transformer which had become grounded to the chassis, thus shorting the rectifier tubes out of the circuit. The only possible repair was substituting a new transformer.

Very often owners of Radiola 28 receivers and 104 loud speakers complain that one or all of the tubes of the set have burnt out. Fortunately, the serviceman usually finds that this is not true. With this combination of receiver and power unit the tubes of the set are heated with current obtained from the B-supply circuit of the power unit. Therefore, when the tubes of the set fail to light it is often indicative of the fact that the emission of one or both of the 216B-type rectifier tubes has decreased. When this trouble develops it is necessary to replace the rectifier tube or tubes in order to bring the B current back to normal.

A peculiar but not uncommon complaint was brought to our attention by the owner of a recent model Atwater Kent electric receiver. It was explained that the set functioned perfectly except for sharp snaps which were heard every once in a while and which *did not* seem to issue from the loud speaker. On his first visit the noise did not occur and the serviceman was forced to report that the set seemed to be in perfect condition. The second evening the noise was more in evidence, and, when the serviceman arrived in response to a call, he was able to satisfy himself that such a condition did exist, but it was necessary to remove the set to the shop in order to locate the trouble. In a 500-volt d.c. test it was found that the snaps were caused by temporary breakdowns in the dielectric of one of the filter condensers, thus permitting an occasional internal discharge.

Sometimes it is possible to "service" a receiver via the telephone and an excellent illustration of this concerns a receiver operated with a Balkite A-power unit. It was explained that, although the set would operate satisfactorily when pulled away from the wall, the tubes would not light when the cabinet was in its usual position against the wall. We told the owner to add water to the cell of the A-power unit and then report on the operation of the set. In this case our guess was correct; the electrolyte in the rectifier cell was so low that it did not touch the electrode unless the front legs of the radio cabinet were raised by the rug when the cabinet was moved away from the wall.

A Stromberg Carlson power unit which would go off and on alternately while the power was turned on proved to be another baffling problem for us to solve. In this case a small break in the filament of one of the 2-ampere Tungar rectifier tubes was the cause of the trouble. The expansion and contraction of the filament, which operates at a fairly high temperature, explained the peculiar performance of the power unit.

Home-Made Repairs

WHEN a receiver ceases to function an over-ambitious set-owner often endeavors to effect a repair before soliciting the aid of a serviceman. An amusing incident of this nature recently came to our attention, and, as usual, the repair attempted by the owner was unsuccessful. The serviceman, who was assigned to the job of eliminating the bad distortion which the set had developed, found the set in perfect condition and discovered that the distortion was caused by too much voltage on the plate of the detector tube. Therefore, the B-supply unit, which was a Philco socket power device, was examined for defects. As soon as the lid was removed the trouble became apparent; the cartridge resistor in the plate circuit of the detector tube was wrapped carefully with tin foil, thus preventing its operation as a voltage reducer. The owner explained that it had burnt out and he tried to repair the "fuse" by wrapping it with tin foil in a manner which he has found effective with automobile fuses. For some reason or other tin foil seems to be considered a universal remedy by set owners.

Corrections

IN NOVEMBER RADIO BROADCAST the writer described an experience in servicing a Radiola 18 which may have been misleading; it was stated that an open circuit in an r.f. transformer manifests all the symptoms of a short. Frankly, we did not take time to ascertain a possible explanation for the seemingly impossible condition, but, after discussing the problem with others in the service field, it has been decided that a short must have been caused by the open ends of the offending r.f. transformer. In this case the repair of the open circuit would have remedied the short.

An error also occurred in the December article of this series which we wish to correct. In a paragraph describing trouble encountered with a deForest reflex receiver, the statement was made that "this particular short manifests itself as an open circuit, and, when the set was tested with a set-checker the results indicated a burnt-out transformer. However, further tests showed that the transformer was perfect, the trouble being caused by shorted condenser in shunt with the winding of the transformer." This statement is incorrect as a check of the records indicates that the set-checker showed a "dead" short. We regret this error as it has confused a number of servicemen who have followed these articles.



A typical serviceman's tool kit

Radio Broadcast's Service Data Sheets

The Philco Electric Radio Receivers, Series 5

THE Philco receivers are available in several different models but all of them use the same fundamental circuit consisting of three stages of tuned and neutralized radio-frequency amplification followed by a detector and a two-stage audio amplifier. There are six tubes in the receiver; four type 226, one type 227, and one type 171A. The receiver can be obtained in several table models or in cabinets. One model is a combination electric phonograph and radio.



Philco set in colored cabinet

Technical Discussion

1. TUNING SYSTEM

Four main tuning condensers are used in the receiver. They are C_1, C_2, C_3 and C_4. The latter three condensers have connected across them small compensating condensers, C_5, C_6, and C_7, which provide a method of compensating slight differences in the circuit capacities, thus bringing all the tuned circuits into exact electrical alignment. Across the first tuning condenser, C_1, is connected the small condenser, C_8, which is called the "range control." This range-control condenser serves normally to tune the first circuit to exact resonance but it also has a second function. A small spring contact on the condenser C_8 serves to ground the grid of the first tube when the condenser is rotated to the extreme left. Under such conditions the gain of the receiver is reduced to a point which is quite satisfactory for average local reception. Each r.f. stage is neutralized by the Hazeltine method, the neutralizing condensers being C_9, C_{10} and C_{11}.

2. DETECTOR AND AUDIO SYSTEM

A grid-leak-condenser-type detector is used followed by a two-stage transformer-coupled a.f. amplifier. The grid leak is R_1 and the grid condenser is C_{12}. In the plate circuit of the detector tube is connected the small by-pass condenser, C_{13}, with a capacity of 0.001 mfd. T_1 is the first audio transformer and T_2 is the second-stage audio transformer. J_1 is a jack into which a phonograph pick-up unit may be connected. When a phonograph pick-up unit is being used the volume control of the receiver should be turned off and the volume regulated by means of the control supplied with the pick-up device. The power tube is a 171A and in its plate circuit are connected the output filter choke coil, L_3, and the condenser C_{14} with a capacity of 0.5 mfd. This filter system functions to keep out of the loud speaker the d.c. currents in the plate circuit.

3. VOLUME CONTROL

The volume-control resistor, R_2, is connected between antenna and ground. The movable arm on this resistor is connected to one end of the primary of the first r.f. transformer.

4. FILAMENT CIRCUITS

The 226-type r.f. amplifiers and the first audio amplifier tube are supplied with approximately 1.5 volts from the secondary S_1 on the power transformer, T, the 227-type detector tube is supplied with 2.5 volts from S_2, and the 171A power tube supplied with 5 volts from S_3. In order to permit an accurate hum balance to be obtained, adjustable potentiometers, R_3 and R_4, are connected across secondaries S_1 and S_2, respectively, and these resistors are adjusted at the factory to a point of minimum hum at the output. The condensers, C_{15} and C_{16}, which are connected between each side of S_1 and ground, serve to bypass to ground the r.f. currents which would otherwise have to flow through the resistor, R_3.

5. PLATE CIRCUITS

The detector tube is supplied with about 35 volts, the r.f. and first a.f. tubes with approximately 90 volts, and the 171A-type power tube with 135 volts. The plate current for each 226-type tube is approximately 3.5 to 4 milliamperes. The 227-type tube draws about 1.5 milliamperes and the power tube requires about 15 milliamperes. The plate circuits of the r.f. tubes are filtered by the by-pass condensers C_{17}, C_{18}, and C_{19} and the resistors R_5, R_6, and R_7. The by-pass condensers each have a capacity of 0.1 mfd.

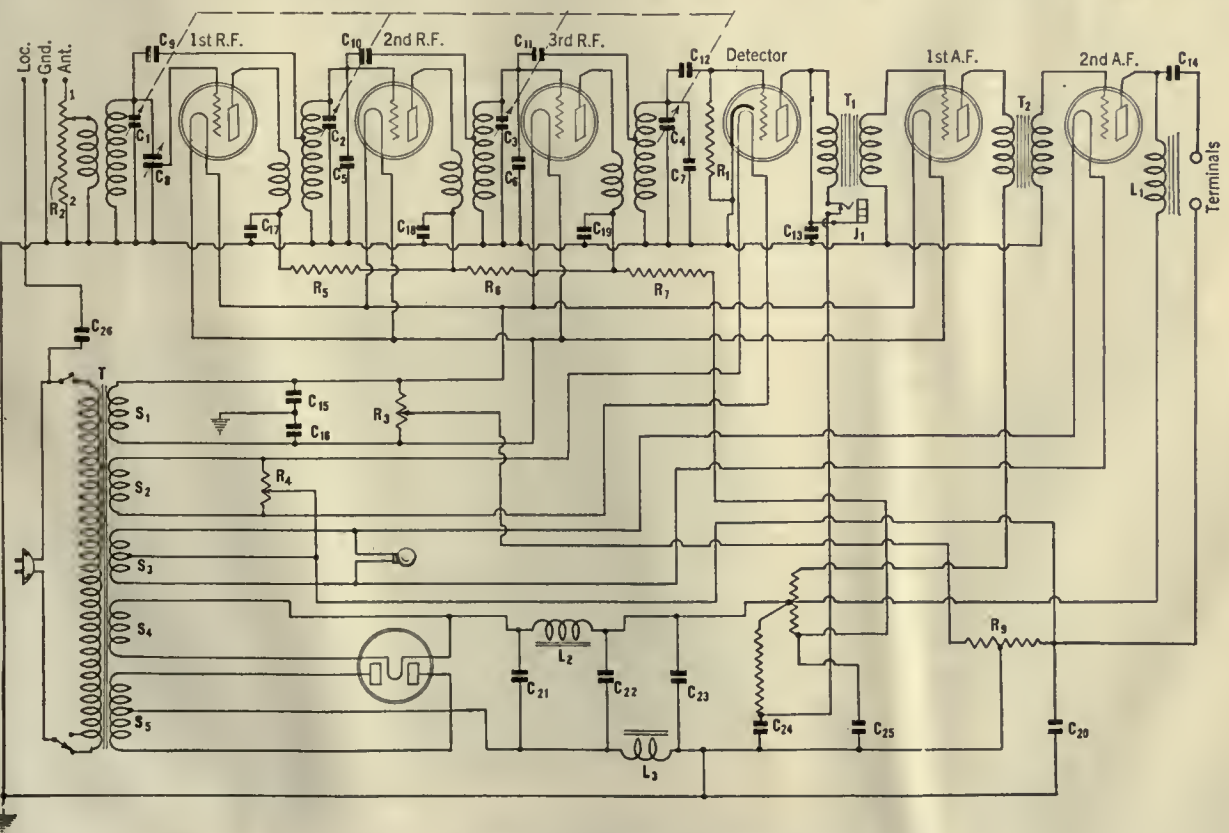
6. GRID CIRCUITS

Grid bias for the various tubes is obtained across the resistor R_9. The C bias on the 226-type tube is approximately 6 volts, and approximately 28 volts is placed on the grid of the 171A power tube. There is no bias on the detector tube. This C-bias resistor is by-passed by an 0.1-mfd. condenser, C_{20}.

7. POWER SUPPLY

The power supply is contained within the receiver cabinet. It consists of a power transformer, T, tapped for various line voltages and containing five secondary windings. S_1, S_2, and S_3 supply filament current for the tubes in the receiver, S_4 supplies filament current for the rectifier tube which is a type 280, and the secondary S_5 supplies plate voltage. The filter system consists of the filter condenser C_{21}, C_{22} and C_{23} and the choke coils L_2 and L_3. The condenser C_{21} has a capacity of 2 mfd., C_{22} has a capacity of 3 mfd., and C_{23} has a capacity of 4 mfd. The by-pass condensers, C_{24} and C_{25}, each have a capacity of 1 mfd. The power supply and filter system are designed for operation on 50- to 60-cycle a.c., but power equipment can be supplied for operation on 25- to 40-cycle power systems.

The small condenser C_{26} is connected between one side of the a.c. line to a terminal on the receiver marked "Loc" meaning local. For local reception satisfactory results can be obtained by connecting the "Loc" terminal to the "Ant" terminal and when this is done the power lines are used as an antenna.



Circuit diagram of receiver and power unit

Radio Broadcast's Service Data Sheets

Browning-Drake Receiver Models 34, 36, and 38

THE Browning-Drake Model 34 receiver is a completely self-contained table-model a.c. set designed for 105–120 volt 50–60 cycle current. In a consolette cabinet with a dynamic or air-chrome speaker the receiver is known as Model 36D or 36A, and in a highboy console it is listed as Model 38.

A noteworthy feature is the symmetrical mechanical construction, all power equipment forming an integral part of the chassis, which is of aluminum and which is perfectly balanced in all dimensions. The seven tubes and rectifier are all mounted along the rear of the chassis, adjacent to the shielding partitions, and form the basis for the description "Eight-in-Line" applied to this receiver in advertising.

The amplifier tubes are all of the 226 type, with the exception of the last stage, which is a 171A. The detector is of the 227 type. A 280-type full-wave rectifier is used.

The coils are at right angles to each other and are mounted on a bakelite strip beneath the base. The variable condensers are ganged and operated by a knob controlling a large drum. A special mechanism prevents slack, the two driving cylinders being joined by a phosphor bronze spring and connected to the drum by a beaded chain. Even illumination is provided by a miniature lamp in back of the scale, which rotates behind a recessed escutcheon plate. The cabinet work of the 1929 models is confined almost entirely to walnut with Dueo finish.

Technical Discussion

1. THE R.F. TUNING SYSTEM

The antenna stage of the receiver is of the untuned type with a 1000-ohm variable resistor, R_1, connected between the grid and filament of the first tube. This unit is controlled from the front panel and constitutes the volume control. The second and third radio-frequency stages and detector are tuned through a single dial. Perfect alignment is secured through the use of small compensating condensers, C_2, C_4, and C_5, across the main tuning condensers, C_1, C_2, and C_3. The compensating condensers are accurately set at the factory and are not accessible in the cabinet models.

2. THE DETECTOR AND AUDIO SYSTEM

The audio amplifier employs a three-stage resistance-coupled circuit. Type 226 tubes in the first two stages and a type 171A tube is employed in the output stage. Grid detection is used in the Model 34 receiver. The leak, R_2, has a resistance of 8 megohms and the condenser, C_6, has a capacity of 0.00005 mfd. In the audio amplifier, plate resistors, R_3, of 100,000 ohms are used, while the grid resistors are 500,000 ohms, R_4, for the first stage and 100,000 ohms, R_5, for the second and third stages. The coupling condensers, C_7, in the amplifier have a capacity of 0.1 mfd.

3. FILAMENT CIRCUITS

The filament supply system consists of five separate windings on the power transformer, T. The supply, S_4, for the 280-type rectifier is center tapped on the winding. The 1.5-volt winding, S_2, for the first two audio amplifier tubes, the 5.0-volt supply, S_3, for the power amplifier, the 2.3-volt filament winding, S_1, for the detector, and the 1.5-volt r.f. filament supply, S_6, are shunted with resistors to get the center point. Through the use of separate windings, for the r.f. and a.f. tubes, tendency toward hum is reduced greatly. Each of the windings, S_1, S_2, S_3, and S_4, is provided with a 60-ohm center-tapped resistor, R_6, accurate to less than 0.5 per cent. Inasmuch as leads are short and the windings are separate, the use of such accurate center-tap connections helps greatly in the elimination of hum. The 1.5-volt radio-frequency supply is bypassed at the sockets by one 0.1 mfd. condenser, C_8, on each side of the filament. This prevents common coupling in the center-tapped resistor and aids in the elimination of 60- or 120-cycle modulation of the incoming signal.

4. PLATE CIRCUITS

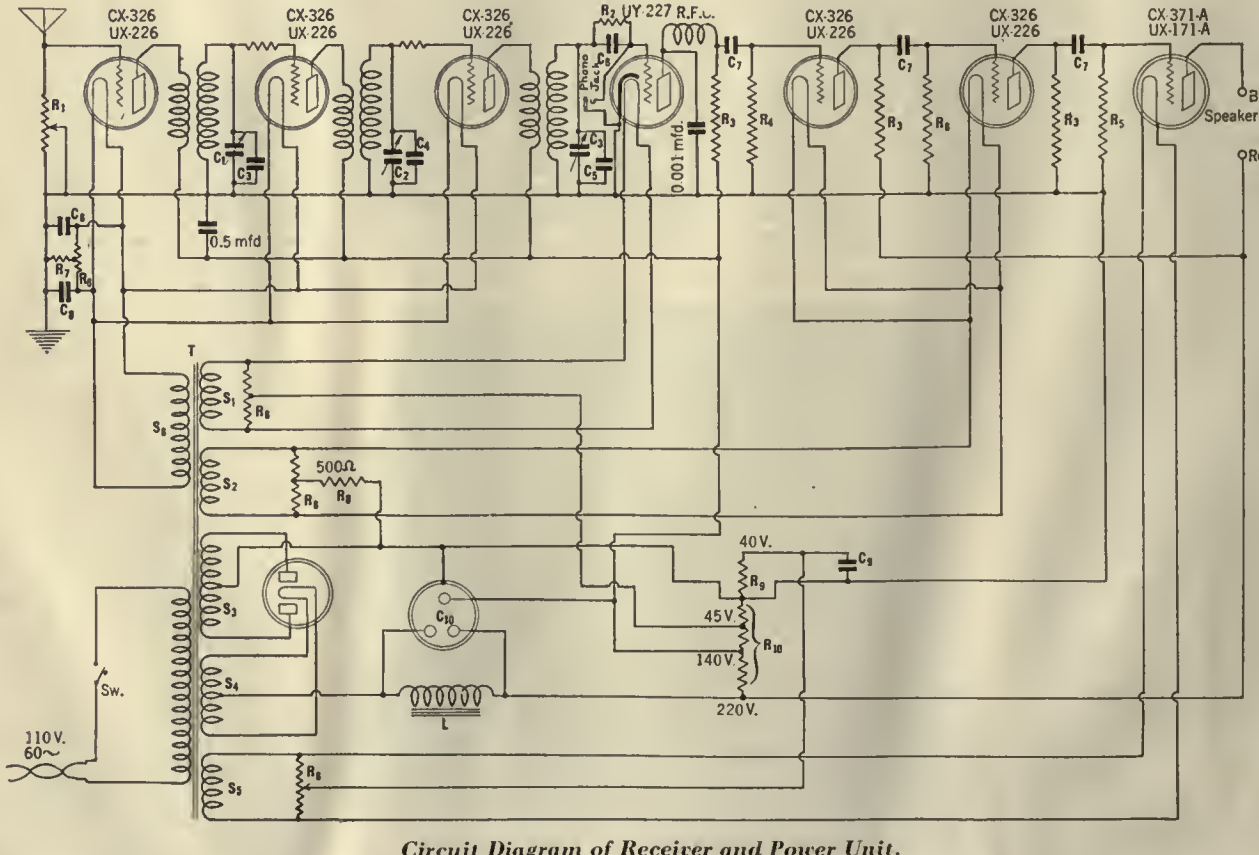
The plates of the radio-frequency tubes are supplied with 140 volts d.c. from the power supply and draw a plate current approximately from ten to twelve milliamperes. The detector plate is supplied with 20 volts and the current drawn in this circuit is one milliampere. The audio amplifier tube plates are furnished from the 200-volt source in the power supply. The voltage drop in their respective plate resistors reduces the plate voltage on the first audio tube to 60 volts and that on the second amplifier to approximately 75 volts. The plate current in each case is between 1.5 and 2.0 milliamperes depending upon the tube. The full voltage of the supply, 220 volts, is impressed on the power amplifier plate. The actual voltage across the tube is less than this value, however, by the amount of the grid-bias voltage as is indicated later. The plate current in the power amplifier tube is 20 milliamperes.

5. GRID CIRCUITS

The radio-frequency amplifier grids are connected to ground or to the chassis frame through their respective r.f. transformer secondaries. The r.f. bias is applied between the filaments and ground and is secured by the IR drop through a 1000-ohm resistor, R_7. The negative bias thus applied to the r.f. grids is from ten to twelve volts. The detector grid is operated at cathode potential, no biasing being required for grid detection. The audio amplifier tube grids carry a negative bias of from 4 to 5 volts furnished by the IR drop across the 500-ohm resistor R_8. The power amplifier grid is biased in the same manner, the plate current to the tube passing through a 2000-ohm resistor, R_9, in the filament circuit. This resistor is a part of the voltage divider and is bypassed with a 1.0-mfd. condenser, C_9. The value of this bias voltage is approximately 40.5 volts.

6. THE POWER SUPPLY

The power supply contains a power transformer, T, a 30-henry filter choke, L, a triple-section Mershon filter condenser, C_{10}, and a voltage divider, R_{10}. The power transformer has a single primary winding, a high-voltage secondary, S_3, having 300 volts on each side of the center tap, a 5-volt center-tapped winding, S_4, for the rectifier, two separate 1.5-volt windings, S_2 and S_6, for the a.f. and r.f. amplifiers, a 5-volt winding, S_5, for the power amplifier, and a 2.3-volt winding, S_1, for the detector. The 2.3-volt winding supplies the dial light as well as the detector. Full-wave rectification with a 280-type tube is employed. The output of the rectifier is passed through the 30-henry choke with 8 mfds. on each side. This filtered d.c. is then carried to the voltage divider where taps are taken off for the 140-volt supply to the radio-frequency plates and 45 volts for the detector heater. The 140-volt tap is bypassed with the remaining 8-mfd. section of the Mershon condenser. The power transformer choke, and filter condenser are all operated well under their normal rating so that excellent filtering and freedom from trouble are assured.



Circuit Diagram of Receiver and Power Unit.

IN THE RADIO MARKETPLACE

News, Useful Data, and Information on the Offerings of the Manufacturer

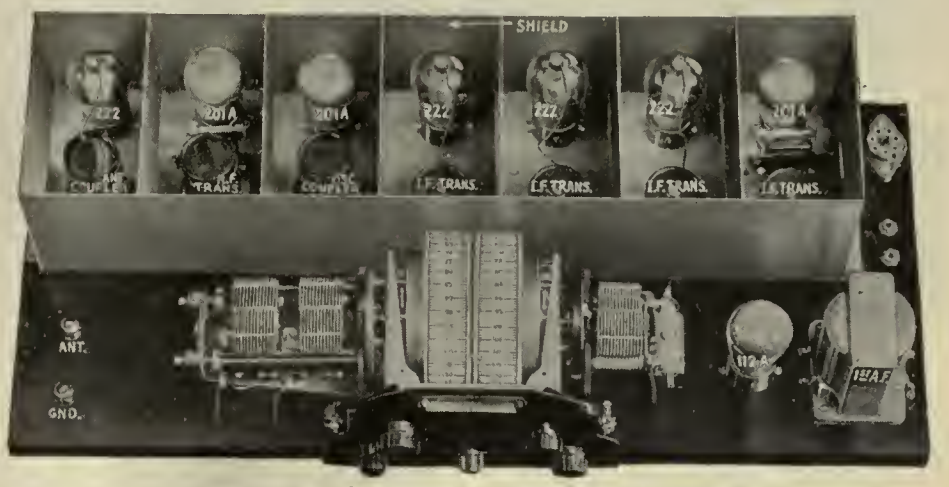
The Remler "29" Super-Heterodyne Receiver

THE Remler "29" is a super-heterodyne receiver intended for use with a short antenna which may be of either the inside or outside variety. The receiver incorporates a stage of screen-grid radio-frequency amplification followed by a regenerative first detector, an oscillator, three stages of transformer-coupled, screen-grid, intermediate-frequency amplification functioning at a frequency of 115 kilocycles, a second detector, and a suitable audio amplifier. The circuit diagram is given in Fig. 1.

The major function of the radio-frequency stage preceding the first detector is to increase the selectivity. The screen-grid tube is used in this stage of radio-frequency amplification because of its inherent stability of operation.

The intermediate amplifier of the "29" employs three tubes of the screen-grid type. Although the screen-grid tube is theoretically capable of providing a gain of 40 or 50 per stage, in no case has such gain been obtained in practice and the necessary degree of selectivity maintained. However, both the gain and the selectivity of the screen-grid intermediate amplifier are far greater than could be obtained from an amplifier employing tubes of the 201A type even if excessive regeneration were used. The gain per stage has, however, purposely been held down somewhat in order to eliminate excessive tube background noise and to maintain the degree of selectivity deemed necessary under present day conditions.

Tubes of the 201A type are used for the oscillator and for the first and second detectors. Both detectors are of the leak-condenser type. The regeneration employed in the first detector circuit is obtained by inductively coupling the plate and grid circuits of the tube by means of a third winding or tickler coil, L_1. The degree of regeneration is controlled from the panel by means of a 2000-ohm variable resistor, R_1, which is shunted across the tickler coil. Maximum regeneration is used only for the reception of distant stations for which a slight sacrifice in quality of reproduction is permissible. For high-quality local and semi-distant reception the regeneration control should be retarded.



Chassis view of receiver with shield covers removed

This section of RADIO BROADCAST *is devoted to describing the uses of apparatus on the market. In this category fall kits from which receivers and power units may be assembled, descriptions of the uses of parts and accessories which may be announced by manufacturers, and practical information of value to the serviceman, custom set builder and experimenter—all of whom are interested in keeping abreast of what is going on. This month, the excellent kit receivers of Remler and Hammarlund-Roberts are described.*

—THE EDITOR.

The heart of the Remler "29" is the No. 712 screen-grid selector-amplifier. This unit incorporates within a single heavy copper case the radio-frequency and intermediate-frequency amplifier tubes, the transformers, the oscillator and the two detectors. Each individual circuit is, in turn, fully shielded. Such shielding of the individual stages is necessary because of the high gain obtained per stage. The amplifier unit is completely wired at the factory and colored leads extend from it for connection to the panel controls, the tuning condensers, the audio components, and the battery cable terminal block. The intermediate transformers are peaked at the factory and vernier adjustments are provided so that differences in tubes or misalignment due to rough handling during shipment may be compensated by the builder of the set.



Power-Suply unit for the Remler "29"

FOUNDATION UNIT

Custom set-builders have in the past occasionally run into trouble due to the improper location of radio-frequency components and wiring. In the design of the Remler "29" great care has been exercised to make the construction such that these difficulties can not arise. All component parts of the "29" are to be mounted by the builder on a pressed-steel chassis which is included in the No. 752 foundation kit. In addition to those parts mounted directly on it, it supports a pressed-steel panel to which are fastened those instruments controlled from the panel. The instrument panel, the escutcheon plate, and all necessary binding posts, phone-tip jacks, brackets, insulating washers, control knobs, screws and nuts are packed with the foundation kit.

There are two major tuning controls which operate, respectively, the Remler Type 632 two-in-line condenser, C_1 and C_2, controlling the radio-frequency amplifier and first detector circuits, and the Remler Type 638 condenser, C_3, controlling the oscillator circuit. A

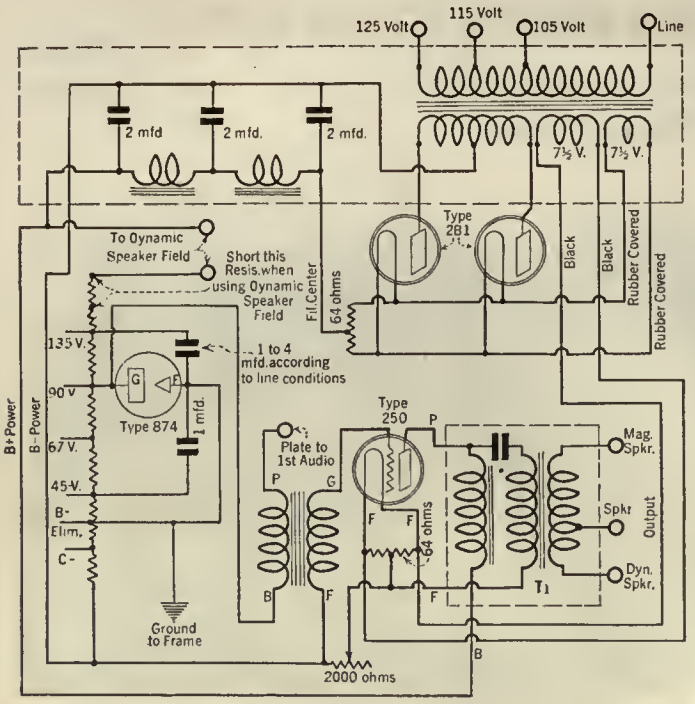


Fig. 2—Schematic diagram of power-supply circuit

single halancing condenser, C_4, is supplied with the amplifier unit for connection across the oscillator tuning condenser so that the two tuning dials can he made to agree closely over the hroadcast band. At the center of the panel is located a switch with which is combined a 6-ohm rheostat, R_2, controlling the scrcen-grid tuhes. A protective resistor, R_3, is connected in series with this rheostat so that excessive voltage can not be applied to the screen-grid tubes. Filamcnt control of the remaining tuhes of the set is automatic. Two more controls, which are of a semi-fixed nature, are located on the panel. One of these, the volume control, is a 500,000-ohm variable resistor, R_4, which controls the voltage applied to the screen-grids of the 222-type tuhes and to the plate of the first detector. The other, the sensitivity control, is a 2000-ohm variahle resistor, R_1, which is shunted across the feed-hack winding of the first detector and which controls the amount of regeneration in the first detector circuit. The receiver is tuned as is any other receiver of the super-heterodyne type.

If a power tuhe of the 112A- or 171A- type is to he used and the first audio stage and second audio stagc (shown in dotted lines) are hoth to be included in the receivcr proper, the Remler first-stage transformcr, No. 900, and Remler second-stage transformer, No. 901, may be employed. (The characteristics of these transformers were given in November, 1928, RADIO BROADCAST, page 29.) Remler transformer No. 901 can be used in the first-stage position if desired. If only the first audio stage is to he built into the recciver proper and the Remler powcr amplifier is to he used, the first-stage transformer should he the Remler No. 920. The second-stagc transformer will then he the Remler No. 921 which will he built into the power amplifier. In either case it is suggested that the first audio tuhe hc of the type 112A and that it he operated at a plate voltage of 135 and a 9-volt negative grid hias.

With power tuhes type 112A or 171A the output transformcr should he respectively either the Remler No. 922 or the Remler No. 923. If the loud speaker is to he of the dynamic type the transformcr should be the No. 923.

POWER AMPLIFIER

The Remler power amplifier and plate supply, Fig. 2, is ideal for use with the Remler "29." It employs full-wave rectification, making use of two 281-type half-wave rectifier tuhes, and incorporates a single 250-type power tuhe. It has ample capacity to supply plate and grid-hias voltages for any type of receiver and it will, in addition, supply field current for a dynamic speaker of the 90-110-volt type. The speaker field is connected in series with the voltage divider and is supplied with about 55 milliamperes. When the speaker field is in use a 2000-ohm resistor in the voltage divider is shorted out. Provision is made for a 874-type voltage regulator or glow tube so that the voltage delivered to the set remains constant.

The Remler No. 950 powcr transformer and choke is designed to supply from 425 to 440 volts to the plate of the power tube under full load. The primary of the transformer is tapped for line voltages of 105, 115 and 125 volts. The filter circuit consists of two 80-henry chokes and either three 2-mfd. condensers or two 2-mfd. and one 4-mfd. condensers. The filter condensers are to be installed hy the huilder in a space provided in the No. 950 case.

Part of the voltage divider of the Remler power amplifier and plate supply consists of three 2000-ohm strip resistors to which sliding contact connections can he made and three 2000-ohm resistors of the potentiometer type. Grid hias for the first audio tuhe is taken from a 400-ohm potentiometer which is in scries with the return path of the current from the receiver and the voltage-regulator tuhe. Grid hias for the power tuhc is supplied by a 2000-ohm variahle resistor which is in series with the rcturn path of the platc current for the powcr tube alone. All component parts of the power amplifier are mounted on a pressed-stccl chassis, $10\frac{1}{8}$" wide by 20" long, which is supplied with the No. 952 power amplifier foundation kit. All resistors of the voltage divider must, of course, bc thoroughly insulated from the steel chassis and insulating washers for this purposc are supplied with the foundation kit. Practically any voltage between the maximum for the power tuhe and zero can he ohtained for the receiver and all of these voltages are continuously variahlc. A pressed-steel cover, finished in brown crystalline enamel, is availablc for the power amplifier if desired. It greatly enhanccs the appearance of the unit and insures freedom from the collection of dust.

The No. 923 output transformer is supplied with three output terminals marked "Mag. Spkr.," "Spcaker," and "Dyn. Spkr." The output winding between terminals "Speaker" and "Mag. Spkr." is of high impedance and is suitable for use when a high-impedance loud spcaker such as onc of the magnetic type is employed. The output winding hetween terminals "Speakcr" and "Dyn. Spkr." is of low impedance and a moving-coil loud speaker may he connccted directly across these transformcr terminals. It is possihle to connect the regular input terminals of a moving-coil loud speaker across the "Spcaker" and "Mag. Spkr." terminals of the No. 923 transformer and to thus obtain fair results, but thc elimination of the transformer in the speaker and the use of the "Speaker" and "Dyn. Spkr." terminals of the transformer as above described is recommended.

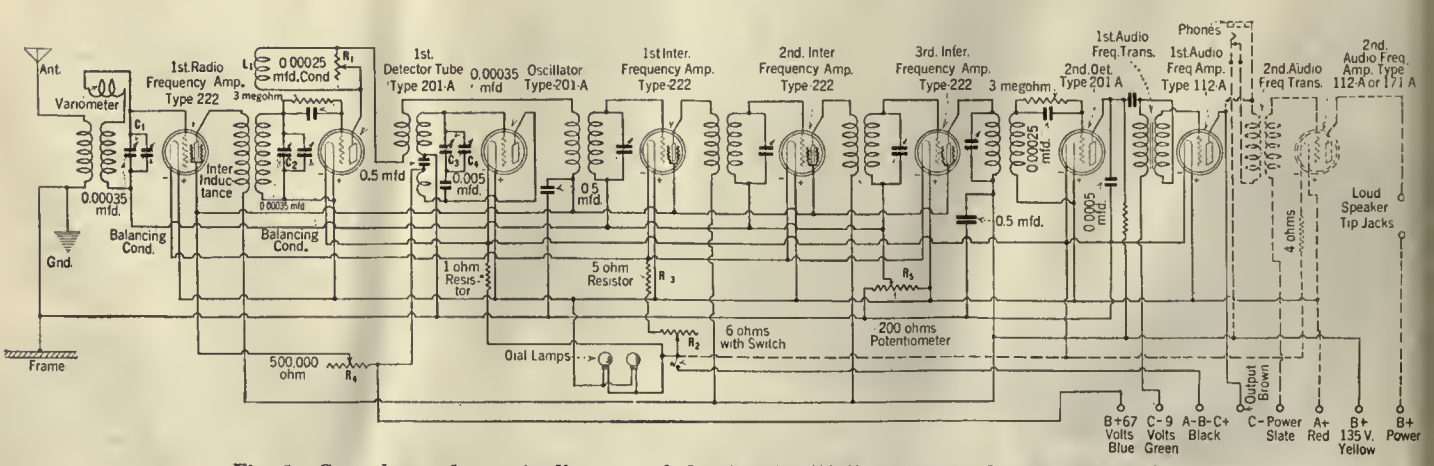


Fig. 1—Complete schematic diagram of the Remler "29" screen-grid super-heterodyne

The Six-Tube, Screen-Grid, Junior Model "Hi-Q 29"

THE "Hi-Q 29" Junior Model has been tested in the Laboratory and was found to be an efficient receiver; that is, it is sensitive, selective, and will bring in stations with good fidelity. In a single evening the receiver brought us a number of out-of-town stations in addition to the old stand-by's such as KDKA and WGY. It has 20-kc. selectivity and this makes it possible here in New York to receive WLW when WOR is on the air. WOR was audible in the background, but the frequency separation of these two stations is only 10 kc. It had more r. f. gain than could be used in this particular locality. The cost of parts, $54.60, brings it within the reach of nearly everyone.

The circuit diagram of the d.c.-operated Junior model is shown in Fig. 1. Two screen-grid tubes are used in the radio-frequency amplifier, and the first, which is untuned, is coupled to the antenna-ground input system through a 3000-ohm variable resistor which serves as the volume control. The receiver is a true single-controlled set, although it employs two sharply tuned circuits.

The plate circuit of the first screen-grid tube looks into a specially designed transformer which has several primary taps, so the experimenter can choose the one that provides the best selectivity. The primaries are small and wound of many turns of fine wire.

Following the first untuned antenna stage are two carefully tuned stages, the second r.f. amplifier and the detector. The voltage gain in the antenna stage is not high, but contrary to many such untuned stages using low-mu tubes (of the 201A type) it provides some voltage gain. The second stage, of course, has a high voltage gain and the detector input, being tuned, adds its bit to the overall radio-frequency amplification of the receiver. The coils are typical Hammarlund spaced winding solenoids of a good shape.

C—BIAS DETECTOR

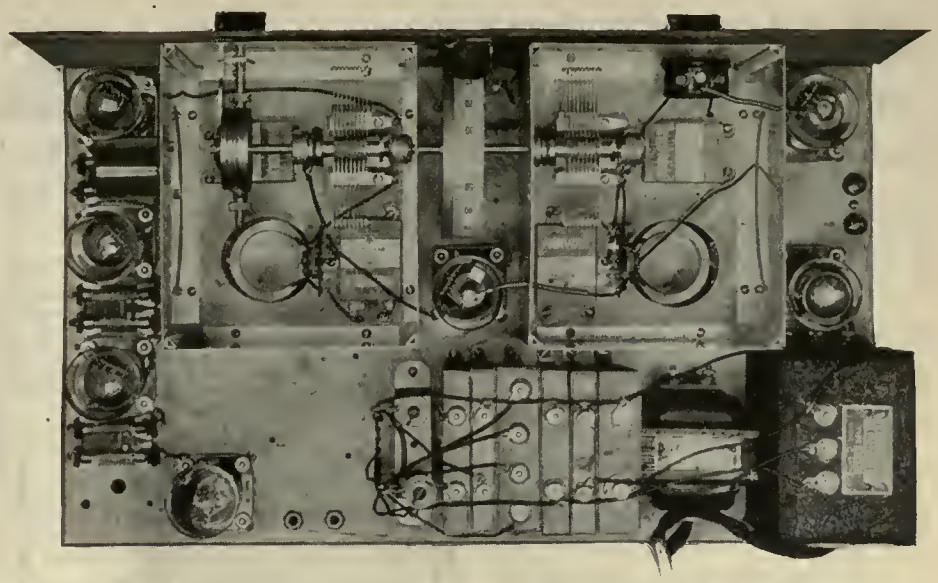
The detector, which is a 201A-type tube, is used in a C-battery circuit because of the greater input voltage handling ability and somewhat greater freedom from high audio-frequency loss. Following this tube is a three-stage resistance-coupled audio amplifier, the first tube being a 240, or hi-mu type, the second a 201A and the final tube a 171A.

The screen-grid tubes are placed outside the shielding boxes which enclose the tuning components. The control-grid leads are shielded, and thus there is little danger of unwanted feed back from one stage to another. The filtering in the r.f. amplifier consists of 5000-ohm resistors in the plate circuit of each tube and 0.5-mfd. by-pass condensers connected from the low-potential side of each primary to the filament of the tube in question. The advantage of such filtering has been pointed out many times in this magazine; its purpose is to keep the r.f. plate currents out of the B supply and to prevent them from becoming mixed with similar currents of another stage.

Bias for the screen-grid tubes is obtained by connecting the low-potential end of the grid input circuit to the battery end of a filament resistor. The correct plate voltage for this value of C bias is obtained through the 5000-filter resistor—the voltage drop across this resistor is small since the normal plate current of the tube is only about one milliampere. Such a grid bias lengthens the life of the tubes appreciably. Bias for the resistance-coupled amplifier tubes is obtained externally as is that for the detector.

A choke coil has been placed in the plate circuit of the detector to prevent r.f. voltages from overloading the resistance-coupled amplifier. In addition a condenser is placed across the input to the amplifier so that the detector will be provided with a low-impedance output (to r.f. currents) with consequent better detection.

All in all, the Junior "Hi-Q 29" is a six-tube receiver, using screen-grid tubes at their best, i.e., well shielded and well filtered, a C-battery detector, a resistance-coupled amplifier provided with values of resistance and capacity that will permit the amplification of all frequencies from below 100 to well over 5000 cycles, and a power tube designed to deliver at least 350 milliwatts of power to an average speaker. Because of the suggested plate voltage on the 171A, 135 volts, an output device is not necessary from the standpoint of protecting the loud speaker, although there is plenty of room for it on the baseboard of the receiver.



Chassis view of the Junior "Hi-Q 29" A. C. Receiver

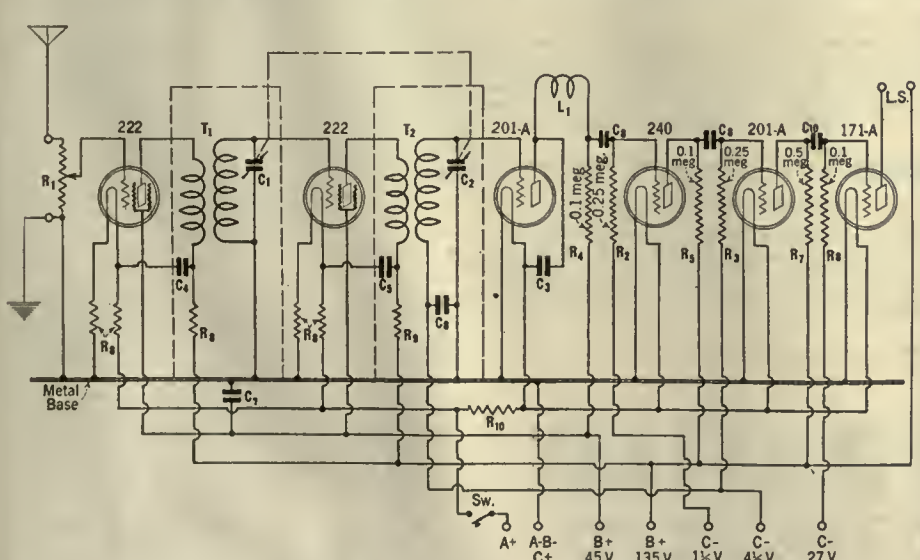


Fig. 1—Schematic diagram of the Junior Model "Hi-Q 29"

LIST OF PARTS

The picture gives a good idea of the internal appearance of the receiver, and the list of parts below indicates the discrimination with which its designers picked out the components. There is an a.c. model of the same general circuit employing Arcturus tubes. The list price of the latter is $104.20, and the receiver as put together is a completely self-contained tuner, amplifier and power supply.

The complete list of parts follows:

C_1, C_2 Two Hammarlund Midline condensers, 0.00035-mfd., type ML-17;
C_3 One Sangamo fixed condenser, 0.001-mfd;
C_4, C_5, C_6, C_7 Four Parvolt by-pass condensers, 0.5-mfd.;
L_1 One Hammarlund r.f. choke coil, type RFC-85;
R_1, One Carter tapered volume control, 3000-ohm, type TP-3M;
R_2, R_3 Two Durham Metalized resistors. 0.25-megohm;
R_4 One Durham Metalized resistor 0.1-megohm;
R_5, R_6 One Durham Powerohm, 100,000-ohm, 1-watt;
R_7 One Durham Powerohm, 50,000-ohm, 1-watt;
T_1, T_2 Two Hammarlund r.f. transformer, type SGT-17;
Sw One Carter battery switch, type 2;
One Hammarlund drum dial, knob-controlled;
Six Benjamin sockets, type 9040;
Two Yaxley phone-tip jacks, type 422;
One Yaxley cable connector, type 660;
One Hi-Q 29 Junior foundation unit containing panel, shields, chassis, coupling condensers, resistor units, resistor clips, binding posts, shafts, wire, screws, etc.

MANUFACTURERS' BOOKLETS

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on this page. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, effect on various circuits, and circuit diagrams of popular kits. RAMIALL COMPANY.

5. CARBORUNDUM IN RADIO—Pertinent data on crystal detectors with hook-ups, and information on the use of resistors. THE CARBORUNDUM COMPANY.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.

17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION.

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with reference to the application of dry cells to radio. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

32. METERS FOR RADIO—A book of meters used in radio, with diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

37. WHY RADIO IS BETTER WITH BATTERY POWER—What dry-cell battery to use; their application to radio, wiring diagrams. NATIONAL CARBON COMPANY.

46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.

47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out r. f. currents from delinite points. SAMSON ELECTRIC COMPANY.

48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use. SAMSON ELECTRIC COMPANY.

53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on reactivation. THE STERLING MANUFACTURING COMPANY.

56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.

57. FILTER DATA—Facts about the filtering of d. c. supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.

58. HOW TO SELECT A RECEIVER—A common-sense booklet describing what a radio set is, and what you should expect from it, in language that anyone can understand. DAY-FAN ELECTRIC COMPANY.

67. WEATHER FOR RADIO—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. TAYLOR INSTRUMENT COMPANIES.

69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit; list of American and Canadian broadcast stations. RADIO CORPORATION OF AMERICA.

72. PLATE SUPPLY SYSTEMS. Technical information on audio and power systems. Bulletins dealing with two-stage transformer amplifier systems, two-stage push-pull, three-stage push-pull, parallel push-pull, and other audio amplifier, plate, and filament supply systems. AMERICAN TRANSFORMER COMPANY.

73. RADIO SIMPLIFIED—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. CROSLEY RADIO CORPORATION.

76. RADIO INSTRUMENTS—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. JEWELL ELECTRICAL INSTRUMENT COMPANY.

78. ELECTRICAL TROUBLES—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the eadmium test for storage batteries. Of interest to the owner of storage batteries. BURTON ROGERS COMPANY.

81. BETTER TUNING—A booklet giving much general information on radio reception with specific illustrations. Primarily for non-technical set-builders. BREMER-TULLY MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

89. SHORT-WAVE TRANSMITTING EQUIPMENT. Data and wiring diagrams on construction of all popular short-wave transmitters, operating instructions, keying, antennas; information and wiring diagrams on receiving apparatus; data on variety of apparatus used in high-frequency work. RADIO ENGINEERING LABORATORIES.

90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification. ALDEN MANUFACTURING COMPANY.

95. Besistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. INTERNATIONAL RESISTANCE COMPANY.

98. COPPER SHIELDING—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. THE COPPER AND BRASS RESEARCH ASSOCIATION.

99. RADIO CONVENIENCE OUTLETS—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set, also antenna, ground and battery connections. YAXLEY MANUFACTURING COMPANY.

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—THE EDITOR.

101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. SAMSON ELECTRIC COMPANY.

102. RADIO POWER BULLETINS—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. RAYTHEON MANUFACTURING COMPANY.

104. OSCILLATION CONTROL WITH THE "PHASATROL"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. ELECTRAD, INCORPORATED.

105. RECEIVING AND TRANSMITTING CIRCUITS. Construction booklet with data on 25 receivers and transmitters together with discussion of low losses in receiver tuning circuits. AERO PRODUCTS COMPANY.

108. VACUUM TUBES—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. ARCTURUS RADIO COMPANY.

112. HEAVY-DUTY RESISTORS—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. WARD LEONARD ELECTRIC COMPANY.

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118. RADIO INSTRUMENTS, CIRCULAR "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. WESTON ELECTRICAL INSTRUMENT CORPORATION.

120. THE RESEARCH WORKER—A monthly bulletin of interest to the engineer and home builder. Each issue contains special articles on radio design and construction with special emphasis on resistors and condensers. AEROVOX WIRELESS CORPORATION.

121. FILTER CONDENSERS—Some practical points on the manufacture and use of filter condensers. The difference between inductive and non-inductive condensers. POLYMET MFG. CORP.

123. B SUPPLY DEVICES—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. ELECTRAD, INC.

124. POWER AMPLIFIER AND B SUPPLY—A booklet giving several circuit arrangements and constructional information and a combined B supply and push-pull audio amplifier, the latter using 210-type tubes. THORDARSON ELECTRIC MFG. CO.

125. A. C. TUBE OPERATION—A small but complete booklet describing a method of filament supply for a.c. tubes. THORDARSON ELECTRIC MFG. CO.

126. MICROMETRIC RESISTANCE—How to use resistances for: sensitivity control; oscillation control; volume control; regeneration control; tone control; detector plate voltage control; resistance and impedance coupling: loud speaker control, etc. CLAROSTAT MFG. CO.

129. TONE—Some model audio hook-ups, with an explanation of the proper use of transformers and chokes. SANGAMO ELECTRIC CO.

130. SCREEN-GRID AUDIO AMPLIFICATION—Diagrams and constructional details for remodeling old audio amplifiers for operation with screen-grid tubes. THORDARSON ELECTRIC MFG. CO.

131. THE MERSHON CONDENSER—An illustrated booklet giving the theory and uses of the electrolytic condenser. AMRAD CORPORATION.

132. THE NATIONAL SCREEN-GRID SHORT-WAVE RECEIVER—Constructional and operating data, with diagrams and photographs. JAMES MILLEN.

133. THE NATIONAL SHIELD-GRID FIVE—A circuit diagram with constructional and operating notes on this receiver. JAMES MILLEN.

134. REMLER SERVICE BULLETINS—A regular service for professional set-builders, giving constructional data, and hints on marketing. GRAY & DANIELSON MFG. CO.

135. THE RADIOBUILDER—A periodic bulletin giving advance information, constructional and operating data on S-M products. SILVER-MARSHALL, INC.

136. SILVER MARSHALL DATA SHEETS—These data sheets cover all problems of construction and operation on Silver-Marshall products. SILVER-MARSHALL, INC.

139. POWER UNIT DESIGN—Periodical data sheets on power unit problems, design, and construction. RAYTHEON MFG. CO.

140. POWER UNIT PROBLEMS—Resistance problems in power units, with informative tables and circuit diagrams. ELECTRAD, INC.

141. AUDIO AND POWER UNITS—Illustrated descriptions of power amplifiers and power supplies, with circuit diagrams. THORDARSON ELECTRIC MFG. CO.

142. USE OF VOLUME AND VOLTAGE CONTROLS. A complete booklet with data on useful apparatus and circuits for application in receiving, power, amateur transmitter, and phonograph pick-up circuits. CENTRAL RADIO LABORATORIES.

143. RADIO THEORY. Simplified explanation of radio phenomena with reference to the vacuum tube, and data on various tubes. DEFOREST RADIO COMPANY.

144. LOW FILAMENT VOLTAGE A. C. TUBES. Data on characteristics and operation of four types of a.c. tubes. ARCTURUS RADIO COMPANY.

145. AUDIO UNITS. Circuits and data on transformers and impedances for use in audio amplifier plate and output impedances and special apparatus for use with dynamic speakers. SANGAMO ELECTRIC COMPANY.

146. RECEIVER CIRCUIT DATA. Circuits for using resistances in receivers, and in power units with descriptions of other apparatus. H. H. FROST, INC.

147. SUPER-HETERODYNE CONSTRUCTION. Construction and operation of a nine-tube screen-grid superheterodyne. SET BUILDERS' SUPPLY COMPANY.

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153. WHAT THE EVEREADY FIDELITY CURVE MEANS TO RADIO RECEPTION. An analysis of the frequency range of musical instruments and the human voice which shows how these tones are reproduced by a receiver with an audio range of 60 to 5000 cycles. NATIONAL CARBON COMPANY.

154. AMPLIFIER AND POWER SUPPLY CONSTRUCTION MANUAL. A booklet giving descriptions, circuit diagrams, and lists of parts of several popular amplifier and power supply circuits. ACME WIRE COMPANY.

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Since they began, in June, 1926, the popularity of the Information Sheets has increased so greatly that it has been decided to reprint the first one hundred and ninety of them (June, 1926-May, 1928) in a single substantially bound volume. This volume, "Radio Broadcast's Data Sheets", may now be bought on the newsstands, or from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Inside each volume is a credit coupon which is worth $1.00 toward the subscription price of this magazine. In other words, a year's subscription to RADIO BROADCAST, accompanied by this $1.00 credit coupon, gives you RADIO BROADCAST for one year for $3.00, instead of the usual subscription price of $4.00.

—THE EDITOR.

No. 256 RADIO BROADCAST Laboratory Information Sheet **February, 1929**

Three Types of Graphs

IF WE have before us a job of plotting a curve of an a.f. amplifier to show how the voltage gain varies with frequency, we must decide just how the curve is to be plotted. Curves may be plotted on several types of cross-section paper which will be illustrated in a future Laboratory Sheet. The problem is this, should we plot the curve on ordinary cross-section paper or on log or log-log paper, and should we plot frequency against DB or against voltage output.

The essential purpose of a curve is to enable one to obtain a visual idea of the characteristics of the amplifier. Since the purpose of an a.f. amplifier is to amplify currents which will finally be converted into sound, it is preferable to plot the curve to such a scale that its final shape indicates as nearly as possible the variations in response as they would be audible to the ear.

Now it has been determined that the ear hears variations in intensity in accordance with a logarithmic function. For this reason, if we are to plot frequency against output voltage, it is advisable to plot the curve on log-log paper so that the variations will be indicated on the curve in their relative importance as heard by the ear.

If we desire to plot frequency against DB then the curve should be plotted on log paper. In such a case we would find that the shape of the resultant curve was the same as that of the preceding curve plotted on log-log paper, for in converting from voltage to DB we take into consideration the logarithmic function.

In all cases the frequency scale should be plotted on a log scale so that each octave in the scale takes up an equal amount of space. Take a piece of cross-section paper with a log scale on it and measure the distance in inches between 10 cycles and 100 cycles, a change in frequency of 10 to 1. Then measure the distance between 100 and 1000 and between 1000 and 10,000. The distances are all equal and equal sections of the curve therefore receive an equal amount of space.

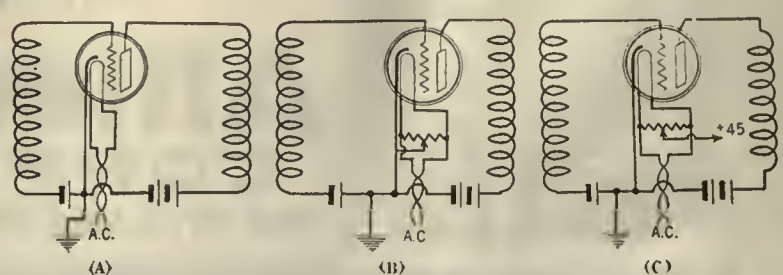
No. 257 RADIO BROADCAST Laboratory Information Sheet **February, 1929**

Heater Connections for A. C. Tubes

AN EXAMINATION of the circuits of various a.c. receivers using one or more 227-type tubes shows several different ways the heaters of these tubes may be connected into the circuit.

In sketch A we show the heater of the tube quite independent of the remainder of the circuit. In sketch B the center tap of a resistor connected across the heater is grounded and in sketch C the center tap of the resistor connected across the heater is connected to the plus 45-volt terminal. Of these three arrangements the one most commonly used is B in which the heater is grounded, since such an arrangement gives satisfactory operation in most cases. It is generally unwise to arrange the circuit as indicated at A, since the heater under such conditions is more or less floating and is liable to introduce hum into some part of the circuit.

The reason for the use of the arrangement shown at C is somewhat complicated. When the heater of the tube becomes hot it, of course, emits some electrons and it is possible for some of these electrons to enter the plate circuit. Since the heater is operated on a.c. the emission from it is not uniform and, therefore, a hum will be produced if any appreciable number of electrons are drawn from the heater.



A LIFE PRESERVER FOR YOUR "B" ELIMINATOR



5000 Hours Instead of 1000!

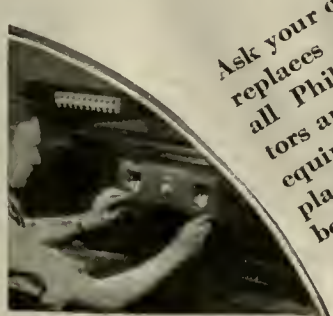
When your fragile 1000 hour rectifier tube in your "B" Eliminator "blows", don't put another just like it in the socket—be modern—get one of the husky, solid, all dry 5000 hour Elkon EBH rectifiers from your dealer and forget your rectifying troubles for 5000 hours, at least.

The new Elkon EBH replaces all BH type rectifiers—no changes in wiring—simply take out the trouble-causing gas tube and plug in the smooth, powerful, trouble-free Elkon—that's all there is to it.

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Ask your dealer about the new dry Elkon rectifier which replaces the wet jar Philcatron type A and type AA in all Philco power units—trickle chargers, "A" Eliminators and A combinations. For the Philco "A" Eliminators equipped with Elkon rectifiers, use the Elkon M-16 for replacement. Eleven "A" Eliminators have used the M-16—be sure you get the M-16 in the red, black and yellow box.

The Elkon V-4 is used for 6 makes of trickle chargers, and the Elkon is the only authorized replacement rectifier for the Balkite Power Units, types N, K and J.



Elkon rectifiers are tested with receiving sets

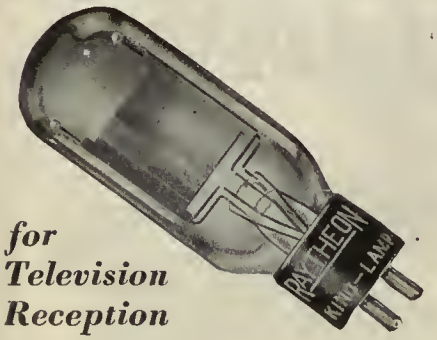
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Division of P. R. Mallory & Co.
350 Madison Ave., New York

ELKON, Inc., Dept. E-32
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Raytheon Kino-Lamp



for Television Reception

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List Price, $7.50

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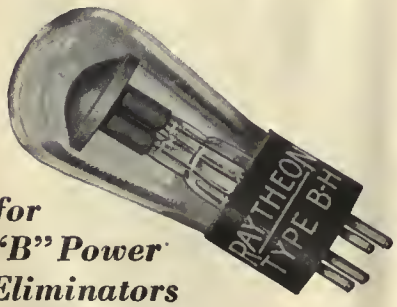


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This is an extra-sensitive broadcasting tube, supplied in either *hard vacuum* or *gas-filled* types, and in two sizes of each.

Information and prices on application

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for "B" Power Eliminators

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Write for further information on any of this equipment

RAYTHEON MFG. CO.
CAMBRIDGE, MASS.

No. 258 RADIO BROADCAST Laboratory Information Sheet **February, 1929**

An Analysis of Filter Circuits

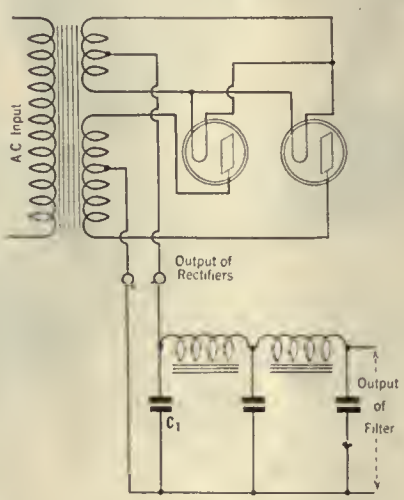
ON LABORATORY Sheet No. 259 are given a circuit diagram and set of curves showing the output voltage from a typical full-wave rectifier using two 281-type tubes. These curves will prove helpful in determining what voltage is necessary across the power transformer to deliver a given voltage to the filter system. The curves show the output of the rectifier with transformer voltages ranging from 550 volts per plate up to 700 volts per plate.

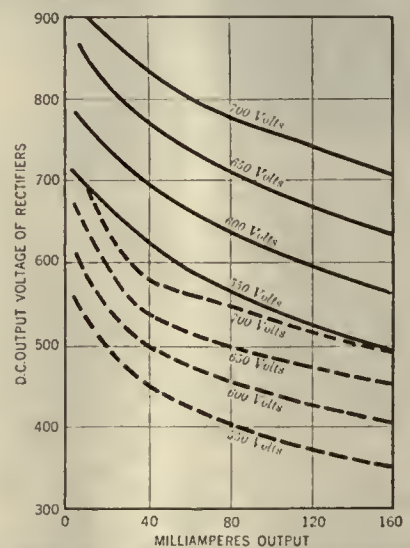
Two sets of curves are given, one set being obtained with the standard filter system indicated in the circuit diagram and the other with a special circuit recommended by the E. T. Cunningham, Inc. The solid curves show the voltages with a standard filter system and the dotted curves show the voltage with a special filter system. In determining the latter curves the first filter condenser, C_1, was omitted.

When using the standard type of filter system the load on the tube is quite heavy and the peak value of current, which the rectifiers are called upon to supply under full-load conditions, reaches values as high as 310 milliamperes, although the average current drawn from the filter system is only 125 milliamperes; the filament must be capable of supplying the maximum value of current, i.e. 310 milliamperes. With the first condenser, C_1, removed from the filter system the voltage output for a given transformer voltage decreases considerably, as indicated by the curve, but with this condenser removed the tube operates under much more satisfactory conditions. The peak value of current used in such a circuit is only 140 milliamperes when the load current is 125 milliamperes. In other words the peak current has been reduced from 310 milliamperes to only 140. This reduction increases the life of the filament, and a tube having a total emission of 150 milliamperes will still give satisfactory operation in the special filter circuit although it would not function satisfactorily in an ordinary filter circuit where the plate current reaches values up to 310 milliamperes. It is recommended that this special filter system be used wherever possible.

No. 259 RADIO BROADCAST Laboratory Information Sheet **February, 1929**

Filter Circuit Characteristics





No. 260 RADIO BROADCAST Laboratory Information Sheet **February, 1929**

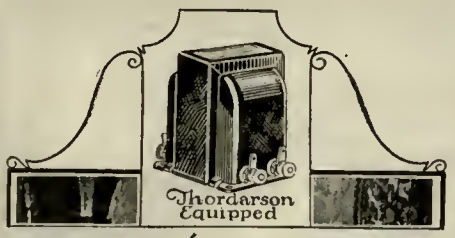
Voltage Gain in Resistance-Coupled Amplifiers

LABORATORY Information Sheets Nos. 242, 243, 249, and 250, discussed resistance-coupled amplifiers; the latter two sheets gave the circuit diagram and a list of parts for the construction of a good amplifier of this type. In this sheet further data is given regarding resistance-coupled amplifiers in comparison with other types.

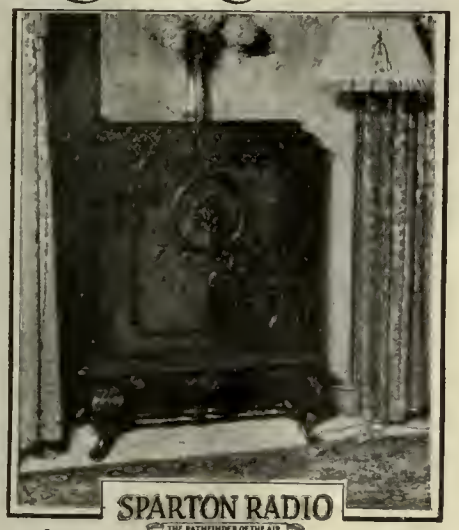
The overall voltage gain in a resistance-coupled amplifier is generally much greater than that of a transformer-coupled amplifier. For example, a standard two-stage transformer-coupled affair has a voltage gain of about 100 from the input to the grid of the power tube. The usual three-stage resistance-coupled amplifier using high-mu tubes has a gain of about 400 from the input to the power tube's grid. This additional gain is not always an advantage. If such an amplifier is used in a receiver operated entirely from batteries this high gain will simply have the effect of increasing the loudness of the signals, but if such an amplifier is used in a receiver operated from a B-power unit it is probable that the hum output will be much greater than it would be if a two-stage transformer-coupled amplifier were substituted for it. This is due to the fact that, as pointed out in Laboratory Sheet No. 261, the hum voltage developed across the loud speaker is a direct function of the overall gain of the amplifier and the amount of hum introduced into the detector circuit. Since the amplifiers have a ratio of about 4:1 in gain, the hum voltage developed when using the resistance-coupled amplifier will be about four times as great, assuming that all other conditions remain the same.

For these reasons it frequently is advisable to construct the resistance-coupled amplifier with somewhat lower gain. For example, if instead of using two 240 tubes we use one 201A and one 240 then the overall gain will be about 150 which is a very satisfactory value.

For some reason the resistance-coupled amplifier has not found wide use in manufactured or home-constructed receivers although when properly designed it is certainly capable of giving results as good as any other type of amplifier.



Thrilling Tone Purity "Radio's Richest Voice"



We hove now been using Thordarson tronsformers for some four yeors, which should be proof conclusive thot we think them copoble of mointoining the high quality of Sparton Rodio Receivers, which we so jeolously guord.

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THE manufacturers of the world's finest receivers realize the important relationship between the choice of transformers (power supply and audio) and the performance of their instruments. Almost universally they have turned to Thordarson as the source of their transformers.

In Thordarson Power Supply Transformers they have found an efficiency of design, an abundance of power and a constancy of performance that makes their power unit free from service calls; and in Thordarson Audio Transformers a fidelity of reproduction that renders their receivers musical instruments of the highest caliber.

The purchaser and builder of radio receivers who seeks the ultimate in performance will insist on Thordarson Radio Transformers.

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Transformer Specialists Since 1895
Huron, Kingsbury and Larrabee Streets
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RADIO
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Supreme in Musical Performance

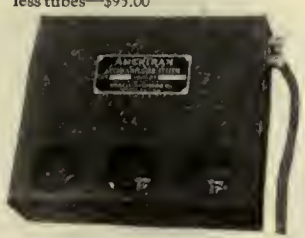


"Isn't it about time, Dad, you eliminated the adenoids"

ANY set with inferior transformers has adenoids. Why not have your set give you what it is capable of—its a mighty simple thing to eliminate the adenoids from your set — and to substitute true tones as given by AmerTran radio products.



AmerTran ABC Hi-Power Box—500 volts DC plate voltage, current up to 110 ma; AC filament current for all tubes for any set. Adjustable bias voltages for all tubes. Price, east of Rockies—less tubes—$95.00



Complete 2 stage audio amplifier. First stage AmerTran DeLuxe for UX 227 AC and second stage AmerTran Push-Pull for two 171 or two 210 Power Tubes. Price, east of Rockies—less tubes —$60.00.

No matter what your set is you have yet to hear the music as it is broadcast from the studio with all of the overtones and shadings from the lowest stop on the organ to the piercing note of the piccolo.

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AMERICAN TRANSFORMER COMPANY
Builders of Transformers for more than 29 years
71 Emmet St. Newark, N. J.



Safeguard Your

A. C. Installation

SATISFACTORY and economical operation of A. C. receivers is contingent upon maintaining close regulation of operating voltages, by means of suitable A. C. measuring instruments. This is necessary because of the wide fluctuation in the potential of secondary lines furnishing current to house lighting circuits.

Set manufacturers, dealers and electric light and power companies everywhere are cooperating to the end that voltage regulation, both on supply lines and in connection with voltage control equipment of the receivers themselves, may be effected for the better operating service of all set owners. For this reason, as well as for other testing requirements outlined in the following, all purchasers of A. C. receivers are urged to provide themselves with an instrument such as is shown in the illustration—known as the Weston Model 528 A. C. Voltmeter, range 150/8/4 volts.

When you find that there is an excessive in-put voltage, it follows that there is too high a voltage on the filament which shortens the operating life of the rectifying tubes. The Model 528 Voltmeter therefore checks the line supply voltage at all times and indicates when adjustments should be made to manually operated line voltage regulators between the power supply and the power transformer.

This voltmeter also indicates when the line voltage is over-rated, thus enabling the operator to make an adjustment in the set for the higher line voltage so that normal life can be obtained from his tubes.

The Model 528 is also made as Ammeters which are especially useful in checking the total load of the A. C. Set—in conformity with set manufacturers' instructions. The determination of A. C. filament flow in A. C. tube filament circuits is easily obtained by means of this instrument.

Write for your copy of Circular J fully describing the Weston Radio Line.

Weston Electrical Instrument Corporation

604 Frelinghuysen Ave.,
Newark, N. J.

WESTON
RADIO
INSTRUMENTS

No. 261 RADIO BROADCAST Laboratory Information Sheet **February, 1929**

Where A. C. Hum Originates

THE amount of a.c. hum audible in a loud speaker connected to a radio receiver depends upon various factors. With a given installation, however, the hum depends to the greatest degree upon the amount of a.c. ripple introduced into the plate circuit of the detector tube. This hum voltage may come from the B-power unit or from a.c. tubes, and in a.c. sets some hum is, of course, obtained from both of these sources.

It is important to realize the importance of any hum in the detector circuit. Consider an ordinary transformer-coupled amplifier using, say, a 3 to 1 ratio transformer between the detector and first a.f. tube, and assume that the first a.f. amplifier tube has a mu of 8. Between the plate circuit of the detector tube and primary winding of second a.f. transformer the gain is, therefore, 24. It follows from this calculation that, if a given amount of hum is obtained from a loud speaker when there is a certain hum voltage in the plate circuit of the first a.f. tube, that the same amount of hum will be obtained with only one-twentyfourth as much hum voltage in the plate circuit of the detector tube. For these reasons it generally is found that amplifiers which are noisy under normal operation are generally quiet if the output of the detector tube is short circuited—a definite indication that the major part of the hum arises in the detector circuit.

Let us consider a concrete example. Suppose that we have a two-stage a.f. amplifier with 3 to 1 transformers, the first audio tube having a mu of 8 and the power amplifier having a mu of 3 and that the load resistance in the output is equivalent to 4000 ohms. Assume that a hum potential of 0.1 volts is existant in the plate circuits of the detector tube and also the first audio amplifier. The hum voltage from the plate circuit of the first a.f. amplifier circuit will produce a hum potential of a 0.6 volts across the 4000-ohm load resistance. The hum voltage in the detector circuit will produce 14.4 volts in the load circuit. Even assuming that these two voltages are 180 degrees out of phase so that they oppose each other the voltage in the load circuit would be 13.8 volts. It follows from these figures that practically all the hum in the output will come from the detector circuit. The importance of proper design in the detector circuit to eliminate any small hum voltages cannot be overemphasized.

No. 262 RADIO BROADCAST Laboratory Information Sheet **February, 1929**

Advantages of Dual Push Pull

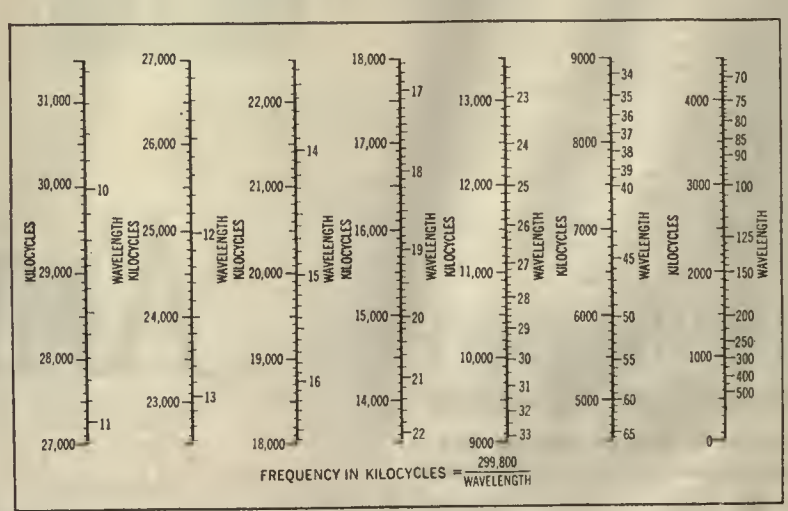
HIGH-GAIN a.c.-operated power amplifiers, designed particularly for use in public-address systems, frequently make use of two 250-type tubes in push pull in the output. If these tubes are operated at their rated voltage in order to obtain the maximum amount of undistorted power a total value of peak signal voltage across the secondary of the push-pull transformer feeding these tubes must be about 160 volts. Assuming that this transformer has a ratio of 3 to 1, the voltage across its primary must be 160 divided by 3, or approximately 53 volts. If the tube feeding this transformer has a mu of 8 then the voltage on its grid must be about 7 volts, and, in order to prevent the possibility of overloading, the grid bias should, therefore, be twice this value plus about 10 per cent. or 15 volts. We might consider using a 226-type tube to feed the push-pull stage, but the maximum rated voltage of this tube is 180 volts with a corresponding grid bias of 13.5 volts which, from the figures given above, is not sufficient.

It is for this reason that we find many of the power amplifiers disigned for public-address work consisting of two push-pull stages, the power output stage being fed by a preceding push-pull stage using 227- or 226-type tubes. Through the use of the push-pull arrangement we are able to handle voltages somewhat greater than twice that which can be handled by a single tube. These tubes in push-pull can then handle without difficulty the voltages required to load up two 250-type tubes in push-pull. It follows obviously, from these figures, that any power amplifier using 250-type tubes in push-pull must be preceded by a push-pull stage if maximum output is desired, since a single 226- or 227-type tube will be badly overloaded when called upon to supply the necessary voltages. The above discussion, of course, does not consider the possibility of using a small power tube in the circuit preceding the push-pull stage.

If we assume that we can obtain from the detector circuit about 0.3 volt and that 160 volts are required on the grids of the power tubes, it follows that the gain in the amplifier must be about 530 (160 divided by 0.3). The gain of an ordinary amplifier, is about 100 and, consequently, when using 250's in push-pull it is essential that a three-stage audio amplifier be used.

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Wavelength-Kilocycle Chart



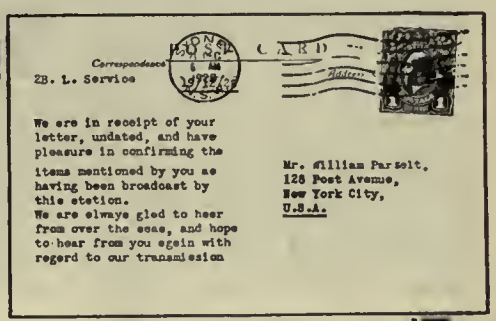
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Australia to New York— Verified Reception

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The great Sargent-Rayment 710 —aptly termed "The Boss of the Air." Everything the most fastidious listener might want—an ultra-sensitive and knife-edge tuning set, which can, nevertheless, be operated when desired as a real one-dial set—with tone quality unsurpassed even in sets not designed for unusual selectivity. All this at $130.00 for the KIT, or $175.00 WIRED—both prices including cabinet!

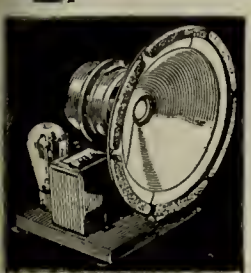


AUSTRALIA to New York City on 353 meters! Direct verification from Station 2BL in Sydney, New South Wales, to a listener by the Hudson—one of the many thousands who have successfully employed the S-M Sargent-Rayment Seven to break through congested local interference.

We congratulate Mr. Parzelt on this feat of reception, and are happy to be able to supply, to all who desire it, a receiver of such caliber.

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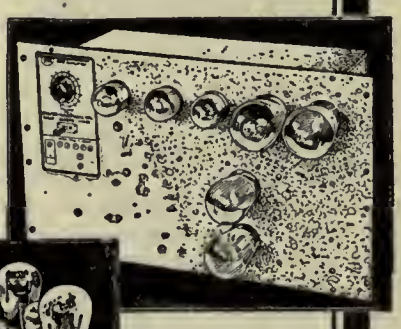
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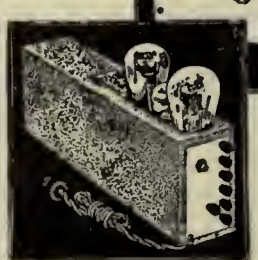
Find out today about the remarkable things that can be done with an amplifier delivering such tremendous power output as 15,000 miliwatts—from phonograph, microphone, or radio-detector input—with three-point switch on the panel, as well as a knob giving smooth fading control whatever input is being taken.

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And the S-M 678PD—powerful enough for small theatres and almost any dance hall, yet priced so low as to be ideal for the home also—supplies, by use of the S-M Clough audio system, the full undistorted power of a '50 type tube to any 110-volt D. C. dynamic speaker; supplies field current also. All power taken from 110-volt A. C. light socket. Price WIRED $73; complete KIT $65.

Get the new S-M catalog—and begin today to look about you for the opportunities that exist everywhere to make good money by installing S-M amplifiers.





Above
S M 690

Left
S-M 678PD

The Radiobuilder, a monthly publication telling the very latest developments of the S-M laboratories, is too valuable for any setbuilder to be without. No. 9 (Jan. 1929) gave full particulars about the new apparatus described above, long before it was available in any other form. Send the coupon for free sample copy, or to enter your subscription if you want it regularly.

If you build professionally, but do not have as yet the S-M Authorized Service Station appointment, ask about it.

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....No. 6. '40" Coast-to-Coast" Screen Grid Four
....No. 7. 675ABC High-Voltage Power Supply and 676 Dynamic Speaker Amplifier
....No. 8. Sargent-Rayment Seven
....No. 9. 678PD Phonograph Amplifier

Name.....

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. . . *among other things*

THE issue before you might be called a special tube number. In addition to the series of charts and explanatory curves which accompany them, we present the article by K. S. Weaver of the Westinghouse Lamp Company on the characteristics of the 250-type tube, some data in "Strays from the Laboratory" on new English tubes of interest, and a useful article by G. F. Lampkin on the use of a vacuum tube circuit to measure very small values of a.c. with inexpensive apparatus.

WE CALL especial attention to the new section of RADIO BROADCAST, "In the Radio Marketplace." This new news section of the magazine will, as our plans develop, become increasingly useful to every reader who is in the radio industry. A new feature, prepared with much the same purpose as our famous "Laboratory Data Sheets," appears in the "Marketplace" this month. It is the "Radio Dealers' Notebook" containing complete information every month on one subject of interest to those who serve the public, radio-wise. We welcome suggestions as to how this feature can be broadened to be of increased value. The article by Charles Williamson on page 299 describing an automatic volume control should be of interest to experimenters and to advanced servicemen who may find it possible to install the device on receivers owned by their clients who are interested in owning the latest improvements.

THE April RADIO BROADCAST will contain among many others, an interesting article by Roger Wise on "Characteristics of Filament Type Rectifiers," illustrated with many tables and curves; the second article by Prof. Terman on "Detection" will appear, this one being devoted to "power detection"; and, a story by K. W. Jarvis on "Selectivity"—a subject on which much should be said because increased attention is being devoted to it.

MANY radio companies are sending printed matter by mail to radio dealers and radio service organizations, particularly the former. Much of what they send is of prime interest to servicemen and the technical head of the business, who, parenthetically, is often one and the same person. It is an unfortunate fact that as things are, much of this information which servicemen really could use never reaches them. The answer? Well, we would rather the mail be addressed to the serviceman or technician than campaign to change the habits of the dealer who offends.

WILLIS KINGSLEY WING.

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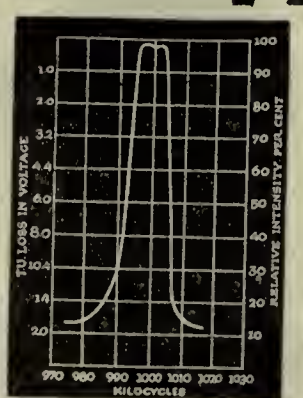
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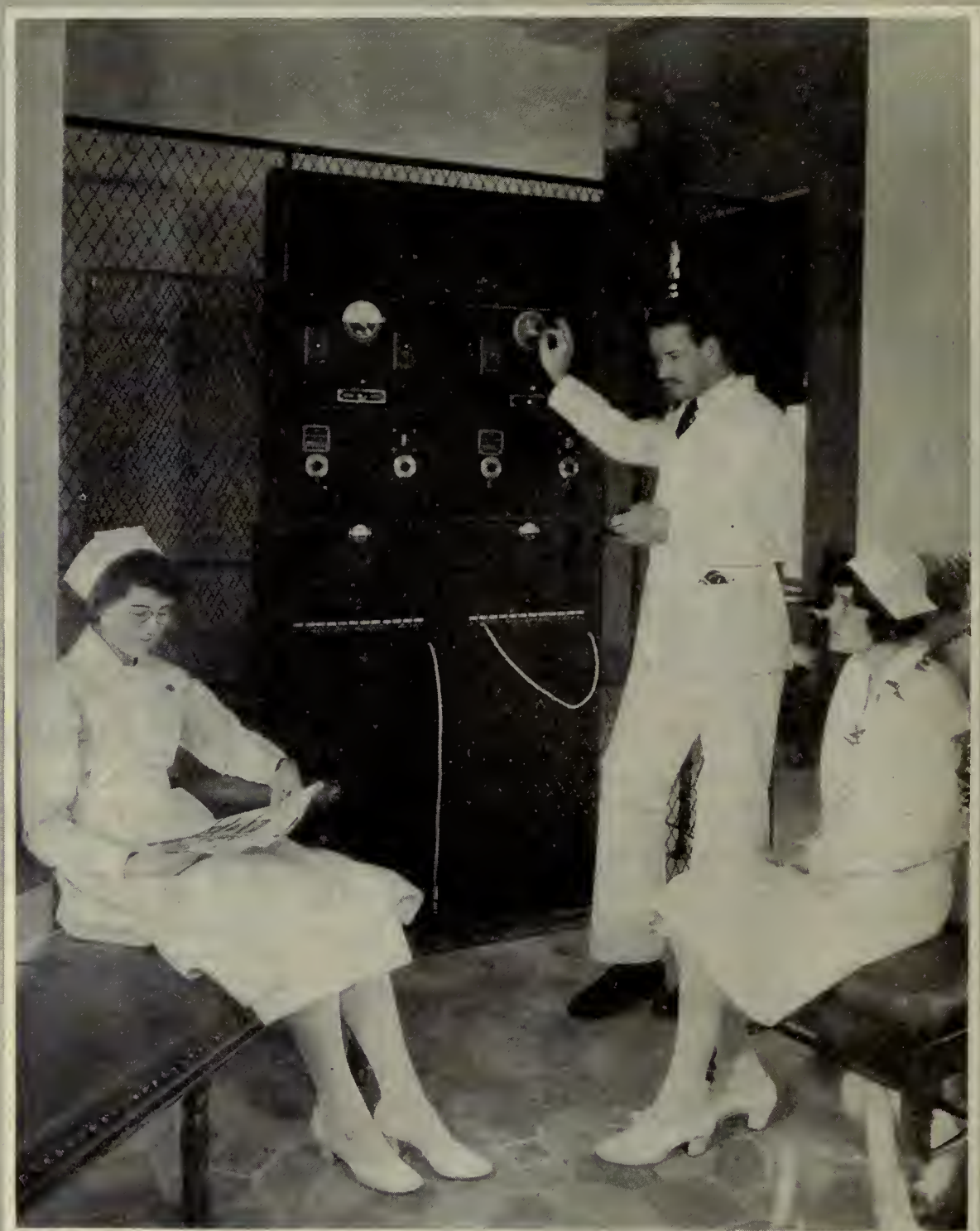
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DE LUXE RADIO SERVICE AVAILABLE IN UP-TO-DATE HOSPITAL

A centralized two-channel radio program distribution system has been installed in the Knickerbocker Hospital, New York City, by the Radio Corporation of America. Loud-speaker and headphone outlets are located in each of the various wards as well as the rooms occupied by the hospital staff. At any of the outlets the listener has a choice of tuning-in either one of the two programs which are being distributed. This picture shows an operator adjusting the control-panel dials of the new installation.

A Device for Apartment Houses

A MULTIPLE-RECEIVER ANTENNA SYSTEM

By V. D. LANDON

Westinghouse Electric & Manufacturing Company

THE nondescript tangle of antennas on the roofs of most large apartment houses is a familiar sight and a frequent source of comment. The opinion most often expressed is that human ingenuity should be able to find a more systematic method of providing the tenants with reception facilities. Nevertheless, no such method previously has made its appearance, the problem being left almost entirely to the devices of the individual tenants.

The result is a maze of wires on the roof which is anything but artistic. It is the "roof jungle" of the modern city. A typical "jungle," which is a sample of what is seen for mile after mile from an elevated train in New York, is shown in Fig. 1.

The "jungle" is not only an eyesore for the landlord, but it results in a great deal of building defacement as well. Nails are driven, holes are bored, and grooves are cut. The ideas as to how it should be done are different with each succeeding tenant. Fig. 2 illustrates the careless way in which many antennas are installed by apartment-house tenants.

In a few instances, this system, or lack of system, has been replaced by a more orderly arrangement supervised or constructed by the building owner. This is usually an improvement from an artistic standpoint, but the radio reception provided is seldom satisfactory for several reasons. The antennas are usually only a few feet above the roof of the buildings and, as practically all modern buildings are of steel framework, which is an excellent ground, the effective height of the antennas is very low. The long lead-in wires, which are usually necessary, have a large capacity to ground which has the effect of partially bypassing what little signal is introduced into the antenna. Although these long lead-in wires do more harm than good in picking up signals, they are very effective in picking up the noise from the various kinds of electrical machinery distributed about the building. Also the close proximity of all these antennas causes a number of undesired effects. If receivers are used that employ tuned input circuits, it will be found that when one receiver is retuned, a change in tuning becomes necessary in the other sets in the building. If some tenants have receivers capable of oscillation, the reception of the others is often interfered with. In addition, each antenna tends to shield the others from the signals.

This article by Mr. Landon of the Westinghouse Company gives technical data on a system of supplying a large number of radio outlets in an apartment house, from a single antenna located on the roof, each outlet making available to the particular apartment in which it is located a signal comparable in strength to that obtained from a good antenna. One good antenna may be used to supply about 100 outlets. The exact arrangement of the system varies depending upon the number of outlets to be supplied and their arrangement—each installation is to a varying extent a special job.

—THE EDITOR.

The result of all this is that an overwhelming demand exists for a satisfactory system of distributing radio signals to tenants. The situation is so acute that builders have expressed a willingness to delay their building program if such apparatus would be available at an early date. Many owners report tenants changing apartments in trying to find a location having good reception facilities.

A New System

THE following describes a system which solves the problem in a manner thoroughly satisfactory to both tenant and owner. The "roof jungle" of antenna wires are replaced by a single antenna of attractive appearance and efficient design. The signals from the common antenna are distributed at radio frequency to each apartment in the building, over conductors which are enclosed in metallic conduit.

Each apartment is equipped with a radio-outlet plate containing antenna and ground terminals. When a radio receiver is connected to these terminals, it will perform in the same manner as though it were connected to a very good isolated antenna. Fig. 5 shows a schematic diagram of an installation.

The received signal causes a radio-frequency voltage drop across R_1 and this voltage is fed to the grids of the amplifier tubes in the antenna-coupling units. There may be any number of antenna-coupling units up to about ten, used on one antenna. These are located on the roof in the pent house. The radio-frequency transformer, T_1, in the plate circuit of each of these tubes feeds a transmission line, or distribution riser which leads to several apartments. The coupling tube or "extension unit" in an individual apartment passes the signal on to the individual receiving set through another radio-frequency transformer T_2.

The unique virtues of this system are:

1. The high signal intensity obtained.
2. The total absence of interaction between receivers.
3. The elimination of the pick-up of interfering electrical noise on the distribution system.
4. The efficient transmission of signals at all frequencies in the broadcast range at the same time.
5. The economy of initial cost and maintenance.
6. Ease of installation.
7. Businesslike arrangement and attractive appearance of the whole system.

A high signal intensity is obtained by the use of a single really good antenna and an efficient distribution system. Interaction between receivers is eliminated by placing a coupling tube in each apartment. Thus a change in the tuning of any receiver does not affect the impedance of the distribution riser in the least. Furthermore, if a receiver oscillates, the generated high-frequency energy does not get past the coupling tube and, hence, does not interfere with the reception of others, except insofar as radiation takes place directly from the coils of one receiver to those of another. Thus interference due to the neighbor's hirdies is reduced greatly.

The interference caused by the operation of the various types of electrical machinery about the building is minimized. Of course, that portion of the radiated noise which reaches the antenna high above the roof, will come through. However, the strong electrical fields close to this machinery will not be picked up by the distribution risers. Any voltage induced in the transmission line wire is induced in the enclosing conduit as well and there is no effective input voltage between grid and filament of the coupling tubes from this source. This will often mean the difference between good reception and poor reception in buildings where noisy electrical machinery is in use.



Fig. 1—View of the "roof jungle" of radio antennas in a New York City apartment-house district. The r.f. distribution system described in this article would correct this condition

Principle of System

EFFICIENT transmission of signals at all frequencies of the broadcast band simultaneously, is obtained by the use of the principles of the loaded transmission line. The grounded neutral circuit (similar to that of a push-pull amplifier) is necessary to eliminate ground current in the conduit which would prevent proper loading of a single sided line. The radio-frequency transformers are used in the plate circuits of the coupling tubes to match properly the tube impedance to the load.

A feature which is essential to the practicability of the system is the centralization of the B supply for the coupling tubes, since the cost of supplying a separate B-power unit for each tube would be prohibitive. One B supply is used for each antenna-coupling unit and all the extension units tapped off the associated distribution riser. This is better than a single large B supply for the entire system because it makes a more flexible arrangement, better adapted to fitting a wide variety of building sizes.

The arrangement for using the r.f. distribution wires for carrying minus B, and the grounded conduit for carrying plus B, is rather unique and effects a distinct saving in apparatus required. As may be seen in Fig. 5. the grid of the coupling tube is connected directly to the line. The signals are prevented from flowing to the filament by the r.f. choke. The d.c. plate current flowing in the resistor R_c supplies bias voltage for the grid. The condenser C_f keeps the filament at ground potential to the signal voltage. The pipe and box are connected to the positive B that is used as the source of B voltage for the plate. The power transformer lights the filament of the tube. If the negative side were grounded and the positive side on the line, as would be more conventional, it would be necessary to add a grid leak and two condensers to each coupling-tube box to obtain equivalent operation.

The economies effected by this method of centralization of B supply, make the cost per apartment of the installation only about the same as the cost of a real good antenna for each apartment.



Fig. 2—Each tenant develops a different way to erect an antenna. The above picture shows the careless construction of a typical apartment-house antenna

The entire system is as easily installed and as "fool-proof" as the wiring for the electric lighting circuits. The distribution risers are run in standard half-inch steel conduit (with no appreciable increase in attenuation—to the surprise of many). Where possible, these risers are run vertically from the roof to the ground floor. Any number of coupling tube boxes from one to five may be tapped off on each floor. However, the usual number will be one or two per floor in multi-storied building, since ten coupling tubes is the practical maximum set for one riser. A set of loading coils is inserted in the line on every other floor.

Coupling Boxes Described

THE coupling-tube boxes of both the central and apartment types are sunk into the walls and covered with flush cover plates. Fig. 4B provides an interior view of a coupling-tube box showing the location of the filament transformer, the tube, and the radio-frequency transformer.

The coils seen just above the filament transformer constitute a set of loading coils for the line. If the coupling-tube box is not in a position where the loading coils are needed, they are omitted. If a set of loading coils is required at a point remote from any coupling-tube box, another type of box is used to mount them separately.

The electrical portion of the coupling-tube box is held in place by two screws. This unit is not inserted in the box until the rest of the installation is complete, thus minimizing the number of damaged units. This assembly is shown in Fig. 4A.

The unit going in the antenna-coupling-tube box is the same except that a slightly different r.f. transformer is used. This is shown in Fig. 4C. The r.f. unit is seen in the top of the box. The bottom of the box contains the B-power unit for one transmission line.

A special outlet plate is installed in each apartment. Antenna and ground pin jacks are provided and also a socket for plugging in a socket-powered receiver. The switch turns off the power on the receiver and on the filament of the coupling tube for that apartment.

The theory of the design and operation of the distribution system is somewhat involved but an attempt will be made to give it in sketchy form. The design is based on the principle of the low-pass filter or loaded transmission line shown in Fig. 3B. The formulas applying to this circuit are:

$$R_t = \sqrt{\frac{L}{C}}$$

$$f_c = \frac{1}{\pi\sqrt{LC}}$$

where f_c is the cut-off frequency. As shown in the operation curve, higher frequencies than f_c are attenuated to a degree which increases rapidly as the frequency is increased. Lower frequencies are transmitted with practically no loss. If E volts is applied at a frequency lower than f_c in series with the first resistor, R_t (commonly called the generator resistance) then E/2 volts will appear across the terminal resistor R_t, providing the circuit is so balanced that the two equations are fulfilled.

Fig. 3A shows a grounded neutral circuit. These same formulas apply to a grounded neutral circuit when the inductance used for L is that of the two loading coils of one section of the line in series, and the capacitance used for C is the capacitance of one side of the line to the other side, for a single section between loading coils. The distributed inductance of the wires is negligible in this case as telephone twisted pair is used and there is very little space between wires.

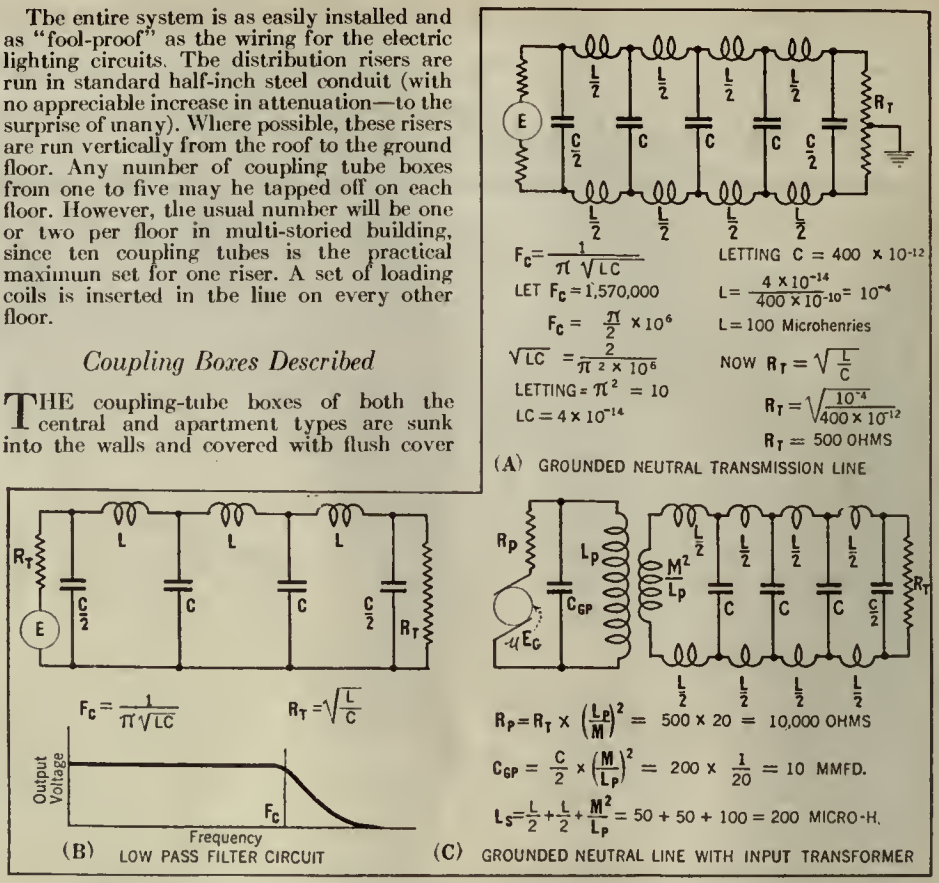


Fig. 3—These circuit diagrams and formulas explain the operation of the apartment-house r. f. distribution system described by the writer

Solving the Formulas

THERE are then a pair of simultaneous equations with four unknowns. Clearly any two of the variables may be fixed at any desired values and the corresponding values of the other two variables are then determined by the two equations.

The easiest value to fix is f_c. A convenient value for arithmetical simplicity and for practical reasons is:

$$f_c = 1{,}570{,}000$$
$$\text{then } LC = 4 \times 10^{-14}$$

If a convenient value is assigned to L, C, or R, the other two values will then be fixed by the two equations. It is most convenient to have the loading coils a distance apart equal to a multiple of the distance between floors in a building since the coils may then be placed in the coupling-tube boxes and special boxes need not be provided and mounted. A handy distance is every two floors, as will be seen. This length (20 or 22 ft.) of No. 18 telephone twisted pair has a capacity of a little

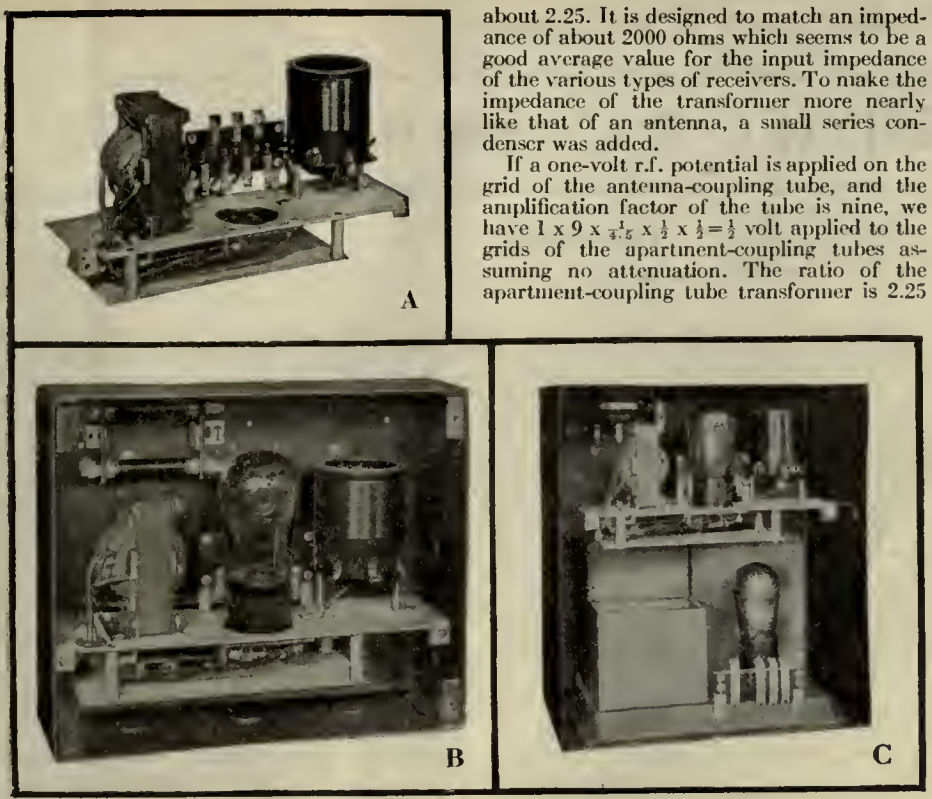


Fig. 4—Pictures of the apparatus used in an apartment-house r. f. distribution system. A shows the electrical portion of the coupling-tube box, B is an interior view of the coupling-tube box, and C is a view of the antenna-coupling box

about 2.25. It is designed to match an impedance of about 2000 ohms which seems to be a good average value for the input impedance of the various types of receivers. To make the impedance of the transformer more nearly like that of an antenna, a small series condenser was added.

If a one-volt r.f. potential is applied on the grid of the antenna-coupling tube, and the amplification factor of the tube is nine, we have $1 \times 9 \times \frac{1}{4.5} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{2}$ volt applied to the grids of the apartment-coupling tubes assuming no attenuation. The ratio of the apartment-coupling tube transformer is 2.25 so that $\frac{1}{2} \times 9 \times \frac{1}{2.25} \times \frac{1}{2}$ or 1 volt is applied to the radio receiver input circuit if its input impedance is 2000 ohms, so as to produce an impedance match. If the impedance is other than 2000 ohms, the input voltage may be greater or smaller but operation has been quite satisfactory with every type of receiver yet tried.

Some time ago a test was made to convince a certain apartment-house owner of the utility of the system. A comparison was made of the sensitivity of a receiver using first, the type of antenna to which he had been limiting his tenants and second the distribution riser to a good antenna 80 ft. long and 30 ft. above the roof. The antenna used for direct connection to the set consisted of about the same length of wire as was used in the antenna on the roof. This wire ran out of a window on the ground floor, up the side of the six-story building and had a ten-foot horizontal section at a height of about 10 ft. above the roof.

The distribution riser delivered more than twenty times the radio-frequency voltage from a local station than the direct-connected antenna provided. This proved that the grounded framework of the building shielded the direct connected antenna very effectively.

The aim of the entire system is to provide signals at each receiver outlet plug which will be the equivalent of what would be obtained if the receiver were located on the roof and had the antenna all to itself.

Since the antenna is to supply such a large number of people, most building owners will find it worth while to put up a really excellent antenna when installing this system. When this is done, the apartment is transformed from an exceedingly poor radio location to one in which reception is exceptionally good.

over 300 mmfd. Allowing about 50 mmfd. apiece for an average number of coupling tubes (two) gives a line capacity of 400 mmfd. Solving for L: (See Fig. 3A):

$$L = 100 \text{ Microhenries}$$
$$R_t = 500 \text{ ohms}$$

A hundred feet of line having these characteristics is found to transmit signals over the entire broadcast band with a negligible amount of attenuation. The length of each section of the line is not very critical. It may be varied 25 per cent. with no bad effects.

Designing the Transformer

REFERRING to Fig. 3c, a further feature to consider is the design of a suitable transformer to match the plate impedance of the tube (10,000 ohms) to the 500-ohm load. This requires a step-down ratio of the square root of 20 or about 4.5 to 1. Since it is impractical to build a 100 per cent. coupled transformer, the leakage reactance must be used as the loading inductance of the first section of the line. The inductance of the primary must be great enough to make an effective transformation at the lowest frequency of the band.

Two millihenries is found sufficient for the primary. That portion of the secondary which may be considered 100 per cent. coupled to the primary must have an inductance of 0.002 divided by 20=100 microhenries. Adding to this the leakage reactance of 100 microhenries gives a transformer with a 2000-micro-henry primary a 200-microhenry secondary, a mutual inductance of 450 microhenries and an effective ratio of transformation of 4.5.

It should be noted that the tube's plate-filament capacity (10 mmfd.) multiplied by the square of the transformation ratio (i.e. 20) supplies the correct terminal capacity for the low-pass filter (i.e. 200 mmfd.).

The design of the output transformer of the apartment-coupling tube is obtained by following a similar line of reasoning. Its ratio is

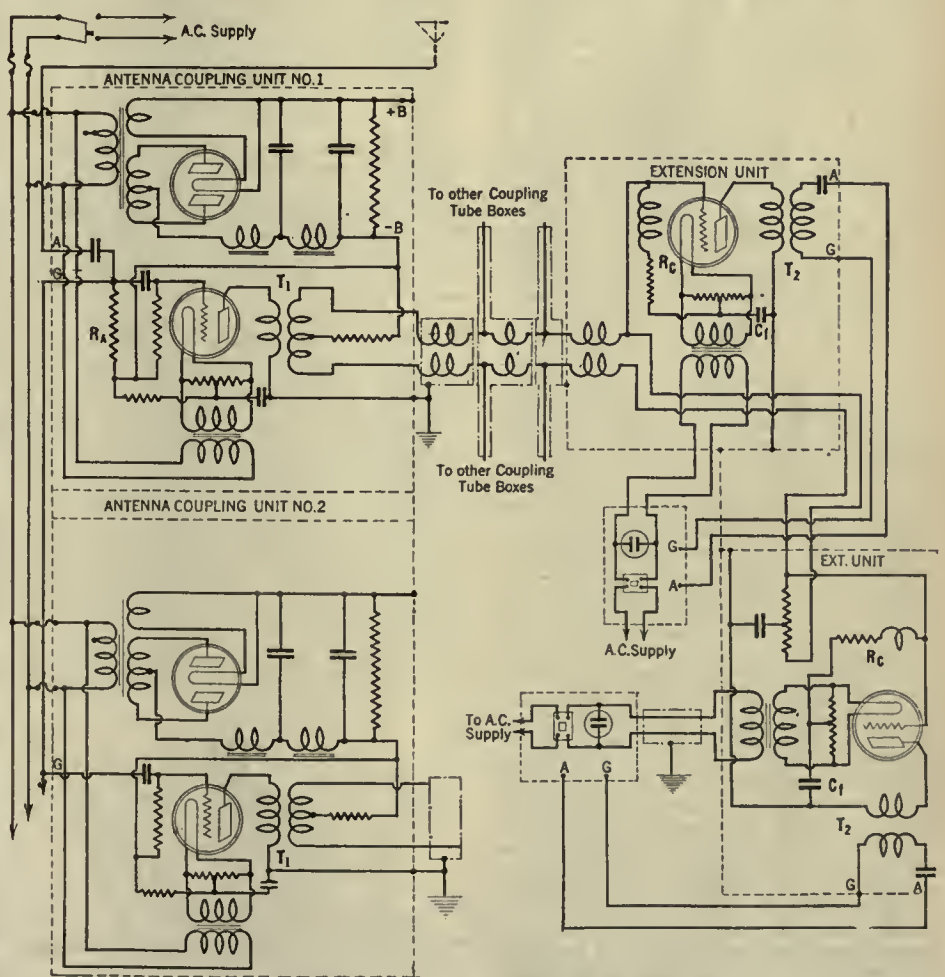


Fig. 5—Schematic wiring diagram of a typical r. f. distribution system of the type designed for apartment house use

To Increase His Efficiency

WHAT THE SERVICE MAN SHOULD STUDY

By JOHN S. DUNHAM

QRV Radio Service, Inc.

BEFORE we delve into the large subject of methods whereby recalcitrant radio receivers may be induced to play again sweet music, which we shall do in following articles, we might profit by a discussion of the elements of knowledge which the serviceman needs to have if he is to be a really good serviceman instead of just an "expert." There are two definite forms of knowledge the gaining of which the serviceman may pursue, and a definition of what each is, plus what each will do, will give us some basis for deciding their relative importance.

Service-Manual Knowledge

LET us first consider the man whose radio knowledge is limited to a thorough acquaintance with the kind of service data presented in manufacturers' service manuals. He knows the physical layout of a number of makes and models of receivers. In a particular model, he knows the name of each part and it's exact placement, the number of each tube socket, and the types of tubes which correspond to the socket numbers. He knows to which socket prong or to what terminal of which canned up something-or-other "unit" each wire from each numbered terminal lug goes. He knows by heart the fact that, testing with a C battery in series with a high-resistance meter, the proper effect from lug number 2 on the left-hand terminal strip to prong 3 in socket 7 is a full reading of the battery potential on his voltmeter, and that if he does not get such a reading there it will then be necessary to replace the coupling, audio, or power assembly which is catalogue number 3452. He knows in detail exactly which shields, controls, and screws to remove and which wires to unsolder in order to remove that part for replacement, as well as exactly the quickest and easiest way to install the new part.

The man who has that sort of knowledge, all of which can be memorized, like dates in history, from the service manuals put out for dealers and distributors by all reputable manufacturers, can do a number of things with it. Servicing a given model and its associated apparatus, with which he has become familiar by studying the manual and by actual practice on that model, he can find and cure all of the ordinary run of troubles in nearly the minimum of time required. He can also find and cure, from instructions given in the manual, most of the more usual antenna-ground system troubles. If the customer is present, he will give the impression, by the ease and rapidity with which he works, that he is a thoroughly competent, highly trained serviceman. Those things are assets which are unquestionably of great value to every serviceman and every service organization.

But, suppose that this man is called upon to service a receiver, of even the same general type as some of those with which he is intimately familiar, the service manual for which he has been unable to obtain, or having obtained one has not even looked at it. (Servicemen have been known to neglect those things, alas!). Suppose also that the chief engineer employed by the maker of this set has unique (and always superior) ideas of the proper placement of sockets, terminal strips, wires, and other parts. The serviceman with only the kind of radio knowledge we have described would be completely at sea, and, on that particular job, he would be a total loss to both himself and his organization.

Even taking for granted that a serviceman could obtain all the service manuals for all the models of receivers put on the market by the large number of reputable manufacturers, it is by no means safe to assume that he would be willing to memorize them to the extent necessary if he is to depend upon them as his only source of service information. Neither is it safe to assume that he will never be called upon to service a Ware "T," a Ther-mi-o-dyne, a deForest, or any one of the four-million. sets "designed" and built by an "expert radio engineer" who is always a "personal friend" of the afflicted but innocently enthusiastic customer. The manufactured sets in daily use, the manufacturers of which are no longer extant and for which no service manuals were ever printed, as well as those sets built by individuals, still comprise a very large proportion of the total number of broadcast receivers which are entertaining or annoying—depending largely upon one's degree of musical education—the American nation, and which cannot, therefore, be ignored by servicemen.

Basic Knowledge

LET us now consider the man who has a broad knowledge of the fundamental theories of tube and circuit operation and thorough understanding from experience of how those theories work out in the few basic *kinds* of circuits which are in general use, but who has never seen a manufacturer's service manual. Such a man knows approximately what sort of operation to expect from any receiver, because he is familiar with the general results to be expected of that particular type or combination of types of circuit. He knows approximately what voltages and currents to expect at various points. He knows the order of values of resistors, capacities, and inductances used, and something of the degree of overall gain to be expected. He is capable of servicing *any* make or model of receiver and of solving *any* problem of cause of trouble as well as the problem of curing any specific trouble found, without having to see the service manual for that particular model of receiver. Because of his general circuit knowledge he can trace out the particular circuit arrangement used, to discover where each part is, and because of his basic knowledge of operation of circuits he can determine definitely whether each part is functioning properly. If any part is failing to do its job, he does not need service data sheets to tell him how to determine why, or what to do about it.



If the customer is present the serviceman will give the impression that he is thoroughly competent.

The man who has that sort of radio training derives from his work a degree of real pleasure, by virtue of his ability to apply *technical knowledge* and *logical thought* to the solution of his service problems, which can never be realized by the man who exercises only his memory of picture diagrams of sockets, terminal lugs, and canned units.

Looked at from the standpoint of service efficiency, however, the work of the man we have just described may not be ideal. Service, to be efficient, must be done thoroughly and it must cope adequately with every problem that arises, no matter how complex, but it must *also* be done in the shortest possible time. The man who can find and cure any trouble which exists in any radio receiver by reason of his broad technical knowledge, but who is not also familiar with the physical layout of parts and terminals, color codes, and most of the specific data of that nature given in service manuals, is laboring under a *serious* disadvantage. While he is capable of discovering whatever of those details he may require in order to service properly a particular model, it will take him *far more time* to do so on each job than would be required had he studied the manual. And time, in the radio service business, represents money just as fully as it does in most other lines of endeavor. While most of us are repairing radio receivers rather than selling bonds, neckties, or what-have-you because we happen to like it better, there are few of us who are not also under the necessity of deriving from it our daily bread and frequent larger sizes of small shoes.

Ideal Knowledge

LET us, then, consider the merits of the man who has the kind of memorized knowledge which may be obtained from manufacturers' service manuals, and who also has a broad background of knowledge of the theories underlying the operation of radio receivers in general coupled with extensive practical knowledge of how those theories perform in the types of circuits which are in use.

Such a serviceman can complete the ordinary service job even faster than the man who has only service-manual knowledge, for his additional technical training and experience very often enables him to make a more rapid diagnosis of the trouble, eliminating some of the steps required by the narrowly trained man. He is not stuck by troubles that are unusual, but confidently attacks each job with the unflurried assurance that no matter what the trouble may be, he can discover it, determine its cause, and effectively cure it. Whether he is curing a trouble as simple as the need for replacement of a thoriated-filament tube whose emission has become too low, or a trouble as comparatively elusive as the detuning effect due to imperfect contact, caused by oxidation, between an r.f. stage shield and its base, he makes a very favorable impression on the



A serviceman may be called upon to repair any one of the four million sets "designed" and built by an "expert radio engineer."

customer by the rapid, thorough, and confident manner in which he goes about it. He cures *all* of the troubles in a receiver, for he discovers minor troubles which very often go unnoticed by the narrowly trained man, and when he has finished his work it is rarely necessary to service that set again for a reasonable length of time.

That kind of a serviceman is, so far as his service efficiency goes, the ideal type. If he is working alone, he will be able to make a really adequate living from his work, and he will soon have to employ other servicemen to help him take care of the demand for such unusually good service. If he is an employee, he will help greatly to increase the number of steady customers of his organization, and it follows that his pay will steadily increase and that he will be given larger responsibility as the growth of the business necessitates more executive work.

Acquiring Knowledge

HOW can all this knowledge and experience be acquired? First of all, we must have a *strong desire* to acquire it in order that we may have the great satisfaction of knowing that our work is really well done and in order that we may attain any real degree of success in the work we have chosen to do. Obviously, the man who relies solely upon the practical experience he can get from actually servicing radio receivers, and does not *supplement that with study*, will never be a good serviceman. Neither will study alone make a good serviceman. Practice and study must go hand in hand, each supplementing and guiding the other, and proficiency cannot be attained in a few months, but can only be acquired by years of steady interest and effort.

The best source of detailed knowledge of particular models of receiving sets is the manufacturer's service manual or service-data sheets. Most manufacturers have discovered the hopelessness of the task of instilling into the average dealer the fact that it would pay him to give really efficiency service to his customers, something which was discovered by a good many service organizations a number of years ago. Some few of the more progressive manufacturers have awakened to the fact that, because of the attitude of the average dealer toward service, most of the service on their sets is performed by service organizations after the end of the period during which the dealer gives free service. Wanting those service organizations to perform really good service on their sets, they are more than glad to help by furnishing service data on all models upon receipt of requests written on the business letterheads of such concerns. RADIO BROADCAST has been publishing, starting with the June, 1928, issue, circuit diagrams of manufactured receivers together with some of the important data about resistance and capacity constants, and voltage values, which are of considerable aid in the absence of the more complete data usually furnished by the manufacturer.

For the more interesting, and far more important study of the basic principles, there is no single source which is more complete and authoritative than Professor J. H. Morecroft's book, *Principles of Radio Communication*. It is published in New York by John Wiley and Sons, Inc., and can be obtained directly from them, or from any good bookshop, at a cost of $7.50. The price may seem high, but as an investment in the acquiring of knowledge its worth is tremendously greater. A shorter work, which is excellent but which does not have the same wealth of material, is the Army Signal Corps handbook, *Principles Underlying Radio Communication*, written by Dr. J. H. Dellinger of the Bureau of Standards, with the assistance of six other well-known physicists and radio engineers, and one well-known professor of mathematics. It may be obtained, at the ridiculously low cost of one dollar, from the Superintendent of Documents, Government Printing Office, Washington, D. C. The author of this article strongly recommends that those of you who have not read either of these books write immediately to Washington for the latter, and when you have assimilated all of it, then tackle the Morecroft. One other publication which is an invaluable addition to any radio library is the Bureau of Standards Circular No. 74, *Radio Instruments and Measurements*. It may be obtained, for sixty cents, also from the Superintendent of Documents. If your mathematics has become rusty, or if you did not have enough of it in high school, then there is a textbook by George Howe, *Mathematics for the Practical Man*, which assumes only a knowledge of elementary arithmetic and gives you in a very easily understood form exactly what you need for a thorough understanding of Morecroft. It is published by D. Van Nostrand and Co., New York, and costs $1.50.

While there are a number of current periodicals which contain articles of value, it is the opinion of the author that it is a mistake to attempt to read all of them, and that one good radio magazine is a sufficient supplement to one's study of books. It is also his opinion that RADIO BROADCAST contains a greater amount of material which is of importance to the serviceman than does any other periodical. The "Home Study Sheets," "Laboratory Information Sheets," and "Strays from the Laboratory," which appear monthly, are mines of clearly presented useful information. There also have been, and will continue to be, various technical articles on timely subjects which no radio serviceman can afford to miss if he is to keep step with new developments in the radio art.

List of Books

[In the preceding paragraphs Mr. Dunham has endeavored to point out the sources where the radio serviceman may obtain accurate information on the phase of radio in which he is interested. If the various books referred to are studied carefully it will be found that they answer practically every requirement. However, the Editor appreciates the fact that the ambitious serviceman will desire to have available a number of reference books and the following fairly inclusive list has been prepared to answer this need. The books named



Practice and study must go hand in hand

below are what we consider the more important radio publications and the descriptive sentence following each title will help classify the book in the reader's mind.—*Editor*]

Radio Instruments and Measurements. A 345-page book, presenting information regarding the more important instruments and measurements actually used in radio work. The contents is of interest to all radio engineers. The book is published by the Department of Commerce and is known as Circular No. 74. Obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., for sixty cents.

Principles Underlying Radio Communication. Another government publication to be recommended. This book is quite an excellent elementary textbook of radio and general electricity and may be easily understood by anyone with a fair knowledge of algebra. Everyone should have it. It is known as Radio Communication Pamphlet No. 40, and the Superintendent of Documents, Government Printing Office, sells it for $1.00.

Principles of Radio Communication, by J. H. Morecroft. This is probably the most complete book on radio engineering. The text deals with all phases of the art of radio communication and the treatment is very complete, the book containing about 1000 pages. John Wiley and Sons, Inc., New York City. Price: $7.50.

Thermionic Vacuum Tube, by H. F. Van Der Bijl. An excellent book setting forth the principles of operation of vacuum tubes. It is a very useful book for any radio engineer. McGraw-Hill Book Co., Inc., New York City. Price: $3.00.

Radio Engineering Principles, by Lauer and Brown. A book less extensive than Morecroft's but excellent for those whose requirements are satisfied with a shorter and less expensive text. It is a very scholarly presentation. McGraw-Hill Book Co., Inc., New York City. Price: $3.50.

Radio Frequency Measurements, by E. B. Moullin. A book dealing with the theory and practice of radio measurements. A handbook for the laboratory and a textbook for advanced students. Many of the measurements are made with the aid of the vacuum tube voltmeter. Published in England but it can be obtained from the J. B. Lippincott Co., in Philadelphia. $10.00.

Practical Radio Construction and Repairing, by Moyer and Wostrel. This book aims to be of service to the amateur constructor and radio serviceman. It is essentially practical in its treatment. McGraw-Hill Book Co., Inc., New York City. Price: $1.75.

Practical Radio Telegraphy, by Arthur R. Nilson and J. L. Hornung. A book expressly for radio students preparing to become radio operators. It will also prove useful as a general handbook on the use and care of modern radio transmitting and receiving equipment. McGraw-Hill Book Co., Inc., New York City. Price: $3.00.

The Elements of Radio Communication, by O. F. Brown. This book describes the fundamental principles governing radio communication in simple straightforward language, supplemented by diagrams. The use of mathematical formulas has been reduced to a minimum, although a few algebraical expressions are employed where they are essential. Oxford University Press, New York. Price: $3.50.

Principles of Modern Radio Receiving, by L. Grant Hector. A 305-page book designed to give to the intelligent but non-technically trained man a unified picture of the science of radio and to give some concrete information to the designers, builders and sellers of radio receivers. Burton Publishing Company, Buffalo, N. Y.

Radio Theory and Operating, by Mary Texanna Loomis. A complete textbook of 992 pages covering the theory of radio communication. In addition it aims to prepare the student to become a radio operator and make it possible for him to pass the government radio operator's examination. Loomis Publishing Company, Washington, D. C. Price: $3.50.

Radio, by Elmer E. Burns. An excellent course of study on radio for students with high-school preparation in physics and mathematics. It serves as an effective introduction to an advanced text. D. Van Nostrand Co., New York City. Price: $2.00.

A Treatise on 25 Testing Units for Servicemen, by John F. Rider. This book provides much practical data on the servicing of radio receivers. It describes the construction and operation of many useful laboratory instruments. Radio Treatise Company, New York City. Price: $1.00.

A Laboratory Treatise on B Battery Eliminator Design and Construction, by John F. Rider. This book is a worthwhile addition to a library of elementary radio texts. It sets forth the essential principles of the design and operation of B-power units and is of value to servicemen and set-builders. Radio Treatise Company, New York City. Price: $1.00.

Radio Broadcast's Data Sheets. This book consists of 190 short articles giving concise and accurate information in the field of radio and closely allied sciences. The book is full of practical information of value to the radio serviceman, set-builder, and experimenter. Doubleday, Doran and Co., Garden City, N. Y. Price: $1.00.

How Radio Receivers Work, by Walter Van B. Roberts. This book is designed to lay a firm foundation of qualitative but definite ideas that will enable the reader to understand clearly the operation of a radio receiver and to read with benefit the more complete treatments of the subject. RADIO BROADCAST, Garden City, N. Y. Price: $1.00.



If he helps to increase the number of steady customers of his organization it follows that his pay will increase steadily and that he will be given larger responsibility

The MARCH OF RADIO

A Study of Program Possibilities May Open New Radio Markets

THE radio industry is engaged in selling devices for reproducing broadcast programs in the home. Only to the degree that radio entertainment is acceptable to the listening public does its market expand. This season's enormous sales are due as much to general program progress as to increased simplicity of receiver operation and maintenance. Stabilization in receiver design precludes the likelihood of revolutionary sales stimulation because of the appearance of entirely new types of receivers, except through the solution of the many problems retarding the commercialization of visual reception.

For the moment, we dismiss the possibility of television because it is predicated upon considerable technical development and upon the establishment of an entirely new broadcasting structure. We are not in possession of sufficient proof of its reasonably early development as a commercial product to predict whether it will be a vital sales factor within one year, five years, or twenty. The commercial history of the motor car, the airplane, and radio broadcasting itself is illustrative of the long period which may elapse between elementary discovery and general commercial development. As early as 1899, substantial stock flotations were launched successfully by companies proposing to exploit the radio telephone and old timers in radio recall entertainment programs heard with crystal sets broadcast as early as 1910, 1912, and 1915. Yet we waited until 1923 before there was a substantial market for home reception.

Assuming that neither visual broadcasting nor radical improvement in the receiver itself are certain to bring about another record-breaking season in the immediate future, we might conclude that we have before us only an era of ordinary, though presumably prosperous, commercial competition, with radio reception as stabilized as the motor car, the typewriter, and the electrical refrigerator. Under those conditions, merchandising skill, service support, and advertising ideas will account for the commercial successes of the future. Indeed, this year's outstanding radio surprise is directly a product of merchandising aggressiveness and a successful appeal to dealer coöperation. Considering that we are far from radio's saturation point and over half the receivers in use are already obsolete, this prospective era of intense commercial competition is by no means a dismal one. The 1928 sales record will probably stand no longer than the end of 1929. There is ample normal demand for radio reception to insure a huge sales volume for many years to come.

The basic commodity of the radio industry, radio programs themselves, however, offer new avenues of public appeal which may uncover unexpectedly large sales fields. Our competent contemporary *Radio Retailing*, recently suggested the idea of a radio set for every office. The present-day program offerings, however, have little more appeal to the average business institution than a kitchen cabinet or a phonograph. A fundamental change in the character of daytime programs is necessary to develop a market for radio reception in the business world. It is one, however, presenting great possibilities if the broadcasting interests possess sufficient initiative to depart from present trends. These possibilities are worthy of the utmost consideration by broadcasting managements because the establishment of specialized audiences at hours now of small commercial value means proportionately increased revenue possibilities.



The newly appointed Royal Canadian Radio Commission who will investigate broadcasting conditions in the Dominion. From left to right they are; Charles A. Bowman, Donald Manson, Dr. Augustin Frigon, and (seated) Sir John Aird, chairman of the Commission.

Certain stations have established daytime audiences of considerable value. While the average standard of programs addressed to the housewife are hopelessly mediocre and fall far short of their mark, nevertheless they have demonstrated the great possibilities of daylight broadcasting. During the day, the major part of these programs is direct advertising of the most flagrant character, restricting response to an undiscriminating though nevertheless large audience. Daytime farm programs have also reached many listeners and great political addresses delivered in daylight hours have been rewarded with adequate response.

EXAMPLE OF BUSINESS APPEAL

There has not, however, been any conclusive test of appeal to the business man. One requirement which must be met is that he be served with precisely the information he needs in a few regularly scheduled minutes of each day. An illuminating instance occurred recently in New York demonstrating that radio service to the business man is appreciated. WMCA has been broadcasting a brief news summary and stock market reports regularly in the late afternoon for some years. Under the new allocation, it shares with WNYC, the municipal station of the City of New York. On one occasion, WMCA relinquished the time devoted to this service, in order that WNYC might broadcast a glowing description of the accomplishments of the city's administration at the occasion of the opening of a new high school. When the customary time for the stock market quotations came around. WMCA's switchboard was immediately tied up by numerous phone calls from protesting investors and a large number of telegrams and letters, objecting to the suspension of this surprisingly important service, were subsequently received. Unquestionably, by judicious planning, not only can large and valuable audiences be built up for business purposes, but with them, a new market for radio receivers of far-reaching proportions.

During the evening hours, program development may also broaden radio's appeal. The tendency of the last few years has been principally in the direction of expansion of networks, better pick-up technique, and higher artistic quality. Radio sales have also been greatly stimulated by "great event" programs, such as presidential addresses, political speeches, sporting events, and receptions to public heroes. Unquestionably, we have bigger and better radio programs. This is, however, only normal progress and not any unexpected manifestation of program ingenuity. Departures from the beaten track are few but encouraging

The continuity program, pioneered four or five years ago in the early Eveready hours under the direction of Paul Stacy, first brought out the possibilities of this field of radio presentation. While Eveready hours stood alone in this field, their successes were national triumphs and their failures appeared to be artistic disasters. Seeking the impossibility of pleasing everyone, Eveready abandoned its brilliant contribution to broadcasting after two seasons of encouraging experiment and rejoined the throng of orchestras with vocal and celebrity programs, only recently returning to a more progressive policy. But such a healthful trend could not be resisted and the continuity is back again in full swing. Nothing has done more to restore it to favor than the outstanding success of WOR's "Main Street Sketches," which have been found sufficiently popular to prove worthy of imitation before every important microphone in the East. The commercial sponsor's demand

for universal appeal has discouraged program pioneering in spite of the fact that radio has scored a much higher percentage of successes with the continuity than its nearest counterpart, the dramatic stage. The continuity has the very important advantage to the commercial broadcaster that it holds its audience's thoughtful attention instead of serving as an almost unidentified background of musical entertainment. We regret that, although the continuity has won a permanent place for itself, most program directors have merely copied the few outstanding successes, despite the infinite variety of original characterization open to writers of continuity scripts.

DRAMATIC PROGRAMS

In the field of radio story telling and enactment, a distinctly different field of continuity, the *True Story* hours are the representative success in the field. A higher plane of story structure is conceivable, but, for vividness of presentation and broadness of appeal, they are superior to later imitations.

"Great Moments in History" remain the unquestioned leaders in serious dramatic presentation of the full-time continuity type. But, for pure acoustic artistry, they have been excelled by the N.B.C.'s "Central Park Sketches" and "Interborough Sketches." Their author has caught radio's most illusive quality, vividness of word-picturization. We predict that they will be widely and often unsuccessfully imitated. Though somewhat buried in an obscurity by a maze of conventional orchestral and vocal features, we regard these short dramatic novelties as an important trend because they have a substantial appeal to a distinctive strata of the radio audience, some of which may be hostile to the stereotyped program trend.

Finally, the Damrosch symphonic educational programs offer a new audience appeal, which means that radio tubes will be functioning at hours when they have been accustomed to rest. That is the real test of an expanding radio market, a program appeal which attracts new listeners and increased listening hours. We are not attempting to review program progress from the standpoint of higher general standards but from that of broadened appeal. We expect radio programs to improve because steady progress is necessary to maintain its position in competition with its real competitors, the phonograph, the motion picture, and the motor car. Expansion of radio's market requires more than holding its own against competing forms of entertainment. It must swing into the fold entirely new listening groups or increase the listening hours of its established followers. Creators of new program services make liberal contributions to radio's potential market. The association of program development with the prosperity of manufacturer, jobber, dealer, and radio serviceman is an intimate yet generally unrealized interdependence.

A New Radio Service to Aviation

SPEAKING at the autumn meeting of the National Academy of Sciences, Dr. E. F. W. Alexanderson described a promising line of research which he has been pursuing, looking toward the development of a means of measuring the height of an airplane above ground. The altimeter, which is conventionally employed, measures barometric pressure and, therefore, gives no indication of height above ground unless the aviator happens to know its exact altitude. Furthermore, the changes in barometric pressure, accompanying changed weather conditions, must be compensated.

The principle of the Alexanderson device is simple. A high-frequency continuous wave is radiated from the plane in flight and the component reflected from the ground is used to heterodyne the frequency generated at the transmitter. When the plane is at a height above ground which is an exact multiple of the transmitting wavelength employed, the reflected signal balances out the radiated signal and the minimum signal is received. As the plane rises through the distance of a wavelength, the signal goes through a complete cyclic change. A graphic record, made on experimental flights, shows that altitudes up to 4000 feet have been determined quite accurately by the method, following exactly simultaneously recorded readings made with an altimeter. The wavelength used was 95 meters and each cycle of the record represents an altitude change of 155 feet.

A POSSIBLE DEVELOPMENT

Dr. Alexanderson made several suggestions as to possible lines of development. He proposes the use of two antennas with an oscillator in each, one having a wavelength of ten meters and the other of eleven. The beat frequency of the two oscillations is then detected and observed. The frequency will be of the order of 3,000,000 cycles but the signal intensity will change cyclically as the plane changes in altitude. It will pass through maxima when the echo wave tends to decrease the frequency of the eleven-meter oscillator at the same time that it increases the frequency of the ten-meter oscillator, producing maxima at heights of 25, 75 and 125 meters, corresponding to 80, 240 and 400 feet.

The experience with the new system is naturally limited and, considering the peculiarities of short wave radiations, it is quite possible that ground conditions will cause sufficient variations in the character of the reflected wave to create practical difficulties. It requires a fair amount of equipment aboard the plane and skillful manipulation and, while the duties of the pilot are so manifold, concerned not only with actual piloting but watching of motor indicators, radio communication, and navigation, it is unlikely that so complex a system will have much practical application until it is further simplified. But Dr. Alexanderson has pointed the way to a fundamental method which shows great promise in solving an important problem in aerial navigation. The trend of development may be in the direction of ground altitude lighthouses which simultaneously radiate two waves of slightly different frequency, operating an automatic altitude indicator aboard the plane. This may be calibrated in feet above ground so that no manipulation will be required on the part of the pilot. The transmitting frequency selected will be such that the pilot can judge with fair accuracy whether he is one, two or three wavelengths above the beacon. For fog use, a signal bell may be helpful in aiding such judgment and, should this be impractical, a triple frequency system may be devised covering the entire range of altitudes without guesswork.



A reconstructed picture of the half circle of 170-foot masts erected at Poldhu in 1901. This antenna, which consisted of 60 wires in the form of a fan, faced the Atlantic and was used successfully in Marconi's early transatlantic experiments. The transmitter was located in the building in the center of the masts

High-Frequency Allocations

THE Federal Radio Commission has allocated 551 of the 639 channels between 1500 and 6000 kilocycles, by assigning 308 channels to fixed stations, 148 to mobile, and 95 to government stations. Of the fixed stations, the greatest surprise is offered in the allotment of the Universal Wireless Communications Company of 40 channels, while no additional channels were turned over to the Radio Corporation of America or the Mackay interests. In view of the fact that the Universal Company is an entirely new venture, proposing to compete directly with wire telegraph circuits, this allotment is causing considerable amazement in communication circles. The company is capitalized at $25,000,000, recruited principally from Buffalo business men. In its directing personnel, as announced, appear no names of executives known to be experienced in traffic management or radio-telegraph technique, although, no doubt, the Commission has been thoroughly satisfied by adequate evidence of sufficient available capital, personnel and technical knowledge or it would certainly not have made such a liberal allotment of valuable channels. This assignment is a distinct departure of the Commission's announced policy of confining high-frequency channel assignment to services which cannot be conducted through non-radio circuits.

Twenty channels are assigned to the press, 73 to marine service, 64 aviation, 5 railroad, 6 portable, including geophysical and police, 138 amateur, 100 visual, 4 experimental, and 70 point to point. Some private communication services granted channels are Ford Motor, Commonwealth Edison, Tropical Radio, Maddux Air Lines, Detroit Edison, Philadelphia Electric, Florida Public Service, Ann Arbor Railroad, Pere Marquette, U. S. Shipping Board, Radiomarine Corporation, Gulf Refining, Humble Oil, Magnolia Petroleum, and Bethlehem Ship, although Ann Arbor and those listed thereafter must also render a general public message service. Armour & Co., Firestone, Goodyear Tire, Morris & Co., Sears Roebuck, Universal Pictures, Cudahy Packing, Montgomery Ward, and Victor Talking Machine were denied the channels they requested.

In the World of Broadcasting

MERLIN AYLESWORTH, president of the National Broadcasting Company, in an end-of-the-year statement broadcast through a nation-wide network, announced that the expenditures made through his company for talent in 1928 were $5,000,000

and for wire network service, $2,000,000. If American listeners had paid for their broadcasting service through direct taxation, as do British listeners at their rate of $250,000 per station per year, American listeners would have paid $192,000,000 per year or from $15 to $25 per set for the maintenance of the 700 stations serving them. The cost of broadcasting is met largely by advertisers who distribute the expense among all classes of listeners and non-listeners. Mr. Aylesworth attempted to show that commercial broadcasting is in no way competitive with newspapers.

APPEALS from decisions of the Federal Radio Commission's decisions have been brought before the Court of Appeals of the District of Columbia by WENR, WCBD, and WLS, and by C. L. Carrell, appearing in behalf of portable stations WKBG, WIBD, and WHBM. The outcome of these cases will determine, in a large measure, whether the Commission has sufficient power to exercise control over the broadcasting situation. Louis G. Caldwell, the Commission's indefatigable chief attorney, has agreed to continue his services through the month of February. If these cases are decided adversely to the Commission, we will enter a new phase in broadcast regulation. Funds will then have to be appropriated, sooner or later, for the confiscation of broadcasting stations so that their number may be reduced to the point that the broadcasting band is no longer overloaded. It will require a long time, however, to put over such a step because neither the broadcasting stations or a majority of the Commission are prepared to face the facts in the matter. Many, like Commissioner Robinson, still favor low-powered broadcasting and heavily overloaded channels thus evading the necessity of reducing the number of stations on the air. Optimists hope for solution of the congestion problem by development of synchronizing methods, which will eventually enable network programs to be radiated on the same frequency. If commercial broadcasting continues to grow, continuous network broadcasting during the night hours would make it possible to maintain synchronized programs with the network stations assigned to regional channels and preserving cleared channels for network key stations and worthy independents. But until both continuous network broadcasting and practical synchronization are accomplished facts, this solution is still in the future.

WNYC has appealed to the courts the decision of the Commission affirming the time sharing order with WMCA. In its brief, filed with the Court of Appeals of the District of Columbia, the city makes much of the point that WNYC is called upon to share time with a commercial station and that the rights of municipal stations are superior to those of commercial stations. Considering that there is no possibility of sharing with any but a commercial station in the metropolitan area and that advertising merchandise is no less useful than advertising the deeds of political incumbents and the gossip of municipal bureaus, this particular plea is based upon apparently unsound foundations. Any superior right which may be established by stations of a political origin over stations operated purely to appeal to the public through their educational and entertainment value would be unfortunate. It is to be hoped that all stations will be compelled to stand upon their service to the public and that no privileged classifications will ever appear in our highly circumscribed broadcasting channels. The most important contribution of WNYC is its "University of the Air," and its potential service in coöperating in health department propaganda and maintaining law and order. It has not been demonstrated that more than half time is required for these very worthy purposes.

THE Federal Radio Commission announced that after January 1st no visual transmissions of any kind would be permitted in the broadcast band, but it reversed its position before the new order became effective, permitting such transmissions between 1 and 6 A.M. It has, however, dallied so long with this problem that many have become discouraged and the effort to bring about a rapid development of visual broadcasting by experimenter participation has been rendered abortive. Many pioneers have suffered heavy financial losses as a result, which would have been somewhat mitigated by early consideration of the problem. The experimenter, having served his purpose of starting the whole broadcasting structure is thus ruddy cast out from a field of activity which showed great promise of a revival of ingenuity and skill in radio reception.

REPRESENTATIVE WALLACE WHITE of Maine has introduced a resolution to extend temporarily the authority of the Federal Radio Commission for another year. If these year to year extensions become habitual, it is quite probable that Congress will ultimately form a communications commission which will have, in addition to the duties of the present Federal Radio Commission, complete regulation over telephone and telegraph systems. Because of its quasi-public nature, the communications business, in common with railroads, suffers from excessive political regulation with the inevitable result that costs of operation are increased proportionately to the political meddling tolerated. Excessive profits in the communications business, and in fact any quasi-public function which is necessarily monopolistic in character, should certainly be regulated so that only a reasonable return is made on the capital invested. As soon, however, as regulation broadens its scope into details of management, it generally works against the public interest. If politicians attempt to rule experts, the results are disastrous and, if experts are substituted for politicians, then the method is wasteful. Had the present commission tackled its problems with greater aggressiveness and expeditiousness, it would now be an appellate body, meeting only on appeals, and regulation would be centered in a bureau of the Department of Commerce, exactly as it was prior to the chaotic conditions brought about in 1926. Congressional meddling is invited by the protraction of the Commission's problems.

IN THE first week in January, the Columbia Broadcasting System has augmented its network from 21 stations confined to the northeastern part of the United States, to 47 transmitters reaching from coast to coast. Approximately 100,000 miles of wire, a third of which carry the programs and the balance are monitoring and emergency circuits, are used. Fifty repeater points are involved and in the inaugural broadcast, two-hundred telephone engineers were employed in maintaining wire service.

WABC is now under the management of the United Independent Broadcasters, operators of the Columbia Chain. As soon as the chain's contract with WOR expires in September, WABC will be the source of all Columbia programs. Alterations in the transmitter are contemplated, and removal to a less-populous area has already taken place. WOR plans no chain affiliations after September and will, therefore, become the leading independent station of the metropolitan area, continuing its policy of originating its own features.

—E. H. F.

Schedule of the Best Short-Wave Programs

Station Call Letters	Wave-length (Meters)	Schedule in Eastern Standard Time						
		Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
W2XAD Schenectady, N. Y., U. S. A.	19.56	5:30 P.M. to 10:30 P.M.	2:00 P.M. to* 4:00 P.M. 5:00 P.M. toP 11:00 P.M.		5:00 P.M. toP 11:00 P.M.	2:00 P.M. to* 4:00 P.M.	5:00 P.M. toP 11:00 P.M.	
5SW Chelmsford, England	25.53		7:30 A.M. to 8:30 A.M. 2:00 P.M. to 7:00 P.M.	7:30 A.M. to 8:30 A.M. 2:00 P.M. to 7:00 P.M.	7:30 A.M. to 8:30 A.M. 2:00 P.M. to 7:00 P.M.	7:30 A.M. to 8:30 A.M. 2:00 P.M. to 7:00 P.M.	7:30 A.M. to 8:30 A.M. 2:00 P.M. to 7:00 P.M.	
W8XK Pittsburgh, Pa., U. S. A.	25.4	11:00 A.M. to 12:00 A.M. 2:00 P.M. to 10:30 P.M.	2:00 P.M. to* 4:00 P.M. 5:00 P.M. toP 10:30 P.M.	5:00 P.M. toP 10:30 P.M.	5:00 P.M. toP 10:30 P.M.	2:00 P.M. to* 4:00 P.M. 5:00 P.M. toP 10:30 P.M.	5:00 P.M. toP 10:30 P.M.	5:00 P.M. to 11:00 P.M.
PCJJ Eindhoven, Holland	31.2		6:00 P.M. to 9:00 P.M.	6:00 P.M. to 9:00 P.M.		6:00 P.M. to 9:00 P.M.		
W2XAF Schenectady, N. Y., U. S. A.	31.48		5:00 P.M. toP 11:00 P.M.	5:00 P.M. to 11:00 P.M.		5:00 P.M. to 12:00 P.M.		6:00 P.M. to 12:00 P.M.
W2XE Richmond Hill, N. Y., U. S. A.	58.5	7:00 P.M. to 11:00 P.M.	7:00 P.M. to 11:00 P.M.	7:00 P.M. to 11:00 P.M.	7:00 P.M. to 11:00 P.M.	7:00 P.M. to 11:00 P.M.	7:00 P.M. to 11:00 P.M.	7:00 P.M. to 11:00 P.M.
W8XK Pittsburgh, Pa., U. S. A.	63.5	8:00 P.M. to 10:30 P.M.	2:00 P.M. to* 4:00 P.M. 8:00 P.M. toP 10:30 P.M.	8:00 P.M. toP 10:30 P.M.	8:00 P.M. toP 10-30 P.M.	2:00 P.M. to* 4:00 P.M. 8:00 P.M. toP 10:30 P.M.	8:00 P.M. toP 10:30 P.M.	8:00 P.M. to 11:00 P.M.
CJRX Winnipeg, Canada	25.6	5:30 P.M. to 10:30 P.M.	5:30 P.M. to 10:30 P.M.	5:30 P.M. to 10:30 P.M.	5:30 P.M. to 10:30 P.M.	5:30 P.M. to 10:30 P.M.	5:30 P.M. to 10:30 P.M.	5:30 P.M. to 10:30 P.M.

*—N.B.C. Red Network programs relayed to British Broadcasting Company, England.
P—During 9:00 P.M. 10:30 P.M. period the N.B.C. Red network program comes through all 4 waves. Other periods have separate programs. At 7:00 P.M. you can set your watch by "Big Ben" from London, England.

Operating Data on a

NEW AUTOMATIC VOLUME CONTROL SYSTEM

By CHARLES WILLIAMSON

Department of Physics, Carnegie Institute of Technology

ALL of us have been annoyed at some time or other by a terrific burst of sound from the loud speaker when, in the course of tuning, we have happened to come across a powerful local station. Sudden loud speaker overloading may also occur with certain types of broadcasting, such as organ music, which exhibits an unusually wide range of volume. In many cases, the voice of the announcer is received at a much higher volume level than that of the music. But the worst case of unexpected sound peaks arises when listening to a distant station that is fading badly. When it comes back, it usually does so with a roar; and static crashes are at their loudest because the sensitivity control has been advanced fully in order to make the program audible when the station fades.

An Automatic Control

LAST August the writer designed a simple and inexpensive device to cure these troubles. It has been tested on several receivers and in each case the difficulty was corrected almost perfectly.

The addition of the writer's device to any d.c.-operated receiver does not require that the circuit of the set be altered in any way. (When using this device in connection with an a.c.-tube receiver the results may not be entirely satisfactory as an increase in hum may result, particularly when the set uses 226-type tubes—*Editor.*) The device is connected across the loud speaker terminals and is operated by the a.c. voltages appearing across the loud speaker. It functions by reducing the plate voltage on the r.f. tubes automatically as the volume from the loud speaker rises.

Since the device described in this article functions due to the changes in voltage across the loud speaker, it will have the effect of contracting the volume range—in other words it does automatically at the receiving end what the monitoring operator does (or should do) at the broadcasting end. Serious distortion of the signal currents will occur only if the device operates with a time lag so short as to be comparable with one fourth of a cycle at the lowest frequency likely to be handled by the audio system. An examination of the circuit (Fig. 1 diagram A) will show that the time constants of the choke-condenser and resistance-condenser combinations are of the order of 0.1 second or greater.

Dr. Charles Heinroth, the eminent organist, assures me that he would not regard a systematic contraction of the dynamic range as undesirable distortion of his programs. In fact, he thinks it would be better than the hit-or-miss monitoring sometimes met with! Hence I think we can regard this type of automatic volume control as distorting only in a formal sense. Not even a musician can detect it in the receiver's output unless he has an unmonitored output with which to compare it.

Manual adjustment of the plate voltage of an r.f. tube will show that large changes may be made over a certain region without noticeably affecting loud speaker volume. If, as is often the case, the amplification of the r.f. stage under control is partly regenerative, it will fall off rapidly at first, as oscillation is left behind. After this there will be less change, since the a.c. plate resistance and the mutual conductance of the tube will change slowly with diminishing plate voltage over a certain region. Later, however, they both begin to change faster, and the amplification of the r.f. circuit is reduced rapidly. Thus, in a receiver of this type, this automatic volume control has the advantage that a loud signal throws the receiver out of oscillation instead of into oscillation.

List of Apparatus

THE parts required for the construction of the volume control described by the writer follow:

R_1 One high-resistance unit (See Table I for proper value);
R_2 One rheostat or filament-ballast unit;
C_1 One fixed condenser, 200-volt, 4-mfd.;
L_1 One choke coil, 30-henry;
One tube socket, UX-type;
One power tube, 171A-type.

The circuit diagram of the automatic volume control device is shown in diagram A of Fig. 1. This circuit also shows the method of connecting the volume control to a receiver having an output transformer. Diagram B shows the input of the device connected to a receiver having a choke-condenser output circuit. It will be noted that in each of these cases the loud speaker return must be made to the negative 45-volt C-bias terminal rather than to the negative A wire as usual. Diagram C shows the device connected to a receiver using a push-pull output circuit. Two condensers, C_2 and C_3, are required, as shown.

In all of the above cases, the control tube may be operated from the same A, B, and C supply as the rest of the receiver, and its filament may be heated by a.c. if desired. Also, with all types of receivers the r.f. tubes obtain their plate potential from the "B+R.F." terminal of the volume control unit.

The high-resistance unit, R_1, should have a value of 50,000 ohms if a plate potential of 180 volts is available, and if there is a negative bias of 4½ volts on the grid of the first r.f. tube. For lower values, either of B or grid bias potentials, the following table shows the proper size resistor to use:

Table I

R.F. Grid Bias (Volts)	Plate Voltage 180	160	140	
−4½	50,000	40,000	30,000	R_1 Ohms
−3	40,000	30,000	20,000	
0	30,000	20,000	10,000	

The values of the resistor R_1 are not especially critical; they are determined by the restriction that the first r.f. tube should not receive more than 90 volts of plate potential. If the r.f. B-plus lead supplies two tubes, the resistances in the above table should be divided by two.

If a variable-resistance unit is used in place of the fixed resistor, it may be set to the best value by placing a high-resistance voltmeter (1000 ohms per volt) across the plate and filament terminals of the first r.f. tube, and adjusting the knob of the variable resistor until the meter reads 90 volts (or whatever other voltage is normally placed on the r.f. tubes). This must be done with the receiver fully turned on, but *not* tuned into any station.

The choke coil, L_1, used in this device, if not bought as a unit, may be made up of almost anything at hand, since, if only one r.f. tube is controlled, it need not handle more than 5 milliamperes at 90 volts. If a speaker filter is available, it can be used in place of C_1 and L_1.

With the receiver in operation, there is nothing to suggest the presence of the automatic volume control, except a gratifying absence of speaker overloading. The original volume control on the set, whatever its type, is not interfered with in any way. It might be supposed that the volume-range of the music would be brought to a dead level; such is not the case, however; the range is merely reduced to an extent that the audio system can handle without noticeable distortion. If desired, the amount of such compensation can be regulated by turning down the filament of the control tube; and, of course, the device can be cut out entirely by turning it off. As to the sensitivity of the set, this is in no way impaired; for the full 90-volt potential is available for the r.f. tubes until a signal begins to come in; and it is not materially reduced until the signal becomes loud.

Both calculations and trial indicate that a 112A- or 120-type tube may be used for the control circuit instead of a 171A-type tube with some loss of efficiency. In these cases the negative grid bias for the control tube should be 9 and 22½ volts, respectively. Of course, the r.f. tube or tubes under control may be of any type whatever except the type 226, which hums badly if its plate voltage is changed.

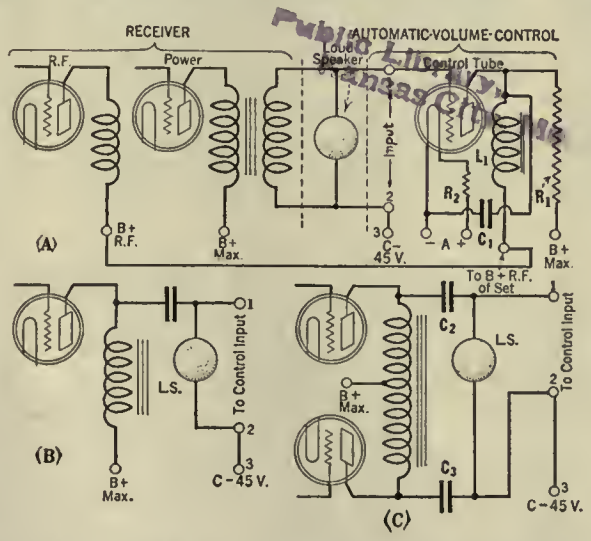
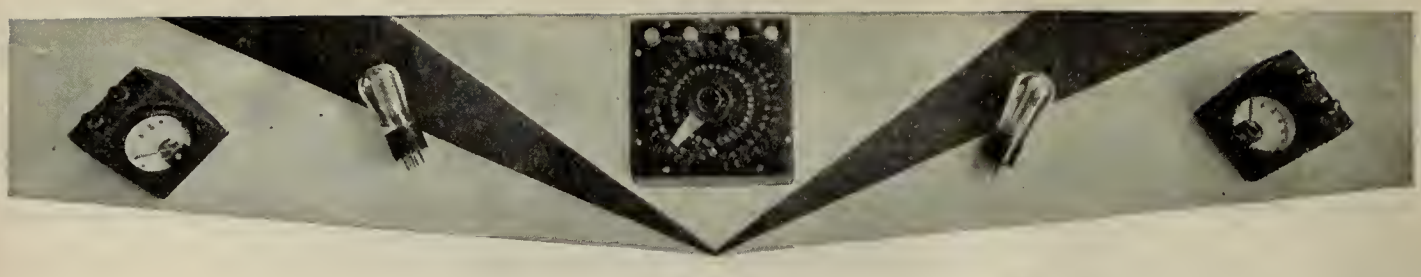


Fig. 1—Diagram A shows the automatic volume control connected with the output transformer of a standard receiver. Diagrams B and C show the input of the device connected with other types of receivers

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STRAYS *from* THE LABORATORY

New Trends in Radio Design

IF THE a.c. screen-grid tube is made available before next year's receivers are designed, it is our bet that many of them will find their way into 1930's receivers, just as they have found their way into the best English sets. Over there 39 per cent. of all the types of sets manufactured during 1928 were three-tube sets—and 30 per cent. of the types used r.f. amplification. Screen-grid tubes were used in 80 per cent. of the sets with r.f. amplifiers.

Data on English receivers: The above figures are but a part of an interesting analysis which was published in *Wireless World*, November 14, 1928, on the receiver situation in England. The other data show that the five-tube receiver, probably the most popular number of tubes in this country, constituted only 14 per cent. of the several types of receivers made in England during 1928. Seven per cent. of the receiver types employed no r.f. amplification at all, 89 per cent. used a grid leak and condenser type of detector, 70 per cent. used transformer coupling in the a.f. amplifier, and 79 per cent. connected the loud speaker directly into the plate circuit of the last tube.

What will be used in next year's receiver? We have read recently several excellent articles on the use of a screen-grid tube as a detector. These articles described the research of J. R. Nelson, of the Cunningham laboratory, and were published in *Radio Engineering*, October, 1928; *Proceedings*, I.R.E., June, 1928; and *Lefax 35*, December, 1928.

The great advantage of the C-bias, screen-grid detector lies in its ability to handle a relatively large input r.f. voltage without overloading, and its relatively high output. According to Mr. Nelson, the first stage of audio can be done away with provided we use a screen-grid tube as a detector, and provided the r.f. amplifier supplies from 2.17 to 18.6 times as much amplification as when an ordinary general-purpose tube is used as detector with a two-stage transformer-coupled a.f. amplifier. Now when the 322 detector tube is compared to a 327 tube connected as a grid leak and condenser detector, the amplification of the r.f. end of the receiver must be 18.6 times as much. Of course, a C bias is used with the 322 detector tube. Compared to the use of a 201A as a C-bias detector, the 322 and one stage of audio amplification requires 3.17 times as much voltage amplification from the r.f. amplifier.

If, then, we use screen-grid r.f. amplifiers, say two stages of them, the gain per stage must lie between 1.78 and 4.32 times as much as with present circuits, and if three of them are used, the increased gain per stage must lie between 1.47 and 2.65 for the two cases.

Now it does not seem difficult to design an r.f. amplifier, using screen-grid tubes, that could produce 18.6 times as much amplification as present-day sets, which used with a screen-grid detector, will work directly into a power tube thereby eliminating one tube. This means an additional voltage gain of about 35 DB to our present-day r.f. amplifiers. We do not consider this impossible—nor are we convinced that it is desirable to substitute r.f. gain for a.f. gain.

One point of importance regarding the use of the screen-grid tube as a detector has not been discussed—what kind of a frequency characteristic can be obtained with it?

The following are among the subjects discussed in "*Strays*" this month:

1. *New Trends in Radio Design*
2. *Two New A.C. Tubes on Way*
3. *Accuracy of Variable Condensers*
4. *New Radio Tubes in England*
5. *Importance of Reducing A.C. Hum*
6. *Receiving on 600 Meters*
7. *Selectivity of Browning Drake*

Selectivity versus sensitivity: The problem is not to get more amplification into our r.f. amplifiers. We have plenty now. The problem is to increase their selectivity without damaging their fidelity of response. It is our bet that the only reason why people tolerate present-day receivers—and their loud speakers which bring out the low notes—is because of the lack of competition from, and comparison with a really high-quality receiver. One only has to look at the selectivity curves, published in Dr. Hull's article, "Measurements on Broadcast Receivers," in February RADIO BROADCAST, or Mr. Jarvis' article in January RADIO BROADCAST, to see how few notes above 3000 cycles we are getting, and anyone has to listen but once on any good night in practically any home in the Middle West to long for a more selective receiver.

The only answer is the solution that engineers have suggested time and again, and which the Members of Congress who meddle with radio affairs, do not seem to understand. This answer is to eliminate about half of the present broadcasting stations. The myth of having 40 cleared channels is amusing indeed to anyone who listens under average conditions. This does not mean listening-in in New York City, or near any great center of broadcasting, but say in Ohio. We had the dubious pleasure of listening-in there during the Christmas week. The receiver was undeniably less selective than many of the two-, three-, and four-stage r.f. amplifiers now on the market, sold as having perfect tone quality.

An hour before sunset in Ohio, we heard stations as far away as Winnepeg, CKY, on a four-tube set of the Lab. Circuit type which has been described many times in this magazine. We could tell at once that the practice of putting two large stations, KDKA and WBZ for example, on adjacent channels is bad. If you live near KDKA it works out fairly well because you can't hear WBZ on the adjacent channel, but if you live equidistant from the two, you can't listen to either of them.

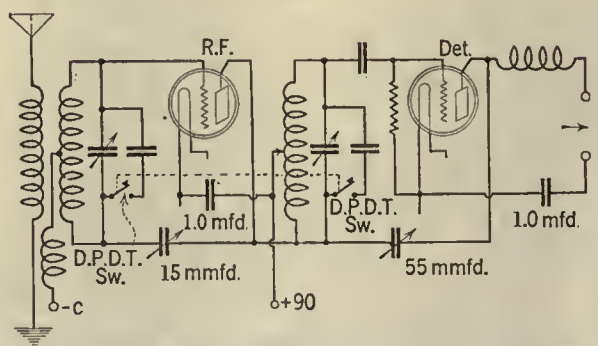


Fig. 1—The diagram of the Lab. Circuit receiver with fixed condensers which increase wavelength range to 800 meters

Two New A.C. Tubes on The Way

IF THERE is anything more interesting than radio gossip, it is speculation on how much of what you hear is true. We are glad to chronicle the gossip regarding two new tubes which—so they say—are soon to appear on the American market. One is an a.c. screen-grid tube of somewhat better characteristics than our present d.c. tube with its fragile and microphonic filament. The tube has a typical heater filament, 2.5 volts and 1.5 amperes. At 180 volts on the plate, a screen-grid potential of 75 volts, and a control-grid bias of minus 1.5 volts, the plate resistance is about 400,000 ohms, its amplification factor about 400, and its mutual conductance about 1000 micromhos. This is considerably better than the d.c. tube with a mutual conductance—which is about all that matters in a tube of this kind—of not much over 300 micrombos. The grid-plate capacity is in the order of 0.01 mmfd., its input capacity about 5 mmfd., and its output capacity about 13 mmfd. The plate current is about 4 mA. and the screen-grid current under normal conditions about 0.3 mA.

The other new tube is a cross between a 171A and a 250, i.e., a tube with about double the power output of the 171A at a maximum plate potential of 250 volts. Many thousands of listeners who overload a single 171 on loud low-note passages, and yet who do not want to overload the house or the neighborhood with the racket from a 250-type tube with 450 volts on the plate, will be pleased with this new tube. Its filament consumes 1.5 amperes at a filament potential of 2.5 volts, and is not of the heater type. Its normal grid bias will be about 50 volts, plate current about 32 mA., amplification factor about 3.5, and power output of 1500 milliwatts.

We have not been able to confirm the rumors that such tubes are going to be announced—but rumors mean that such tubes are in the process of development and that is the im-

portant thing. Sooner or later they will appear whether their constants resemble those give above or not.

Accuracy of Variable Condensers

LAST month we spoke of the effect on the tuning of a receiver in which one of several ganged condensers was incorrect in its capacity. We have a letter from M. H. Bennett, Electrical Engineer, Scoville Manufacturing Company, which states that an engineering laboratory has determined that on a hundred-degree dial, a discrepancy of 3 mmfd. at 100° is equivalent to detuning one of the condensers by one dial degree, and that such a detuning will cause a reduction in signal strength of about 5 per cent.

Another prominent engineer remarks that the figure of one quarter of one per cent. is too high to be maintained in production—we suspect the question of cost enters here—and that the rest of a radio receiver at the present time cannot be built with such a high degree of accuracy.

New Radio Tubes in England

TABLE I gives some data on new Marconi tubes which are available in England, the land of many tubes. Unfortunately all of the data on these tubes are not available, but interest in this country will be directed toward the low filament consumption of some of these samples of foreign economical tubes.

Importance of Reducing A.C. Hum

WE HAVE spoken about hum several times. Here is a problem in hum voltages. Let us suppose the power tube delivers 1000 milliwatts to the loud speaker at the loudest signal to be received, and that the weakest signal will be 40 DB below this value. This is the normal range of broadcasting, 40 DB, corresponding to a power ratio of 10,000 times. Now suppose that at the lowest signal to be heard, the hum output from the loud speaker is not to be objectionable. This means that it ought to be about 20 DB below the signal output. This makes the hum power output 60 DB below 1000 milliwatts, or one microwatt.

If the resistance of the loud speaker to the hum producing voltage is 4000 ohms, the voltage across it is 0.063 volts. Suppose the amplifier is a conventional two-stage transformer-coupled affair using transformers with turns ratio of 3:1 each. The voltage gain of such an amplifier, from resistance output to the primary of the first audio transformer is about 150. The hum voltage across this primary is 0.063÷150 or about 0.00042 volts or 0.42 millivolts.

All of this indicates that the maximum hum appearing across the first audio transformer must be no greater than 0.42 millivolts—and yet we remember reading somewhere that the hum voltage in the plate circuit of a heater-type detector tube is of the order of several millivolts.

Let us look at the plate-supply device. If the total output potential is about 200 volts, the hum output will be about 50 millivolts. Across the 45-volt tap will be roughly one quarter of this hum voltage or 12 millivolts. For the sake of argument, let us assume that 90 per cent. of this voltage, which is impressed across the plate-filament circuit of the detector finds its way across the primary of the transformer. This means that due to the plate-supply device alone 10.8 millivolts of hum appears across the input. This voltage multiplied by 150 becomes 1.62 volts across the loud speaker. Let us suppose there is already this much there from the use of an a.c. tube detector, or 3.24 volts in all. This amounts to 2.53 milliwatts, or only 26 DB below the maximum output of the amplifier! An assumed hum voltage of 10 millivolts across the 45-volt tap is high because the filter condensers across it, and those across the 90-volt tap, get rid of much of the a.c. voltage creating the hum. It is certain, however, that a fairly large capacity should be across the 90- and 45-volt taps. This analysis may account for the fact that many experimenters who have built amplifiers to go down to 120 cycles prefer to use a d.c. tube for a detector and obtain its plate voltage from a 45-volt B battery. And it is surprising how much the low frequencies come up in apparent volume when the a.c. hum is cleaned out of one's receiver, amplifier, power supply, and loud speaker. It is true that so long as the receiver ensemble hums, no signal frequencies lower in pitch than this hum can be heard, and that few signals of the same frequency as the hum can be heard. They must be much louder than the hum—all of which points out some interesting psychological facts. A quiet receiver will always seem to have a much better low-frequency response than one which has a lot of hum in its output.

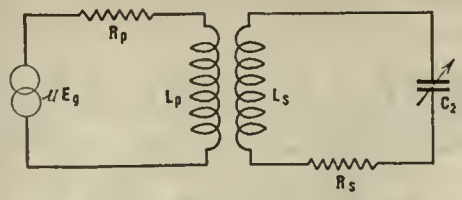


Fig. 2.—Mr. Browning uses this diagram to demonstrate his selectivity formulas

Receiving on 600 Meters With Lab. Set

DURING the *Vestris* disaster we listened-in to the traffic to and from ships in the vicinity of the wreck, and discovered many interesting things about the chaotic condition of the ether during such periods. We used our Lab. Circuit receiver with the addition of two fixed condensers which could be thrown across the tuning condensers. These fixed condensers brought the maximum wavelength that could be received up to nearly 800 meters, and thereby permitted the reception of all of the ship-to-shore traffic on the several channels between 600 and 800 meters. The circuit diagram is given in Fig. 1. The Yaxley switch is a simple double-pole double-throw unit and the condensers had a capacity of 250 mmfd.

Selectivity in the Browning-Drake Set

IN SEPTEMBER RADIO BROADCAST, Glenn Browning described some of the engineering behind the 1929 Browning-Drake receiver. This receiver uses somewhat closer coupling between primary and secondary of the interstage r.f. transformer than has been attained heretofore, with the result, according to Mr. Browning, that better selectivity is secured. This statement "closer coupling, better selectivity" bothers many readers, and so we have asked Mr. Browning to explain it. We reproduce some of the mathematics below.

A brief statement of what happens is as follows: for a fixed amount of amplification in a tuned radio-frequency transformer working in conjunction with a given amplifier tube, the selectivity may be increased by advancing the coefficient of coupling and at the same time decreasing the number of turns on the primary so that the amplification remains the same. This is due to the fact that as the number of turns is decreased and the coupling increased the resistance reflected into the secondary circuit from the primary decreases, and hence the selectivity of the secondary circuit approaches more nearly its selectivity when standing alone and not connected to the plate resistance of the previous tube.

Let η_p and η_s be the ratio of resistance to reactance of primary and secondary circuits and η_{sl} be the ratio of resistance to reactance of the secondary when the primary is present. Let R_{sl} be the apparent resistance of secondary when primary is present.

TABLE

$$R_{sl} = R_s + \frac{M^2\omega^2}{Z_p^2} R_p \quad \ldots\ldots (1)$$

$$\eta_p = \frac{R_p}{L_p\omega} \; ; \; \eta_s = \frac{R_s}{L_s\omega} \; ; \; \eta_{sl} = \frac{R_{sl}}{L_s\omega} \quad \ldots\ldots (2)$$

$$\eta_{sl} = \eta_s + \frac{\tau}{\eta_p} \text{ in general} \quad \ldots\ldots (3)$$

$\tau^2 = K\eta_p\eta_s$ for a given amount of amplification.... (4)

Where R_s = Secondary resistance
R_p = Plate resistance of tube
R_{sl} = Apparent resistance of secondary with primary present
τ = Coefficient of coupling
K = Proportionality factor less than 1.

$$\text{Therefore } \eta_{sl} = \eta_s + \frac{K\eta_s}{\tau}$$

and as τ is increased the selectivity factor of the secondary increases. It is worth noting that if unity coupling prevails and if the proper number of turns are used for maximum amplification, K = 1, the selectivity of the tuned circuit is halved, as all mathematics and experience dictates.

Removing Noise in Shielded Receiver

THE following letter from a reader in Farmington, Michigan, may help others who have shielded receivers.

"I would like to pass along a discovery I made regarding the Sargent-Rayment Seven. I had considerable difficulty at first owing to instability in the r.f. stage. At one time it would work perfectly and the next day it would fly into oscillation for no reason at all. I finally found this to be due to poor electrical contact between the partitions and the removable cover. I procured a piece of aluminum 8 inches wide and long enough to cover the r.f. stages and bolted it securely to the partitions. This cured my trouble."

Many experimenters find their receivers do not work after shielding has been added. The trouble lies not with the shielding material of the coils but in the fact that the whole arrangement has not been properly designed. A coil too near a metallic plate will not only lose inductance at an alarming rate but have an astonishing increase in resistance as well.

League of Nations to Broadcast

The Secretariat of the League of Nations intends to resume the short-wave broadcast trials which took place in Geneva in May and June of last year. The special purpose of this second series will be to examine the possibility of transmitting speeches from Geneva to the Americas, Japan and Australasia.

The trials will take place in the same technical conditions as those held last year. A studio in the League Secretariat in Geneva will be connected by ordinary telephone cable with the Dutch station of Kootwijk (call letters PCLL) kindly put at the disposal of the League by the Dutch Post Office authorities.

Sixty-minute speeches will be broadcast at 5:00 P.M. (E.S.T.) on 38.8 meters in English, French, and Spanish on March 12, 19, and 26. Thirty minute speeches will also be broadcast in Japanese on March 13, 20, and 27 at 8:40 P. M. on a wavelength of 18.4 meters, and on March 14, 21, and 28 special thirty-minute Australian programs will be broadcast in English at 8:40 P. M. on a wavelength of 18.4 meters.

—KEITH HENNEY

Table I

Type No.		Ef	It	μ	Gm	Rp	Ip	Ep	Eg
DEH	210	2.0	.10	35	700	50000			
DEL	610	6.0	.10	15	2000	7500			
P	625	6.0	.25	6	2500	2400	21.5	160	13
P	625a	6.0	.25	3.7	2300	1600	25	140	18
P	425	4.0	.25	4.5	1950	2300	22	140	14
HL	610	6.0	.10	30	1000	30000			
H	8	.8	.8	40	730	55000			
HL	8	.8	.8	17	1000	17000			
P	8	.8	.8	6	1000	6000			

AN UNUSUAL ORGANIZATION

By ROBERT S. KRUSE

ABOUT seven years ago there was formed in the town of Boonton, N. J., the Radio Frequency Laboratories, Inc., an organization devoted to research—a task that has long been a proudly accepted function of the university.

The first members of the staff were men known to have a permanent interest in the questions "why?" and "how?" Their orders were to get together the necessary apparatus and attack the important problems in radio. I remember clearly the glee with which that prospect was greeted.

That laboratory, with the same frame of mind, is the present Research Division of R. F. L. As its contributions have reached commerical form they have been put into the hands of licensed manufacturers who maintain their contact through an Engineering Division, created for that purpose. Lately there has also been added an Aircraft Radio Laboratory as another major division.

Surprisingly the R.F.L. is not widely known, though it has made fundamental contributions and has for licensees manufacturers whose output is a large share of all that comes to market. Perhaps this is because the contacts have been mainly with the engineers of these organizations, for which R. F. L. is a centralized bureau of research, although working on its original problems as well.

Accomplishments

BECAUSE of the highly interlocking nature of the research and engineering problems I find it difficult to formulate the work done by these laboratories. However, in the course of various friendly visits made without any such story as this in mind, there has stuck in my recollection some matters that are mentioned in the following paragraphs—the list admittedly being neither complete nor frightfully accurate.

The laboratories developed one of the first neutralized radio receivers, and, incidentally, this was also one of the first single-control sets to be produced.

Methods were developed for determining the sensitivity, selectivity, and fidelity of a radio receiver and these methods have been adopted by the Institute of Radio Engineers as one of the standard methods for measuring a radio receiver's performance.

In collaboration with General Radio, there was developed (and placed on the market by G. R.) a standard signal generator for use in measuring radio receivers.

The Laboratories developed a technique of making sound measurements which made it possible to measure the overall receiver performance from the antenna to the sound wave produced by the loud speaker.

A basic study of detection was made particularly at high signal levels, and detectors were developed which do not produce distortion and which are not subject to overload under normal conditions. These studies applied particularly to 100 per cent. modulated r.f. signals. The use of 100 per cent. modulation is increasing—or perhaps we had better say that there is an increased tendency for transmitting stations to attempt such modulation.

Four-element tubes were designed, constructed, and used in the development of receivers pending the availability of such tubes on the market.

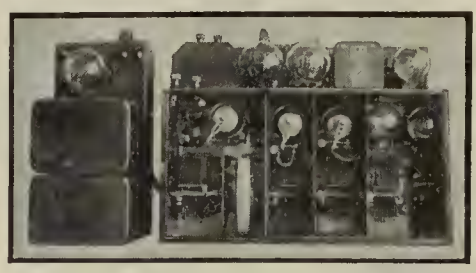


Fig. 1—This compact receiver was developed for use on airplanes with a seven-foot rod antenna

The active research problems are quite beyond such a brief account as this: the designs for the next year's broadcast sets of the licensees are still confidential—though I yearn to write about two features thereof. However, R. F. L. is engaged in another task which may be described. In the commercial progress of aircraft, there has developed a need for a reliable means of guiding an airship—a method that will prove equally reliable during day and night and in all sorts of weather. For this purpose radio beacons have been used but there has existed no receiver for airplane use that would provide the necessary sensitivity and at the same time be able to function without a trailing antenna. The Radio Frequency Laboratories were asked to cooperate with the Department of Commerce in developing a receiver that would do these things.

The Airplane Receiver

AT THE opening of the Aircraft Radio Laboratory on January 9, demonstration flights were made with a new beacon receiver. This receiver uses but five tubes of which the last two are resistance-coupled audio and the first two are of the screen-grid type. It is rather startling to have such a receiver, working with a seven-foot rod antenna, produce a headset signal which, at 30 miles from Hadley Field's beacon station, is far beyond the scale of any ordinary audibility meter and wrecks headsets in short order. With voice modulation at the beacon station, the Wright J-5 motor's roar meekly retreated behind the signal. In I. R. E. language, the set has a sensitivity of 5 microvolts on a 30 per cent. modulated signal. The sets may be used either on the "A & N" beacon system or with the vibrating-reed system. Of these two systems, we will speak but briefly. In both cases there are sent out two beams, diverging slightly and the course lies down the center of the angle. With the "A & N" system the letter A (· —) is being sent on one beam and the letter N (— ·) is sent on the other beam. The timing is such that if the two beams are being received equally well the two letters interlock to make a steady signal. In the reed system the two beams are modulated at audio frequency, one at 65 cycles and the other at 85 cycles per second. At the receiving end, therefore, the output of the amplifier carried both modulations equally if one is on the course. If the plane falls off course the 65-cycle modulation may be picked up less and the 85-cycle one more (or the reverse) and one reed spreads out more while the other narrows down, thus advising the pilot as to the direction in which he is off. With the receiver mentioned here the system is dependable up to 150 miles, with a normal 2 kw. beacon station and a seven-foot rod antenna on the plane.

Airplane Height Indicator

THERE is at present being developed by the Aircraft Radio Division of the R. F. L. a height indicator. In its present state of development this device is used to give a series of two or three separate indications (such as the lighting of different colored lamps) each of which corresponds to a definite height above the earth or water over which the plane is being flown. It must be clearly understood that the device is not an altimeter, the device at present used in airships and which tells the pilot the height of his plane above sea level. The R. F. L. height indicator will have no reference to sea level but uses the surface under the plane as the datum point—it is of small interest to a pilot how high he is above sea level when he is flying above a mountain and the tree tops are only 50 feet below.

This new apparatus was first installed in a D. H. plane and successfully operated over land, fresh water, and salt water. A later installation has been made in a radio test plane of the laboratory. The apparatus is in the forward cockpit of the ship and is housed in an aluminum box, the whole weighing about 7 pounds. The antenna is a doublet stretched between wingtips, and lying beneath the wing.

In its present form the device is useful for landing in ground fog, and for landing on smooth water in clear weather. When flying over trees the indicator flickers continually.

Of course, it is felt that aviation radio will become of steadily increasing importance. The Laboratories have acquired an airport. For the hangar we can say that it has better than average accommodations, including garages, living quarters, a shop, an office, and an 80 x 100-foot space for planes, which enter through doors with 18-foot headroom. Amazingly enough the place is heated well. It does not stick in my recollection that I have ever been in an airplane hangar that was not several degrees colder than outdoors.

In another corner of the field is a laboratory containing living quarters, kitchen, lounge and library, bridge measurement room, a transmitting room, transmitting and receiving laboratories, private laboratories, director's conference room, office, and a finely equipped shop.



Fig. 2—This apparatus is used in the laboratories of the R.F.L. for measuring the sensitivity of broadcast receiving sets

Part I of a Series

GRID-LEAK GRID-CONDENSER DETECTION

By FREDERICK EMMONS TERMAN

Stanford University

DETECTION is a subject upon which little real information is available to the radio experimenter. While amplifier circuits are designed with full knowledge of the results that will be obtained under different conditions, the detector is left to chance. Recent investigations have shown that grid-leak grid-condenser detection of weak or moderate-strength signals is determined by a single new tube constant, and that the exact behavior of the detector can be obtained simply by using this new constant. The sensitiveness and distortion resulting with grid-leak detection when strong signals are being received can also be readily analyzed, and it will be shown that a properly operated grid-leak "power" detector is more sensitive and gives less distortion than the usual plate-rectification detector.

A few of the worth-while articles which have considered this subject are as follows:

"A Theoretical and Experimental Investigation of Detection of Small Signals," by E. L. Chaffee and G. H. Browning, *Proc.* I. R. E., 15, 113; February, 1927.

"The Rectification of Small Radio-Frequency Potential Differences by Means of Triode Valves," by F. M. Colebrook, *Experimental Wireless*, 2, 865; 1925.

"Detection by Grid Rectification with the High-Vacuum Triode," by Stuart Ballantine, *Proc.* I. R. E., 16, 593; May, 1928.

"Some Principles of Grid-Leak Grid-Condenser Detection," by Frederick Emmons Terman, *Proc.* I. R. E., Vol. 16, p. 1384, Oct. 1928.

"Detection Characteristics of Three-Element Vacuum Tubes," by Frederick Emmons Terman and Thomas M. Googin, *Proc.* I. R. E. Vol. 17, Jan. 1929.

Process of Detection

DETECTION is the name given to the rectification of high-frequency alternating-current voltages in radio receivers. In the grid-leak method of detection, the circuit for which is shown in Fig. 2, the rectification takes place in the grid circuit by making use of the curvature of the grid-current grid-voltage characteristic.

The case of weak signals will be considered first. The grid-leak "power" detector acts very differently, and will be taken up in another article.

The relation between grid voltage and grid current in a typical vacuum tube is given in Fig. 1. It will be noted that there is a small grid current even when the grid is negative with respect to the *negative side of the filament*. This is the result of the velocity which the electrons have as they leave the filament.

In the absence of a radio signal voltage, the grid assumes a voltage which is the potential of the grid return lead (the lead which completes the circuit from the grid back to the filament) minus the voltage drop due to the grid current flowing through the grid leak. This can be readily seen by examining Fig. 2. This actual grid voltage is the *operating grid potential*, and gives the point on the grid-voltage grid-current characteristic of Fig. 1 at which the detector operates. The operating grid potential is usually within a fraction of a volt of the negative filament voltage when the grid return lead is connected to the positive side of the filament. A higher resistance grid leak makes the operating grid potential more negative (or less positive), but the grid voltage changes only a volt or so when the grid-leak resistance is varied from ½ to 10 megohms. The principal function of the grid leak is to fix the operating grid potential at a point on the grid voltage-current characteristic suitable for rectification in the grid circuit.

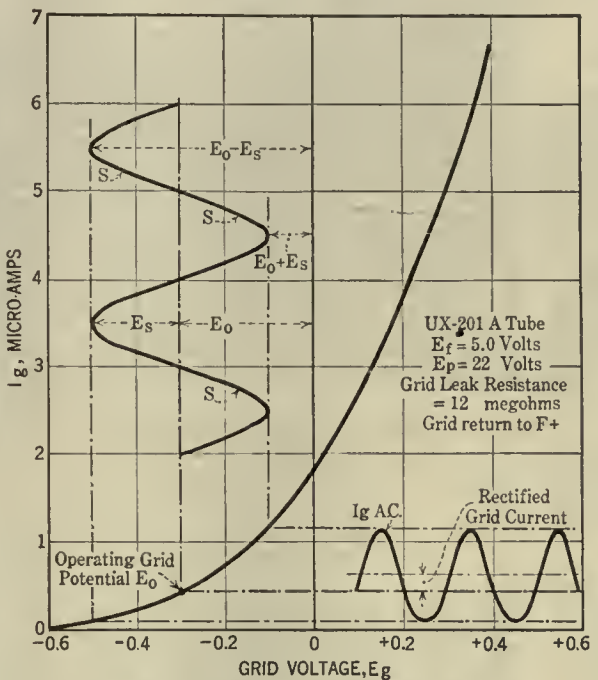


Fig. 1—Grid-current grid-voltage characteristic of a 201A-type tube

When a radio-frequency signal, such as developed by the tuned circuit LC of Fig. 2 is applied to the detector grid this voltage is superimposed on the operating grid potential, making the actual grid voltage alternately more and less than the operating grid potential. This is illustrated in Fig. 1 in which E_0 is the operating grid potential, E_s is the amplitude of signal voltage, and the curve SSS is the variation in actual grid potential when the signal voltage is present.

What goes on in a detector circuit is not the easiest thing in the world to understand, but we believe Professor Terman has made the operation of grid-leak grid-condenser detectors as clear as possible. In this article he points out that there are two detector constants that tell the whole story about what a tube will do as a detector, and advocates that tube manufacturers put the values of these constants on tube cartons. We agree. Several other articles on the long-neglected subject of detection are awaiting publication. Some are from Professor Terman and others are from Roger Wise and his former associates at the Cunningham laboratory.

THE EDITOR.

Principle of Detection

THE signal makes the instantaneous grid voltage swing alternately from $E_0 + E_s$ to $E_0 - E_s$, as indicated in Fig. 1. This fluctuation in grid voltage causes the grid current to vary, but, due to the curvature of the grid voltage-current characteristic, the grid current increases more during the half cycles when the signal voltage is positive than it decreases during the half cycles when the signal voltage is negative. The net result is a rectified current flowing in the grid circuit produced by the application of the radio-frequency signal voltage to the grid.

Reference to Fig. 1 will make clear how the rectification is accomplished. When the signal is present the instantaneous grid potential varies as indicated by the sine wave SSS. This variation in grid potential causes the grid current, $I_{g\,a.c.}$, to vary according to the curve to the right in Fig. 1. The middle dot-dash horizontal line shows the grid current that flows when the grid potential is E_0 (no signal present). The average grid current that flows when the signal is present is indicated by the light dash line. The difference between these two horizontal lines represents the rectified current flowing in the grid circuit as a result of the application of the signal voltage to the grid.

The amplitude of the rectified grid current depends upon the amplitude of the signal voltage. When the signal is a modulated alternating-current voltage, the rectified grid current varies in amplitude at the frequency of modulation. Thus, when the signal is modulated at 1000 cycles, the rectified grid current pulsates in amplitude at a 1000-cycle rate. In Fig. 3 there is shown the rectified grid current resulting when an unmodulated, a simply modulated, and a complexly modulated wave is rectified in the grid circuit of a detector.

The rectified grid current produced in the manner that has been described by the application of a signal voltage must flow through the impedance offered by the grid-leak grid-condenser combination, and will produce a voltage drop in this impedance. This drop causes the grid potential to become more negative by the amount of the drop, and the change of grid potential thus produced affects the plate circuit by ordinary amplifier action. It is the change of grid potential caused by the rectified grid current flowing through the grid-leak grid-condenser impedance that gives the detection of the signal.

The explanation that has been given of grid-leak detection with weak signals differs considerably from the familiar one in which the function of the grid leak is to let the grid-condenser charge leak off and return to the filament.

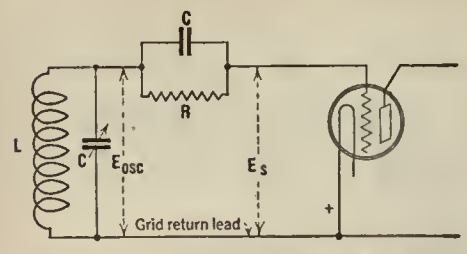


Fig. 2—Circuit for a grid-leak grid-condenser detector

Features of Practical Detection

IT WILL he ohserved that the grid-leak detector combines two distinct functions. First is the rectification of the signal voltage, and the utilization of the rectified signal current to produce a change of grid potential, and second is the amplification of this change of grid potential in the plate circuit. This latter problem is purely a matter of audio-frequency amplification, and is quite generally understood. The real problem of grid-leak detection is therefore centered around the determination of the change of grid potential hy the rectifying process, and the rest of this article will he devoted to a discussion of the factors controlling the rectified grid current, and the voltage drop it produces.

In the analysis of practical detection it is necessary to consider only the audio-frequency components of the rectified grid current. The direct-current component can produce no sound in the loud speaker and so is unimportant.

The sensitiveness of the detector (i.e. the change of grid potential produced hy a given input signal voltage) is obviously determined hy the effectiveness with which the signal voltage is rectified, and hy the amount of opposition which the grid leak-condenser combination offers to the flow of the audio-frequency components of the rectified current. The impedance which the grid leak-condenser combination offers to the rectified grid current depends greatly upon the frequency of this current. At low frequencies, such as 50 cycles, this impedance is very high because the low-frequency current has difficulty in getting through the grid condenser and is accordingly forced through the high resistance of the grid leak. On the other hand, at high audio frequencies, such as 5000 cycles, the grid condenser offers an easy path to the current, practically short-circuiting the grid leak.

The result is that the rectified grid current tends to produce less change of grid potential on the high audio frequencies than on the low notes. This reduction of sensitiveness at the higher audio frequencies can he quite serious, and unless the detector is adjusted properly will lead to very had quality. Satisfactory reproduction of the high notes requires that the smallest possible grid condenser capacity be used in order to minimize the short-circuiting effect of the grid condenser on the grid leak. If the grid condenser is made too small, however, an appreciable part of the radio-frequency voltage developed hy the tuned circuit supplying the grid will be used up in the grid condenser, and the signal voltage, E_s, actually applied to the grid will he seriously reduced (see Fig. 2). The best value of grid condenser for all standard type tubes is from 0.0001 to 0.00025 mfds. Larger capacities should never he used.

The Equivalent Circuit

FROM the discussion that has been given it is seen that the most important features of the grid-leak detector are the amount of rectified grid current produced hy a given signal, and the amount of voltage drop which this rectified current produces in flowing through the grid leak-condenser combination. Recent investigations, both theoretical and experimental, have shown that *the rectified grid current produced by the application of a small radio signal voltage to the detector grid acts exactly as though it were produced by a suitable series of low-frequency generators acting between the grid and filament in series with the grid-filament resistance of the tube.*

There is one such generator for each component of the rectified grid current. The most important of these equivalent generators is the one of modulation frequency.

The action that takes place in the grid circuit of a grid-leak detector can he conveniently described in terms of the equivalent grid circuit shown in Fig. 4. Here the rectifying effect of the grid circuit on the radio signal is replaced by the equivalent generators, E_r, which are considered as producing the rectified grid current in place of the radio signal that actually does. These equivalent generators act in a circuit consisting of the grid leak-condenser combination, RC, in series with the grid-filament tube resistance, R_g. This grid resistance, R_g, is analogous in all respects to the plate resistance, R_p, and is the reciprocal of the slope of the grid voltage-current curve shown in Fig. 1. While the grid resistance in amplifiers is commonly considered as infinite, this is not the case with grid-leak detectors because the detector works with a small but



Fig. 3—Rectified current for various kinds of modulation

definite grid current. The grid resistance, R_g, depends upon the grid, plate, and filament voltages of the tube, and becomes higher as the grid is made more negative. High grid-leak resistances accordingly give a high grid resistance because such leaks give a more negative operating grid potential, while low resistance leaks will fix the operating grid potential where the grid resistance is low.

Tube Capacity

THE capacity C_g' indicated in Fig. 4 is the input grid-filament tube capacity to audio frequencies. This capacity is larger than the interelectrode capacity hy an amount depending upon the plate circuit impedance, and will he in the order of 70 mmfd. with 226, 227, 112A, and 201A tubes when there is a transformer in the plate circuit. The capacity C_g' is in parallel with the actual grid condenser, C, so that the effective grid condenser capacity is the actual capacity plus C_g'.

The generators that can he assumed acting between the filament and grid in series with the dynamic grid resistance to produce the rectified grid current have no actual existence. It is merely that the effect of applying a signal voltage to the grid is the same as though these fictitious generators actually were present, and as though they and not the signal voltage were the forces really producing the rectified grid current. The voltage developed by this series of fictitious generators can conveniently he called the *rectified grid voltage*, and will be represented hy the symbol E_r.

One of the fundamental features of the law of detectors is that the size of the equivalent rectified grid voltage, E_r, which can be considered as acting to produce the rectified grid current, depends only upon the strength and type of signal and upon the tube characteristics at the operating grid potential. *The size of grid condenser and grid leak has no effect on the amplitude of the rectified grid voltage, E_r, except in so far as the grid-leak resistance affects the operating grid potential.*

Part of the rectified voltage, E_r, in the equivalent grid circuit of Fig. 4 is used up as voltage drop in the grid leak-condenser combination and part is used up across R_g. The change of grid potential which the rectified grid current produces in flowing through the grid leak and condenser is the grid voltage change which is amplified by the tube in the usual audio-frequency manner. Under ordinary circumstances only the modulation-frequency component of rectified grid voltage, E_r, need he considered in this process as this component represents the useful output of the detector.

Detector Voltage Constant

THE size of rectified grid voltage, E_r, used in the equivalent detector circuit of Fig. 4 depends upon the tube characteristics at the operating grid potential and upon the signal voltage. The action of the tube in rectifying the radio-frequency signal voltage can he completely taken into account by a single tube constant called the voltage constant of the grid and represented by the symbol V_g. The voltage constant, V_g, is measured in terms of volts and varies between —0.2 and —0.5 volts for nearly all properly adjusted detectors. The voltage constant of the grid depends upon the slope of the grid voltage-current characteristic at the operating point, and upon the way in which this slope varies with grid voltage. Mathematically it is defined by

$$V_g = \frac{2R_g}{\frac{dR_g}{dE_g}}$$

It can he measured by determining the grid resistance at the operating grid voltage, and at grid voltages slightly more and less than the operating voltage.

As has been pointed out, the modulation-frequency component of the rectified grid voltage is the important part. The crest or peak value of this component of E_r is equal to mE_s^2/V_g where m is the degree of modulation, which must lie between 1.00 and zero, and will only reach 1.00 when the music or speech is very loud, and E_s is the peak amplitude of the signal carrier wave. The crest amplitude is 1.414 times the effective (or r.m.s.) amplitude. It is to he remembered that field strengths, etc., are ordinarily expressed in effective values, while amplifier inputs must he expressed in crest amplitudes because it is the crest amplitude of the sine wave that overloads the amplifier.

Practical Example

AS A simple example, consider the case of a signal modulated 20 per cent. or 0.20 at 1000 cycles, with a carrier crest amplitude of 0.05 volts being applied to a detector grid operated where the voltage constant is —0.25 volts. The crest value of the 1000-cycle component of rectified grid voltage is then $0.20 \times (0.05)^2 / (-0.25) = -0.002$ volts crest value. The amount of 1000-cycle rectified grid current existing in the grid circuit of the actual detector is the same as the current which this —0.002 volts of 1000 cycles will produce acting in the equivalent grid circuit of Fig. 4. The 1000-cycle voltage drop produced

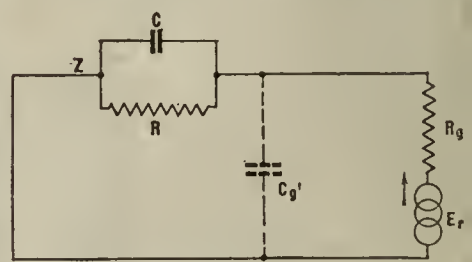


Fig. 4—Equivalent circuit of grid-leak grid-condenser detector

across the grid leak-condenser combination in the equivalent circuit by the action of the —0.002 volts is the amount of 1000-cycle voltage drop in grid potential existing in the actual detector, and is the amount of 1000-cycle voltage which is applied to the input of the audio amplifying system. (This does not mean the voltage applied to the primary of the first audio transformer, for example, but is the audio-frequency voltage impressed on the grid of the detector, which the author considers as the beginning of the audio system. If the mu of the detector tube is 8, the maximum voltage across the primary under these conditions would be 8 x 0.002 or 0.016 volts—*Editor.*) The negative sign of the rectified grid voltage is caused by the fact that the voltage constant, V_g, of the grid is negative, and this merely means that the voltage acts in a direction opposite to that indicated by the arrow in Fig. 4.

It is apparent from a study of Fig. 4 that the fraction of the rectified grid voltage which is usefully used to produce change of grid potential is determined by the ratio of impedance to the rectified grid voltage, which the grid leak-condenser combination offers to the grid-resistance, R_g. The higher this ratio, the more sensitive will be the detector, *but in no case will the change of grid potential ever exceed the rectified grid voltage.*

In order that the detector may reproduce the high notes as well as the low notes it is necessary that the impedance of the grid leak-condenser combination at the highest note desired be sufficiently great relative to the grid resistance, R_g, as to cause most of the rectified grid voltage of this high frequency to be used up as voltage drop across the grid leak and condenser. Then the high notes will be reproduced with full sensitivity and, as the low notes are already as loud as possible, the detector will give good quality output covering the entire audio-frequency range.

The quality of the detector output will be worse for operating points which give a high grid resistance, R_g, than for conditions which give a low grid resistance. Thus, high-resistance grid leaks give poorer quality than low-resistance ones. With a given size grid condenser, however, the quality is not improved appreciably after the grid resistance gets less than a critical value to be discussed later. The maximum allowable grid resistance, R_g, is determined by the highest audio frequency to be reproduced at full sensitivity, and by the size of grid condenser. The grid-leak resistance has little effect on the quality at the high notes except as a means of controlling the operating grid potential, and hence of controlling the grid resistance, R_g, because the rectified grid currents of high audio frequency very largely go through the grid condenser shunting the grid leak.

Detection Data

THE most satisfactory way to represent detector characteristics is to plot grid voltage constant, V_g, as a function of grid

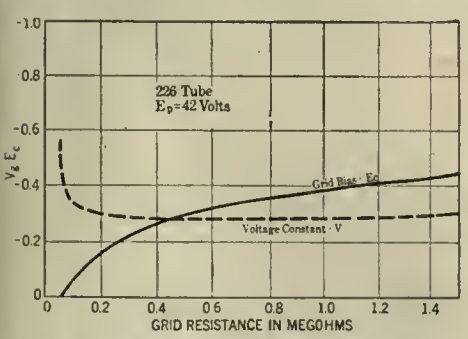


Fig. 5—Rectifying characteristics of a 226-type tube used as a grid-leak grid-condenser detector

resistance, R_g, at the operating point. Since the sensitiveness of the detector is proportional to the rectified voltage and this in turn is determined by V_g, while the possible quality is dependent upon R_g, such a curve can be considered as showing the relation between sensitivity and quality.

A typical relation between the grid voltage constant, V_g, and grid resistance, R_g, is shown in Fig. 5. This figure also shows the operating grid potential required to give different values of grid resistance. In examining the V_g–R_g characteristic it is to be remembered that, since the rectified grid voltage is inversely proportional to V_g, the *sensitiveness is greatest when the grid voltage constant, V_g, is smallest.* In Fig. 5 it is accordingly seen that as the operating grid potential gets more negative, and the grid resistance, R_g, increases, the sensitivity rapidly increases until R_g equals about 150,000 to 200,000 ohms. *For all grid resistances higher than approximately 150,000 ohms the sensitivity as indicated by the V_g curve is substantially the same, and is the maximum sensitivity which is obtainable from this particular tube.*

While Fig. 5 gives the V_g–R_g characteristic of a particular tube at particular values of

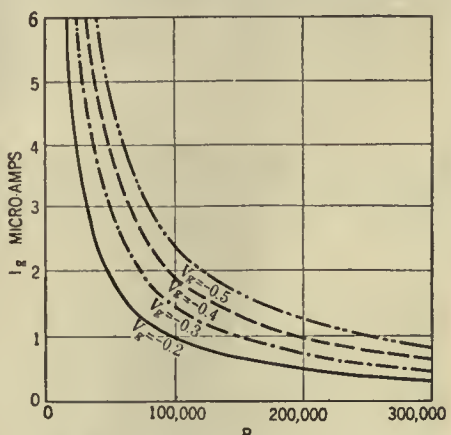


Fig. 6—Grid current as a function of grid resistance and V_g

plate and filament voltages, an investigation in which over 1000 measurements of V_g were made showed that every tube tested had a V_g–R_g characteristic similar in shape to Fig. 5. In every case there was the same rapid decrease in V_g at increasing values of grid resistance and this was followed by the low flat part of the curve at all grid resistances above a critical value.

Not only does every tube have the same type of V_g–R_g characteristic, but *every tube of the same type was found to have substantially the same characteristic for all plate and filament voltages* (provided there was sufficient electron emission from the filament). Furthermore using the tube, or even rejuvenating it (in the case of thoriated filaments) had no effect on the V_g–R_g relation as long as the filament was reasonably active. The only point on which tubes of the same type differ is in the grid voltage required to give a particular value of grid resistance. At high plate and low filament potentials the operating grid voltage must be slightly more positive to obtain a given grid resistance than at low plate and high filament potentials. Even at the same filament and plate conditions different tubes of the same type will sometimes require operating grid voltages differing in extreme cases by as much as 0.5 volts to give the same R_g.

Characteristic Curves

The V_g–R_g characteristics for standard types of tubes are given in Figs. 8 and 9. These curves are all for a plate voltage of 42

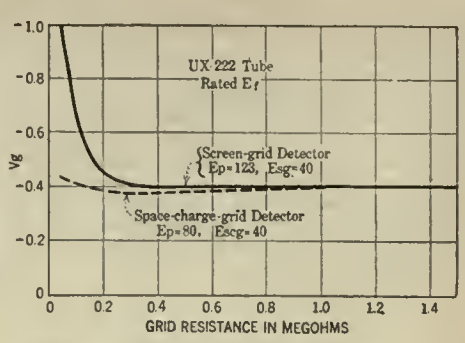


Fig. 7—Detection characteristics of four-element tubes

and rated filament conditions, but would be substantially unchanged if measured at other plate and filament voltages. The important differences between the various tube types are (a) the value of voltage constant on the flat part of the curve, and (b) the value of grid resistance at which the low flat part of the curve begins. These characteristics are tabulated in Table I. The values in the third column determine the sensitivity of the detector as a rectifier. The tube with the smallest V_g is the best rectifier, and will produce the greatest change of grid potential with a given signal. The second particular in which different types of tubes differ, i.e., the point at which the flat part of the curve begins, has an important influence in determining the effectiveness with which the high notes may be reproduced. *The lower the value of grid resistance at which the low flat part of the V_g–R_g curve begins, the better the detector.*

Practical Detection

THE principles and data of the preceding paragraphs will now be applied to the problems involved in selecting detector tubes and adjusting their circuits. In selecting detector tubes it is necessary to remember that the sensitiveness depends upon, *first*, the maximum change of grid potential obtainable, which is inversely proportional to the value of V_g over the low flat part as tabulated in Table I, and *second*, the amplification (produced in the tube) of this change of grid potential. While both the 201A and the 199 have substantially the same V_g, the 201A tube is a better amplifier because of its higher mu and lower R_p and is, therefore, superior. The 227 tube is a more sensitive detector than the 226 tube because, although they are equally good amplifiers, the 227 tube has a smaller V_g, and so gives a greater change of grid voltage to amplify. On this basis the 227 heater-type tube is the most sensitive detector, closely followed by the 226 and the 112A types. Other tubes, such as the 201A, 199, 171A, 120, and 12 varieties are distinctly less sensitive, either because of high grid voltage constant or because of low audio-frequency amplification per stage. The 200A gas tube and the 240 high-mu tube are no better rectifiers than the 201A tube, but as both have a high mu they are more sensitive than other detector tubes in resistance-coupled circuits.

Securing Sensitivity

IN ORDER to realize the full sensitivity of the detector tube the operating grid potential must be such as to give a grid resistance that is on the low flat part of the V_g–R_g characteristic. No detector tube should be operated at a grid resistance lower than the value given in the fourth column of Table I. If this rule is violated great loss in sensitivity will result.

Since R_g is not the same as the grid-leak resistance the next step is the selection of a value for the latter that will give the best operating grid potential. In general, the most

favorable operating point is the one that gives the lowest permissible grid resistance, as indicated in the fourth column of Table I, except that it is best not to operate with R_g less than 100,000 to 75,000 ohms in ordinary cases because of losses in the grid circuit. The value of grid-leak resistance controls the operating point, as has been explained. The greater the leak resistance, the more will be the voltage drop in the leak, the more negative will this make the actual operating grid potential, and the larger will be R_g.

The value of grid-leak resistance giving a desired operating grid resistance can be determined exactly by certain obvious measurements, which, however, require apparatus frequently not available, or they can be determined approximately with the aid of Fig. 6, which shows the grid current that will flow *when the operating point is on the low flat part of the V_g–R_g characteristic*, and when the tube's V_g is on the flat part, and the desired R_g is known. To select the grid leak in this approximate way one first determines the grid current that will flow at the desired operating grid resistance, using Fig. 6, and then computes the resistance this current would have to flow through to produce a voltage drop equal to the voltage drop in the filament. The resistance thus obtained when used for the grid leak will give the desired grid resistance usually without more than 20 per cent. error for all plate voltages within the usual operating range, and for all tubes of that type. Thus in the case of a 201A tube to be operated at R_g = 150,000 ohms, the grid current as determined from Fig. 6 (V_g = —0.47) is approximately 1.57 microamperes and the grid-leak resistance for rated filament potential of 5.0 volts would be 5/1.57 = 3.2 megohms. The grid return lead would then be brought back to the positive leg of the filament.

This approximate method can be satisfactorily applied to all tubes except the 200A and the 227. With 227 tubes satisfactory results will be obtained when the grid leak is such as to give a drop of 0.9 volts when the grid current at the desired operating grid resistance is flowing through the leak.

Grid-Condenser Determination

AFTER selecting the tube, the proper operating grid resistance, and the grid leak that will give the operating R_g desired, there remains the determination of the grid condenser. The grid condenser capacity is determined by the highest audio frequency that is to be satisfactorily reproduced, and by the operating grid resistance. The rule is that the reactance of the effective grid condenser capacity (which is the actual grid condenser capacity plus the input grid-filament tube capacity to audio frequencies) at the highest note to be reproduced at least 70 per cent. as well as the low notes must be equal to the grid resistance. Therefore, if f is this highest frequency and C_{eff} is the capacity, then

$$C_{eff} = \frac{1}{2\pi f R_g}$$

The actual grid condenser size is C_{eff} minus the tube input capacity—about 70 mmfd. for tubes with mu = 9 and for the other tubes it will be roughly proportional to mu.

In the case of the 201A tube considered, if the highest note is to be 5000 cycles, then

$$C_{eff} = \frac{1}{2\pi \times 5000 \times 150{,}000} = 0.000212$$

mfd. As the tube input capacity is about 70 mmfd. a grid condenser capacity of 0.000142 mmfd. will be required. With this capacity notes of 10,000 cycles will be reproduced half as well as the low notes.

In Table I there is tabulated the value of grid-leak resistance which will put the operating grid resistance at approximately the value corresponding to the lowest permissible figure as given in the fourth column of the Table. This table also gives the value of C_{eff} that reproduces 5000 cycles 70 per cent. as well as the low notes when the grid resistance is the minimum value giving full sensitivity. Values of C_{eff} twice as big as those given in the table will reproduce 5000 cycles one half as well as the low notes.

Table I

DETECTION CHARACTERISTICS OF THREE-ELEMENT TUBES

Type	Mu	V_g (volts)	R_g at start of flat part (approximate) (ohms)	Leak resistance to give R_g in column four (megohms)	C_{eff} for 70% reproduction of 5000 cycles (mfd.)
201A	9	—0.47	150,000	3.20	0.000212
200A	20	—0.47	50,000	1.06	0.000636
240	30	—0.47	150,000	3.20	0.000212
199	6	—0.50	125,000	1.50	0.000255
120	3	—0.45	125,000	1.67	0.000255
171A	3	—0.28	200,000	7.2	0.000160
112A	8	—0.26	150,000	5.8	0.000212
226	8	—0.29	150,000	1.6	0.000212
227	8	—0.23	50,000	3.9	0.000636
12	6	—0.27	50,000	4.0	0.000636

Note: Values of Vg are averages for a number of tubes.
Values of Ceff are values for grid resistance as given in fourth column. The actual grid condenser capacity is Ceff minus tube input capacity.
Values of Ceff twice the value given in table reproduce 5000 cycles 45 per cent. as well as the low notes instead of 70 per cent.
All tubes are RCA or Cunningham.

In general it is best to use the largest size grid condenser that is consistent with the quality of reproduction desired. Large grid condensers use up less of the radio-frequency signal voltage, as explained in connection with Fig. 2. There is not much to be gained by going to condensers over 0.00025 mfds., however, while capacities much less than 0.0001 mfd. are also to be avoided if possible.

The final decision to be made regarding the detector is the choice of plate voltage. Since the rectifying action in the grid (i.e., the form of the E_g–I_g curve—*Editor*) is unaffected by the plate potential, it is desirable to make the plate voltage as high as possible consistent with the safe or allowable plate current. Such a plate potential will give a low plate resistance and hence good amplification. Unusually high plate potentials cannot be used with moderate mu tubes, however, because of the high plate current with the grid operating point near zero potential.

Measurements of V_g of four-element tubes operated as space-charge-grid and screen-grid (222 type) tubes show that the rectifying action in the control grid of four-element tubes is of exactly the same character as in three-element tubes. Fig. 9 shows the V_g–R_g characteristic of four-element tubes compared with the 201A tube. The curves for four-element tubes are independent of filament, plate, and auxiliary grid potentials for both space-charge-grid and screen-grid tubes. The only difference between the two connections is that the low flat part of the V_g–R_g curve extends down to very much lower values of grid resistance in the case of the space-charge-grid tube.

The screen-grid and space-charge-grid tubes can, accordingly, be used very satisfactorily as grid-leak detectors. In particular, the space-charge grid tube combines fair grid rectification with unusual amplifying properties. When arrangements are worked out to satisfactorily utilize the tremendous amplifying properties of the screen-grid tube for audio-frequency amplification grid-leak detection with the screen-grid tube can be used with great success.

Comparison of Detector Tubes

THE indications are that the merit of a detector tube as a rectifier depends primarily upon the characteristics of the filament, or the electron emitting cathode, and only secondarily, if at all, upon other features such as the mu, electrode voltages, number of elements, power capacity, and the like. The oxide-coated filament is definitely superior to the thoriated-tungsten filament, which, in turn, is better than straight tungsten. At the same time there is some difference between different types of tubes with the same kind of filament material.

In selecting a detector tube the choice depends upon several conditions. If the audio system is resistance coupled the high-mu 240 and 200A tubes are best. When the detector is transformer coupled and is operated by storage battery, the 112A is best, being definitely superior both in amplification and rectification to the 201A which consumes the same filament power. Of the dry-cell filament tubes the obsolescent cx-12 is much more sensitive than the 199. Of the a.c. tubes, the 227 type is the best detector, being better than any of the d.c. or other a.c. tubes.

It is interesting to note that the gas-filled 200A "super-sensitive" detector is no more sensitive than would be a 201A tube built with the same high mu. *The gas apparently contributes substantially nothing to the 200A tube but an objectionable hiss!*

In conclusion it is worth pointing out that the value of the grid-voltage constant, V_g, over the low flat part of the curve, and the value of grid resistance, R_g, at which the flat part begins, are tube constants which should be published by tube manufacturers. Both of these quantities are as truly characteristic of a given make and type of tube as is the mu and plate resistance. Both detection constants are substantially independent of age, filament, and plate voltages within the operating range of values.

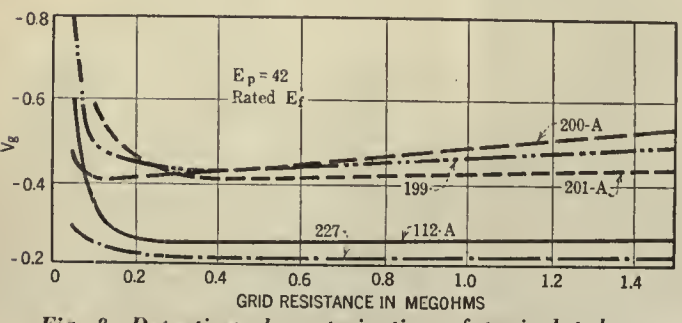


Fig. 8—Detecting characterization of typical tubes

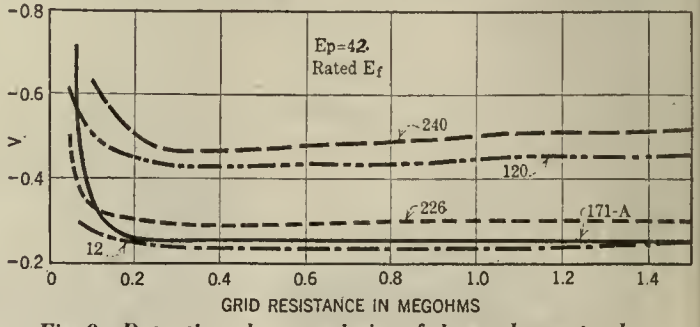


Fig. 9—Detection characteristics of three-element tubes

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PLOTTING CURVES—PART I

ALL experimenters should be able to draw curves, graphs, or plots and to interpret what these pictures mean. Also they should be able to interpret what the curves drawn by other experimenters mean. A note book full of curves is a source of concentrated information of infinite variety. In a few pages it may contain a summary of a month's work in a laboratory, or of many week's work with complex mathematical formulas. It is always a visual picture or representation of some physical, electrical, or mechanical phenomenon. This "Home-Study Sheet" is written in the hope that some of the less apparent facts about curve plotting may be brought to light and that it may encourage more experimenters to keep their data in this convenient form.

To state that a graph is a visual representation of a mathematical expression may not convey

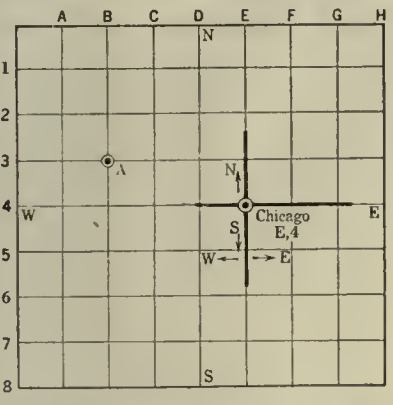


Fig. 1—A map is a form of graph

much to the average experimenter, but such is a fact nevertheless. Every graph or plot or curve may be expressed in the form of a mathematical equation. Some curves, however, are so complex that the expression would be very difficult to figure out. Conversely, every mathematical expression may be plotted in the form of a graph.

A graph is a visual statement that two factors are related to each other in some fashion, either simple or complex. Thus, one factor may increase when the other increases, directly or according to a square or a more complicated law, or it may decrease as the other increases.

A form of graph with which everyone is familiar is a map. We say that a certain town, "A," is so many miles north and so many miles west of Chicago. Anyone with a map could put his finger on such a place at a moment's notice. A map has the essentials of every graph, namely, two coördinates (axes) or directions, north-south and east-west, an origin, in this case Chicago, and a point which we wish to locate with respect to this origin. Fig. 1 shows how we would locate the town of "A." Some maps have the coördinates marked off as shown at the top and down the left side of Fig. 1 and so "A" on such a map would be defined as existing at (B, 3). In this case the origin is at the top left-hand corner of the graph.

Problem 1. Mark on the map a town, "B," which is at (F, 6).

Such a means of locating a point on a map is everyday knowledge.

The next problem is a bit more complex. How would you state that a railroad runs north and south and at a distance of 50 miles from Chicago? Here we must locate not a point on a map but a straight line perpendicular to one axis (coördinate) and parallel to another. A simple expression for such a line, representing a railroad, would be (west 50 miles) signifying that the road ran north and south and was 50 miles west of Chicago at its nearest point.

Problem 2. A road runs south of Chicago through (D, 6) and straight east and west. Mark it on the map.

The next problem would be to describe a road that ran at an angle to the two axes and approached to within 50 miles to Chicago. We could state that it ran through two towns and then give their locations on the map just as we located the point (B, 3) above.

Problem 3. A road runs through (B, 2) and (F, 6.5). Place it on the map. How far south of Chicago is the nearest approach?

A point on a map is located at the intersection of two lines; a line is defined when two points through which it passes are located. The points are always given in certain distances away from vertical and horizontal axes or coördinates.

Other Types of Graphs

A graph is no different from a map, even though the axes or coördinates may be called X and Y instead of north-south and east-west. Also such high-sounding words as "ordinates" and "abssissa," etc., may be used to express the distance up or down, and right or left, from some point chosen as the origin. In a graph the units of measurements, instead of being miles or feet, may be amperes, dollars, watts, volts, or merely unnamed units.

Generally the origin is at the lower left-hand corner of the graph, although there is no reason why it cannot be somewhere else; for example in plotting the plate current of a vacuum tube against the grid voltage, the vertical axis (representing plate current) is usually near the center of the graph instead of at one corner of it so that both positive and negative values of grid voltage may be represented. Wherever the origin is, to plot the position of a point with respect to the origin, we need only move a certain number of units to the right (or left) and erect a perpendicular line; then move a certain number of units up (or down) and make a horizontal line. Where these two lines cross each other is the position or location of the point.

For example, on Fig. 2 is plotted the point (X=5, Y=5). We find this position by moving 5 units to the right of the origin (where both X and Y are equal to zero). At this point we erect the perpendicular line which contains all points which are 5 units to the right of X=0. Then we draw the line Y=5 and let them cross.

Equation of a straight line

A point is represented as follows, (X = 5, Y = 5). A straight line is a bit more complex because it goes through two points whose locations must be given. We can get around this complexity by knowing one point through which it goes and the slope of the line, that is the change in its Y units that are caused by a change along its X axis. In general a line is represented by an equation of this form, $Y = MX + B$, where M is the slope of the line, and B is the point where it crosses the Y axis. Thus the line $Y = 2X - 4$ crosses the Y axis 4 units below the X axis and has a slope of 2.

A line parallel to the Y axis is expressed as X = so-and-so; X = 5, for example, because it represents all points 5 units to the right of Y. Similarly a line parallel to the X axis and so many units above it is described in the same manner. For example, a line parallel to the X axis and 5 units above it is represented as Y = 5.

A line going through the origin, such as OA of Fig. 3, crosses the Y axis at Y = 0 and so B in the equation above equals zero. The formula then becomes simpler, Y = MX where M is the slope and is actually equal to Y/X. In Fig. 3 M is equal to $\frac{3}{6}$ or 0.5 and so the equation of this line becomes Y = 0.5 X.

A line going through points B and C, Fig. 3, crosses the Y axis at Y = 10 and has a slope equal to—Y/X (because it points in the opposite direction to OA) or $-\frac{10}{8}$ and so the line becomes $Y = -\frac{5}{4}X$

Problem 4. Locate on Fig. 2 a point (X = 3, Y = 2). Describe in mathematical language the position of the point P on Fig. 2.

Problem 5. Mark off several units in both X and Y directions on a sheet of cross-section paper. Draw on it the following lines,

(a) Y = 3, (b) X = —4, (c) Y = 4 x + 3, (d) Y = 3 X + 4, (e) Y = X — 3, (f) Y = 2X — 3.

Ohm's Law

The equation representing Ohm's law reads, I = E/R, may be written I = (1/R) E which looks

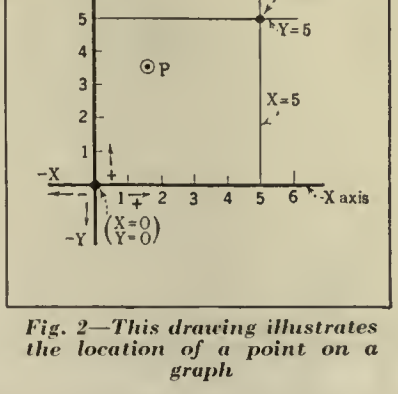


Fig. 2—This drawing illustrates the location of a point on a graph

like the general expression for a straight line through the origin, Y = MX in which M = 1/R. Now the reciprocal of the resistance of a circuit, is called its "conductance" and the lower the resistance the greater the conductance. We may write Ohm's law as I = K E in which K is the conductance and is always equal to 1 ÷ R. K (or 1/R) is the slope of the line which expresses the relation between the current and voltage in a circuit.

Problem 6. Assume the resistance of a circuit is 1 ohm, and plot the relation between E and I, making E the X axis and I the Y axis. (Assume various values for E, calculate I when R = 1, and plot). Then assume several other values to R and plot all on the same sheet of graph paper.

Suppose, however, we have a current of 4 amperes flowing in a circuit having a resistance of 2 ohms. If we add another battery and vary its voltage

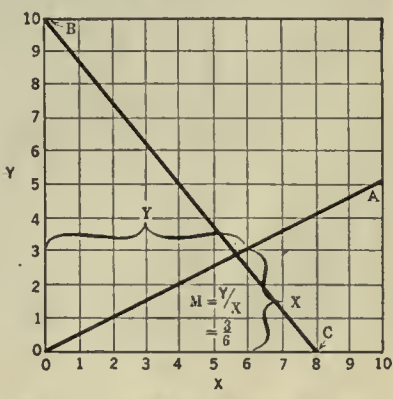


Fig. 3—Drawing shows method of plotting a line on a graph

the current in the circuit will change. How can we express the relation between the total current flowing and the varintions in the additional voltages? Let I be equal to the current flowing. Then

$$I = \frac{E}{R} + 4 \text{ or } \frac{1}{R}E + 4 \text{ or } I = \frac{1}{2}E + 4$$

The above formula looks like our general expression, $Y = MX + B$. In this case a current of 4 amperes is always flowing; and so when E = 0, I = 4 and the line crosses the vertical or current axis at I = 4. When E = 4 volts, I = 4/2 + 4 = 6 amperes. And so on.

Problem 7. Assume several values for E in the above case and plot the current on cross-section paper. Draw a line through them. Then assume another value of R and replot. Then assume a negative value of E, calculate I and plot. This is equivalent to reversing the battery so that it bucks the battery which is producing the steady current of 4 amperes.

Units

The appearance of a curve may be changed somewhat by changing the units into which the vertical and horizontal axes are divided. As an example, plot the following data which give the d.c. output voltage of a cx-380 rectifier tube as the load current is changed, and as various a.c. voltages are put on the plate of the tube. There will be three curves for the three plate voltages applied to the tube. First make the vertical divisions, 100, 150, 200, 250 volts, etc. Then make the same divisions, 100, 200, 300, etc. and note how much flatter the curves seem. The slope of these curves is an indication of the "regulation" of the rectifier, that is, how many volts drop is caused by increasing the output current.

Problem 8. The ratio between the voltage and the current at any point on these curves gives the d.c. resistance of the rectifier. The slope of the line, that is the change in voltage divided by the change in current is the a.c. resistance of the rectifier. Calculate the d.c. resistance at each value of output current and plot against current.

Data for Example

	Volts per plate			
Current output Milliamperes	300	260	220	
20	375	330	280	Volts output of Rectifier
40	350	300	250	
60	330	280	230	
80	310	260	210	
100	290	240	190	
120	280	230	180	

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PLOTTING CURVES—PART II

CURVES may be plotted either from a mathematical formula or equation or from a set of data obtained in a laboratory or from someone who has already done the laboratory work. To plot these curves properly, all one needs is a hard pencil or a ruling pen, some India Ink (Higgins' American India ink), a celluloid triangle or rule, a French curve, and some cross-section paper. The latter may be bought from Keuffel and Esser, Deitzgen, Codex, and several other manufacturers, and it comes in many colors, many rulings, and sizes, some of which are punched for loose-leaf note books.

Keuffel and Esser paper No. 359–6 and 355–2R are both convenient and are ruled 10 x 10 to the inch and are punched for standard size note books. Another good paper is Keuffel and Esser No. 359–11 which is ruled 20 x 20 to the inch. Dietzgen No. 340–10 is ruled 10 x 10 and is punched. Codex 2 and 3 cycle logarithmic paper, No. 3135 and 3112, and Keuffel and Esser double logarithmic three cycles, No. 359–120, are useful in plotting frequency characteristics of audio transformers, amplifiers, loud speakers, etc.

Vacuum-Tube Characteristics

The characteristics of a vacuum tube are usually represented on a sheet of graph paper and are called the characteristic curves. Because there are three variable factors involved, plate current, grid voltage, and plate voltage, a complete picture of the tube and its action in a circuit cannot be represented on a single sheet of paper, (which has only two dimensions), but two curves are needed, or better still a three dimension model made of plaster of Paris or wax. Some very beautiful models of this sort are used in the course on vacuum tubes given at Cruft Laboratory, Harvard University, and are part of the equipment of any good radio engineering course. We can get a good idea of what a tube will do by making two curves called the Eg-Ip and the Ep-Ip curves. These show what the plate current is at various values of grid and plate voltage. The slopes of these curves are important tube factors.

Problem 1. Plot the data in Table 1, making the vertical axis, the current axis (in mA.). Determine the slope and, remembering that the mutual conductance is the change in amperes divided by change in grid volts, calculate the mutual conductance. The slope of the plate-voltage plate-current curve, using amperes and volts of course, gives the reciprocal of the plate resistance of the tube. The slope of the curve must be divided into 1.0 to get the resistance. Calculate the plate resistance at several points on the curve. Plot the mutual conductance and the plate resistance against grid volts, plate volts, and plate current. In each case assume one of the variable as fixed, e.g., when calculating and plotting the plate resistance assume the grid voltage is some constant value for one set of values, and then assume another value for another set of data.

Table 1

Grid volts = Eg	plate volts = Ep 60	80	135	
0	2.75	4.5	10.25	} =Ip mils
—4	.25	1.0	4.75	
—6	0	.25	2.75	
—8	0		1.25	

Correcting Errors of Measurement

A curve which is a visual picture of a given laboratory experiment may be very useful in detecting or correcting errors in measurement. For example, if we know that the relation between two factors is a straight line, and when we plot the curve, several points seem to be off this line, these points indicate errors in measurement. In calibrating a wavemeter, according to "Home-Study Sheet No. 13," errors may occur, and the only way to tell them is to plot the curve of wavelength squared against capacity, or wavelength against condenser degrees. The first of these curves will be a straight line, and the latter will be a smooth curve. Points off the curve should be considered wrong and must be repeated or disregarded.

Problem 2. Plot the data in Table 2, first, showing the relation between wavelength squared and condenser capacity, and, secondly, the variation of wavelength with condenser degrees. Determine which points are wrong, and indicate what the wavelength should be instead of the values given. If the slope of the straight line, i.e., $(\text{wavelength})^2$ against capacity is divided by 3.54, the inductance of the circuit will result. Determine the inductance.

Table 2

Wavelength meters	Condenser degrees	Condenser capacity
197.5	15	100 mmfd.
245.	25	150 "
253	35	200 "
300	55	300 "

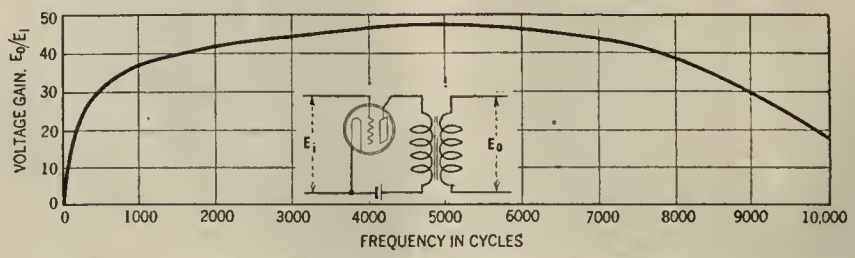


Fig. 1—Frequency characteristics of transformer plotted on cross-section paper

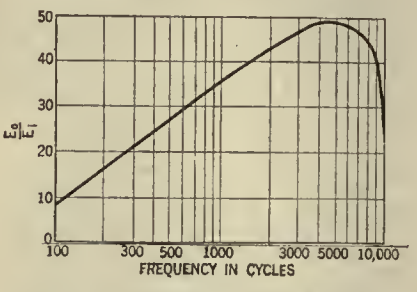


Fig. 2—Frequency characteristics of transformer plotted on logarithmic paper

Amplification-Frequency Characteristics

The frequency characteristics of amplifiers and audio transformers may be plotted directly against frequency. It has now become standard practice to plot amplification against frequency arranged in octaves, so that each change in frequency gets equal attention. For example, the curve of Fig. 1 represents a transformer of the olden days when low-frequency amplification was unthought of. Note what a long flat portion the curve has. Then look at the curve of Fig. 2 in which the same data is presented on logarithmic paper. Here the low frequencies, i.e., from 100 to 1000 cycles are not all cramped into a very small part of the whole horizontal scale but get the same horizontal space as does the range from 1000 to 10,000 cycles—and both of these spaces represent a 10 to 1 change in frequency.

The ear hears according to a logarithmic scale, and so amplifier characteristics are usually plotted against transmission units (DB) of loss or gain with some given frequency as standard. That is, the response at all frequencies is plotted with respect to the response of some intermediate frequency as standard. For example, we may measure the power output of an amplifier obtained at 1000 cycles and then compare the power output of other frequencies to the value at 1000 cycles. Or we may simply plot the power output at all frequencies without regard to any given frequency as standard. One curve gives the characteristic, the other tells us the power output. The characteristic may be obtained from the power output curve by noting from it how much more power is obtained at one frequency than another.

Characteristics of amplifiers should always be plotted with a logarithmic horizontal frequency scale and preferably with a vertical scale either in logarithmic units (DB) or on a logarithmic scale.

Problem 3. Transfer the data given in the curve of Fig. 3 to DN, first calculating the number of DB up or down from 1000 cycles, where the voltage amplification is 850 and secondly plotting the number of DB corresponding to the voltage amplification, e.g., a voltage amplification of 100 corresponds to a DN of 40.

Remembering that the ear can hear with some difficulty changes in power output of 3 DB and cannot hear smaller changes than this, plot the data in Table 3 and determine whether or not the amplifier is a good one. Plot in DB using the power output at 1000 cycles as standard. Will the loss in response at 100 and 5000 cycles be noticeable to the ear?

Table 3

Frequency cycles	Power output milliwatts
60	175
100	350
200	600
400	700
1000	700
2000	700
4000	435
6000	280
8000	105

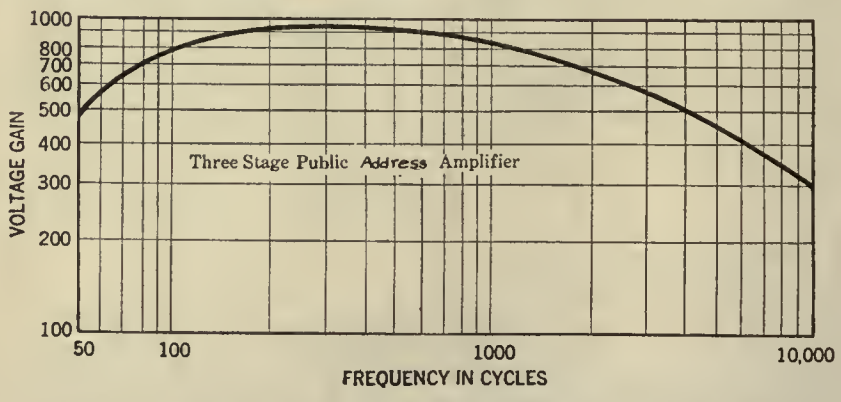


Fig. 3—Power output of an amplifier plotted on Log-Log paper

Summary

A graph is a visual representation of some physical or mathematical law. To plot the curve when the law or equation is known, it is only necessary to assume various values for one of the related factors and to calculate what the other values are. Thus we can plot Ohm's Law by assuming values of voltage and calculating what the current will be at a known resistance. Then voltage and current values are plotted against each other. More complicated relations between two factors give curves which are not straight lines and the mathematical equation or formula is seldom known.

Simplified Autodyne Circuit Used in

A DOUBLE-DETECTION SHORT-WAVE SET

By ROBERT S. KRUSE

IN THE writer's article published in February RADIO BROADCAST the advantages of double-detection receivers over other short-wave receivers were discussed. In order to facilitate the comparison there was described a species of adapter which may be applied readily to an ordinary detector-audio set, converting it into a double-detection (super-heterodyne) receiver. Since the device employed a heterodyne oscillator two tuning controls were required. This same complication also existed in the two other forms of the circuit which were described, namely a double-detection adapter (to proceed an ordinary broadcast receiver) and an outright short-wave receiver of the double-detection type.

When it is desired to simplify the control and retain the advantages of the tuner, one naturally thinks of combining the tuning controls. The first suggestion is that this may be accomplished by the use of a two-gang condenser after the universal practice employed in broadcast-receiver construction. The solution is not satisfactory, however, since the problem is not the same as the one encountered in the 500–1500-kc. band. The broadcast designer or builder has to make only two coil-condenser combinations work together, but in short-wave work we would be required to make the circuits remain in alignment with four or five sets of coils which are plugged into tuner and heterodyne, respectively. Of course, this can be done, but commercial coils are not matched accurately enough for the purpose since the makers have not anticipated such an arrangement. Indeed, it would be difficult to make them sufficiently alike at a cost approaching the coils now on the market. One may then leave this idea and turn to the alternative, which is to avoid the necessity of tuning two circuits by the process of omitting one of the circuits; patently this involves a transfer of the second circuit's functions to the remaining circuit which must now serve two purposes.

Therefore, we may proceed by investigating the possibility of combining the functions of the oscillator and the first detector in a single tube and a single tuned circuit. The possible difficulties are loss of sensitivity, selectivity and audio quality. The audio quality consideration may be determined more easily by trial than by other means and the reader is asked to accept the rather dogmatic statement that in the arrangement which follows audio quality does not suffer. The selectivity is certainly not improved by the combination of the two circuits, but as it happens the present arrangement is one in which the i.f. amplifier supplies the selectivity and we are not so seriously concerned with that matter.

Sensitivity of System

WHEN the question of sensitivity arises one must confess that a definite loss has taken place by reason of the choice of 95 kc. as an intermediate frequency. However, this loss is not serious as the presence of a pair of screen-grid tubes in the complete system produces an overall gain that is materially above that of the system described last month, and is, in fact, above normal requirements. The choice of 95 kc. as an intermediate frequency is due to the desire to avoid any damage to audio quality, while at the same time avoiding an excessive amount of detuning of the autodyne detector in process of transferring the signal into the i.f. system. This contrary pair of considerations may require a word of explanation. If audio quality were the only consideration we would choose an intermediate frequency in the vicinity of, perhaps, 1000 kc., thus securing a noiseless amplifier and complete certainty that the harmonics of the oscillating detector would do no damage. This plan was followed in the February article with a separate oscillator (heterodyne). But with an autodyne (combined oscillator and first detector) we cannot use as high an intermediate frequency for we would then be compelled at all times to tune 1000 kc. off the desired signal so as to transfer it to the 1000 kc. amplifier. Such mistuning would, of course, weaken the signal materially whereas the detuning necessary to produce a 100 kc. beat is not fatal. Fortunately this—like the other difficulties—turns out to be an academic, and not a practical, difficulty.

The i.f. system used consists of a pair of Rusco 95 kc. air-core transformers and a Rusco band-pass filter working at 95 kc.



View of the converted short-wave tuner, i.f. amplifier, and a.f. amplifier.

There are two ways of making a short-wave super-heterodyne, as Mr. Kruse pointed out in February RADIO BROADCAST. *One involves turning a short-wave tuner into the frequency changer and one's broadcast receiver into an intermediate-frequency amplifier. In this article he tells how to make a receiver that starts with the antenna and ends with the audio output—and it is a double-detection set of considerable amplification and selectivity. It does not involve playing tricks on one's short- or broadcast-wave receiver.*

—THE EDITOR

The tuner with which the device has been associated in the writer's experiments is made by the National Company and has a wavelength range of 14.5 to 115 meters. At the 115-meter end of the range a 95 kc. beatnote requires nearly 4 per cent. mistuning, which seems rather bad to one accustomed to broadcast work. At the 14.5-meter end the mistuning is about ½ per cent. Fortunately one is saved by the very thing that suggested the band-pass, namely, the comparative lack of selectivity of a lonesome tuned circuit. In practice the signal obtained is not materially weaker than that obtained with a heterodyne, the rest of the equipment remaining the same. This is, to a considerable degree, accounted for by the fact that the strength of the oscillation was adjusted in all cases to a favorable value by use of the normal controls of the tuner, operating in the normal manner.

Radiation from the autodyne's first detector is prevented by the 222-type tube in the first socket of the receiver.

The circuits, which are shown in Figs. 1, 2, and 3, do not seem to require much explanation. However, some readers may be confused by the band-pass filter, but its purpose may be explained by the simple statement that its business is to *pass* only the band of frequencies lying between 90 kc. and 100 kc., while stopping lower and higher frequencies. It follows that the only signals to get through the system are those which the autodyne system has transferred into the "pass-band." The purpose of this device is, therefore, to provide the selectivity of the system and to suppress noise as well. Since the Rusco band-pass filter consists of four shunt sections (and the corresponding series parts), it is sufficiently complex to give a good flat top and sharp cut-off, unlike the usual arrays of tuned circuits.

Adjustment of Filter

ONE difficulty may arise which has caused several filters to be denounced as "no good." A filter, unless terminating in the proper sort of a load, will produce all sorts of

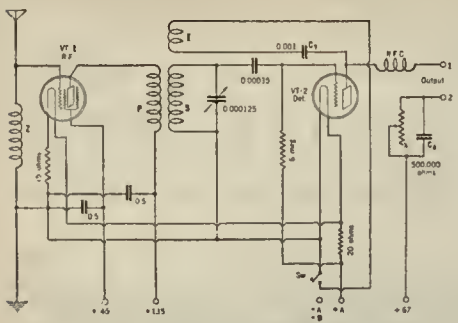


Fig. 1—Complete circuit diagram of the original National short-wave tuner.

weird response effects with bumps of signal coming through where there should be none. If your band-pass filter does not perform properly it is suggested that you shunt a 500,000-ohm Frost resistor across the output, and, by pure cut and try, adjust the terminal conditions so that the desired action is obtained. When the action is correct the signal "snaps" in, stays for a while as the tuning dial of the receiver is turned, and then "snaps" out.

Observe that the output circuit of the National tuner has been altered a bit. This is to permit the 95 kc. output to enter the i.f. system, at the same time permitting the regeneration control to function. The numberings shows what has been done, as do the diagrams of Figs. 1 and 2. The r.f. choke has been eliminated, C_3 has been moved, and the wiring has been changed slightly. These changes also improve the control when using the smallest tuner-coil.

Rather than draw the complete schematic diagram it has been considered best to mark various posts of the adapter (Fig. 3), such as "A+," as often as necessary, even though only a single terminal is required in the receiver. Therefore, it should be understood that all binding posts with the same markings on either the set or the adapter are to be connected together.

In the second i.f. stage a 222-type tube is shown. The gain obtained in this way is more than required, but if anyone desires more gain he is welcome to use a 222-type tube in the first i.f. socket as well—providing he can invent a way to match the high plate impedence to the lower impedance of the band-pass filter. This is strictly necessary to secure decent filter action, not to speak of decent gain. On the other hand, it is perfectly practical to use 201A-type tubes in both of the i.f. positions. If this plan is followed the circuits will tend to oscillate and stabilization of some sort must be provided. The simplest thing is the old standby; return the grids to a potentiometer across the A supply and turn the knob to suit. The potentiometer may conveniently have a resistance of 400 ohms and the grid returns should be bypassed directly to their own filaments with 0.1mfd.

If anyone has available other i.f. transformers they may be used, provided the first contains a primary by-pass condenser. Usually it is of the "tuned" variety and has such a condenser. Frequencies materially above 100 kc. are not to be recommended because of the detuning required, while very low frequencies tend to cause difficulties from noise and damaged quality.

Concerning A.C. Operation

A RECEIVER akin to the one here described has been operated for some weeks with various portions of the circuit modified to permit the use of a.c. tubes. On the whole the performance has been satisfactory but previous experience with such matters teaches the writer to believe *nothing* about an a.c. job until it has been thoroughly time-tried.

We must not stop without mention of television reception. If the transmission is being made with a 24-hole disc at 15 pictures per second, or a 48-hole disc at 7½ pictures a second, we have a "basic" frequency of modulation amounting to 360 cycles and a tolerably probable impulse frequency running up toward 9000 cycles. This means that the carrier plus both sidebands will be about 18,000 cycles wide, which is about twice as wide as the "pass" band of the Rusco filter. The set is, therefore, not good for the purpose unless a filter with a wider pass band is used, and even then it does not have much to recommend it since there are easier ways to attack the problem. For this sort of work it is recomended that an entirely different amplifier of the usual "television type" be used which can be done with the greatest ease as the tuner has not been incapacitated in any way. It should be noted that the tuner controls are at all times operated in the same manner whether it be used with the "television" amplifier, the band-pass amplifier or the usual audio amplifier alone.

Since mention has been made of satisfactory gain through the system it may be of interest to run hurriedly through the circuit with this in mind. The first 222-type tube, which is used as a "coupling tube," produces a gain of about 2, the autodyne detector produces a gain that is varied with adjustment and signal strength, the first i.f. tube (201A) produces a gain that is not up to the usual at such frequencies because of its peculiar plate load. The 222-type tube which follows the filter operates with a moderately good plate load and provides most of the gain in the i.f. system, which may be further improved by using a "tuned impedance" at this point, making sure that the condenser between this circuit and the next grid is of very high leakage resistance. The following 201A-type tube, acting as second detector, produces the slight gain which is normal in that position and this is generally sufficient to cause the signal to overload either this tube or the 112A-type audio tube, although the latter is working under proper conditions. To take care of this condition a Frost high-resistance rheostat has been mounted on the hitherto blank panel of the adapter and has been connected across the secondary of the first 95 kc. transformer. By a minor operation it has been modified so as to open at one end of the scale, thus permitting the removal of the shunt when it is not desired. If no very strong signals are encountered it is better to connect this control across the secondary of the second 95 kc. transformer since then it will have no effect on the detector regeneration.

Another feature of the receiver described by the writer is that the use of the National steel cases and the various part shields results in a complete freedom from the bothersome hand capacity common to short-wave receivers. To complete this effect the panel of the right-hand (i.f. and a.f.) case was backed by a sheet of aluminum.

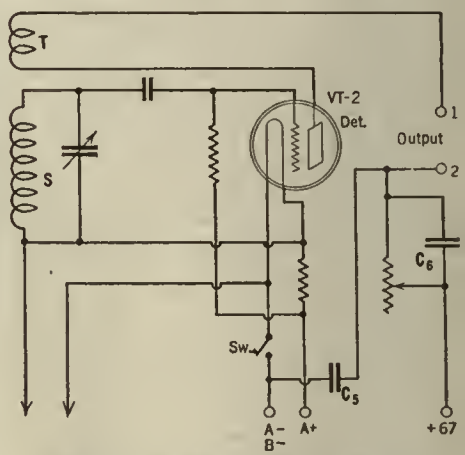


Fig. 2—Changes which must be made in the detector plate circuit of the tuner.

List of Apparatus

THE parts required for the construction of the double-detection short-wave receiver described in this article follow:

One National screen-grid short-wave tuner;
One blank panel, aluminum;
One bakelite basepanel, 9" x 11";
One Rusco band-pass filter, 95-kc.;
Two Rusco i.f. transformers, 95-kc.;
Four tube sockets, UX-type, spring-construction;
Three Carter resistors, 1-ohm, 2-ohm, and 15-ohm;
Two Sangamo mica condensers, 0.001-mfd., and 0.0005-mfd.;
One Durham grid resistor, 1½-megohm;
One Twin-Coupler 222-type shield;
Clips for grid leak, brass angles for connecting panel and base, machine screws, wire, binding posts, etc.

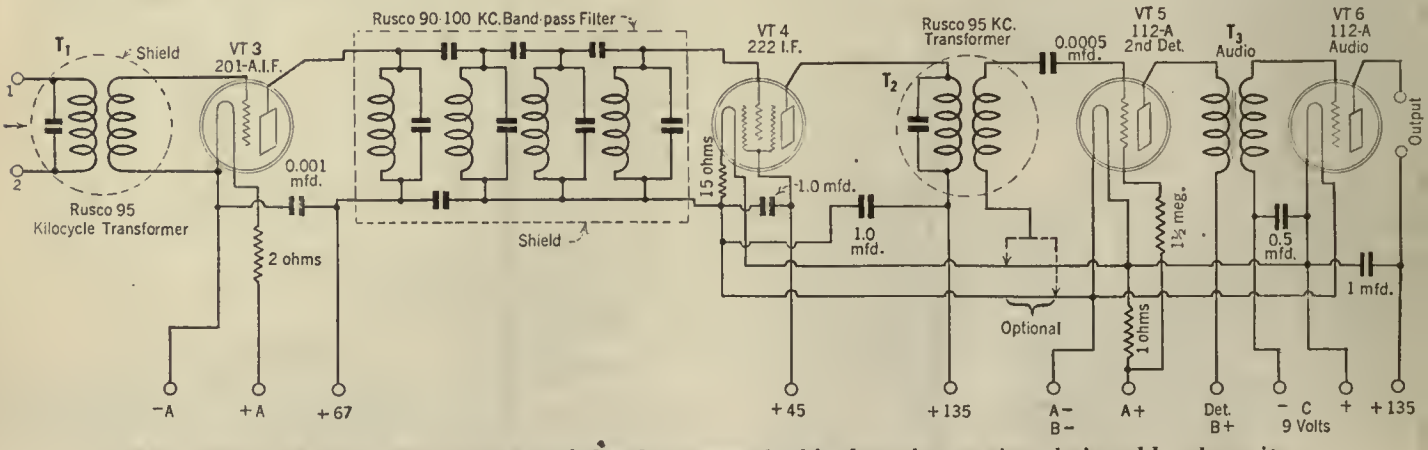


Fig. 3—Circuit of the i.f and a.f stages of the short-wave double-deteetion receiver designed by the writer.

BROADCAST ENGINEERING

BY CARL DREHER

Pick-Up Characteristics of Microphones

CONSIDERABLE work is being done in determining the behavior of microphones under various conditions of studio pick-up. While the results will probably not be reported for months or years, the literature already contains some material of practical value for those who are interested in securing the best possible quality of reproduction as well as for laboratory technicians who use microphones in sound-measurement determinations.

B. F. Miessner's article in the September, 1926, RADIO BROADCAST, on "The Importance of Acoustics in Broadcasting" is worth rereading in this connection. Miessner was concerned in this paper with possible distortion in radio reproduction caused by the directional characteristics of microphones and loud speakers. He concluded that these devices usually vary in directional characteristics with frequency. For horn speakers and flat diaphragms enclosed on one side he secured a polar diagram, reproduced herewith as Fig. 1, which shows a regular falling off in intensity from front to rear at low frequencies, the presence of a minimum at 90-120 degrees at higher frequencies, and a marked beam effect at still higher frequencies. This beam effect was also very noticeable with cone- and baffleboard-type loud speakers, as well as the dynamic units.

Miessner argued that such an effect as that of Fig. 1, secured by measurements on a horn or diaphragm of about 12" diameter, would also be noted in pick-up work with the same device, the action being a reversible one. "It is plainly evident," he wrote, "that if a musical instrument, say a 'cello with low-pitched fundamental and high-pitched overtones, be placed at an angle of 45 degrees to the face, as it well might in a studio, the fundamental would be received about 75 per cent. as loud as if it were in front of the microphone, while overtones of the order of 5000 cycles would be reduced to less than 10 per cent." He went on to raise the point that a square-law effect might be involved when the directional distortion of the microphone is repeated by the loud speaker. While this is true, quantitatively Miessner's illustration of the 'cello is somewhat misleading under practical conditions, as he himself recognizes, for toward the end of the article he modifies his conclusions as applied to the then standard broadcasting microphone of the Western Electric 373-w double-button carbon type, now superseded by the 387-w. Although this microphone has a closed back, it responds to sounds from the rear because of diffraction around the housing. The facility with which the sound wave bends around the obstruction depends on the wavelength compared to the size of the obstacle. If the microphone housing is small compared to the wavelength, diffraction takes place with little loss in intensity. For higher frequencies, on the other hand, the diaphragm may be in a region of pronounced acoustic shadow, resulting in discrimination against high notes. With an actual microphone diaphragm and housing the ratio of dimensions to wavelength is not as unfavorable as Miessner's curves of Fig. 1 would indicate, and he gives another set of polar diagrams, (Fig. 7 in the original article) here reproduced as Fig. 2, which approximate actual broadcast pick-up conditions. In the latter, it will be noted, the discrimination at 45 degrees against a 5000-cycle tone, compared to a 100-cycle fundamental, is not of the order of 7.5, but only about 2.3.

A simple expedient used by broadcast engineers in order to reduce loss of the high frequencies in picking up music over a wide front, as in the case of an orchestra of good size, is to employ two microphones facing outwards at right angles (Fig. 3) mounted on a single stand a few inches apart. This doubles the angle in which pick-up occurs without serious directional distortion. If this angle is 90 degrees for each transmitter, the two will cover a total of 180 degrees, or all of the space in front of the microphone stand. The outputs of the two microphones are mixed in the usual way (Fig. 4) where the repeating coils have 200-ohm windings to match the impedance of the microphones, and the potentiometers are about 400 ohms each, the combination working into the 200-ohm input of the amplifier. An additional advantage of such a combination lies in the fact that pick-up is not confined to one point in the room and there is less chance of running into any serious acoustic anomalies arising from interference of reflected waves or other effects of the room characteristics. However, a right-angle microphone combination of this type presents no advantage in picking up announcements or other close-talking material.

THE BEAM EFFECT

The beam effect of projection of high frequencies is well recognized now in human articulation, the output of many musical instruments, and in loud speaker design. Pick-up of ordinary speech with present-day equipment is generally defective when the speaker is not talking directly into the microphone because the high frequencies, which are so important in the interpretation of speech, issue in a beam in the direction in which the

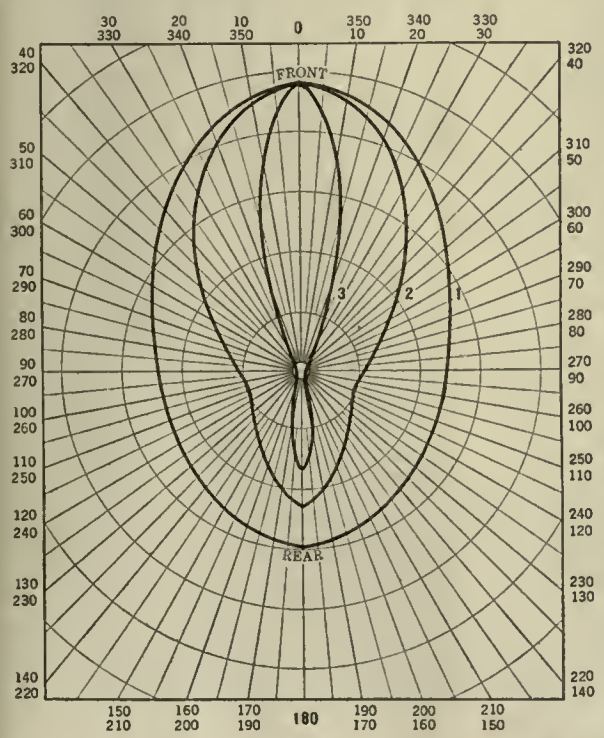
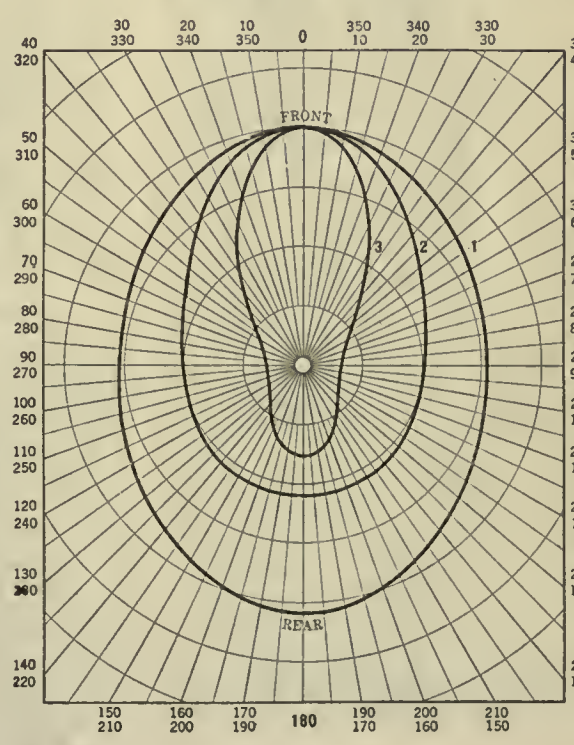


Fig. 1 — (left) Polar curves showing directional characteristics of horns and flat diaphragms enclosed on one side at frequencies of (1) 100, (2) 1000, and (3) 5000 cycles

Fig. 2 — (right) Approximate directional characteristics for broadcast microphones at standard test frequencies of 100, 1000, and 5000 cycles, respectively



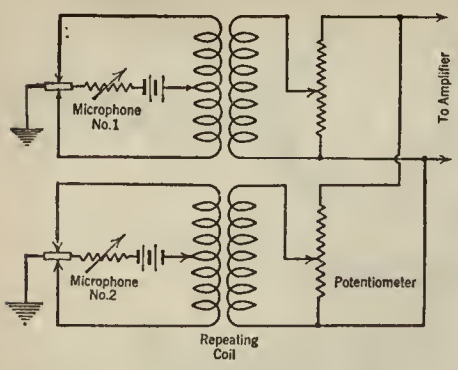


Fig. 4—Circuit used for mixing the output of two microphones

speaker is looking. Likewise, in listening to a loud speaker from a position well to one side of the orifice, one gets the bass with almost full volume, but the 3000-5000-cycle range is partly lost. The same effect is observed in listening to a loud speaker in another room—considerable sound comes through the intervening corridor, but intelligibility is poor because the high frequencies, probably deficient to begin with, do not bend around corners as well as the longer waves. Transmission of high frequencies is always a delicate job, and constant precautions are necessary to retain them. A cone loud speaker designed with a certain kind of paper, for example, loses the high frequencies first of all when a heavier grade of paper is substituted. The high notes are lost before the low ones in transmission along a telephone line. Directionally, likewise, discrimination is usually against the upper frequency range.

MICROPHONES IN LAB. WORK

Microphones, useful to the broadcast engineer as a means of sound pick-up, also serve as measuring instruments in the laboratory. The condenser transmitter is the form most used for this purpose, its construction and mode of operation being favorable to constancy of characteristics over long periods, while a carbon microphone, obviously, cannot be depended upon to the same extent. Stuart Ballantine has recently reported in part on his work on "The Effect of Reflection by the Microphone in Sound Measurements," in the December, 1928, *Physical Review*. The article, which appears in slightly abridged form in the same month's issue of the I.R.E. *Proceedings*, is of more interest to laboratory technicians than to broadcast operating engineers, but should not be entirely ignored by those of the latter who want to be known as up-to-date workers.

The condenser transmitter is used in acoustic work to measure sounds which, after it picks them up and converts the energy into corresponding electrical variations, are amplified and operate a recording system, such as a vacuum-tube voltmeter and galvanometer. Fig. 5, for example, shows the use of such a system in measuring loud-speaker characteristics.

The only trouble with this scheme is that the condenser transmitter is so large that it tends to distort the sound field which it is supposed to measure. It is as if, in measuring the flow of a stream, we introduced an object so large that it changed the velocity and direction of the current. There is one method of acoustic measurement which does not suffer from this defect, or does so, at least, to a lesser degree. This is the Rayleigh disc, which is affected by the velocity component of the sound wave, while the condenser microphone is a pressure-operated device. The usual form of the disc is a thin, light, elliptical piece of mica, suspended at the end of the long axis by a fine fibre, and silvered on one side to reflect a beam of light. Under the impact of a sound wave the disc, which is only about half an inch long, is deflected. The angle of deflection is measured by means of the light lever and gives an indication of the acoustic forces at work. A condenser transmitter, being a relatively cumbersome implement, requires some correction for its own effect on the forces it measures, and what Ballantine has set out to do in the article cited is to assess the correction required at different frequencies.

If the waves are long they bend around the microphone (diffraction) with little influence by the obstruction on the field, but short waves are reflected with a consequent increase in the apparent value of the pressure before the diaphragm. A tightly stretched diaphragm of infinite extent would reflect all sound waves perfectly and the indicated pressure would be double the pressure which would prevail were the microphone out of the way. The microphone is large enough to act as such an obstruction for short sound waves. The problem then is to evaluate the extent to which the microphone raises the instantaneous sound pressure at various frequencies.

Ballantine goes about this with a simple but ingenious procedure. He mounts his condenser transmitter with its first stage of amplification in a spherical "bullet," with the diaphragm sensibly in the surface of the sphere. The diffraction of sound by a spherical obstacle is a classical problem, soluble by intricate but known methods. Ballantine has performed the calculations and drawn his results in the form of a curve showing the ratio of the indicated pressure to the pressure in the undisturbed field (microphone removed) at various frequencies. With a sphere six inches in diameter, he finds that this ratio is unity at 100 cycles (no correction required), about 1.25 at 500 cycles, 1.56 at 1000 cycles, 1.77 at 2000 cycles, up to nearly 2.0 at 10,000 cycles. He has also determined the curve for a 12-inch spherical mounting. The results may be applied experimentally to the more usual forms of microphone mountings, which are not amenable to calculation. Ballantine

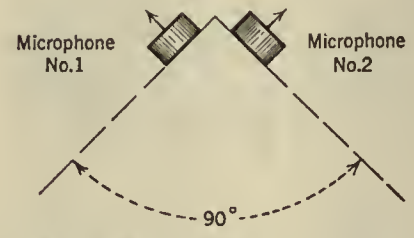


Fig. 3—Microphones mounted at right angles double the angle in which pick-up occurs

has this work under way. When the correction curves for practical mountings are published, more accurate determinations of sound pressures by the use of ordinary condenser microphones will be possible.

Correction After a Decade

MY OPINION of engineers, I being one of them, is that they are valuable members of society. But I must admit that sometimes they are all wrong.

In the summary of the paper by Bailey, Dean, and Wintringham on "The Receiving System for Long-Wave Transatlantic Radio Telephony," presented before the Institute of Radio Engineers, I find a calculation of the effect of a receiving location in Maine (for reception of British transatlantic telephone signals) and wave antenna arrays instead of a simple antenna. "If the receiving were to be accomplished near New York using a loop antenna," it reads, "we would have to increase the power of the British transmitting station 20,000 times to obtain the same signal-to-noise ratio."

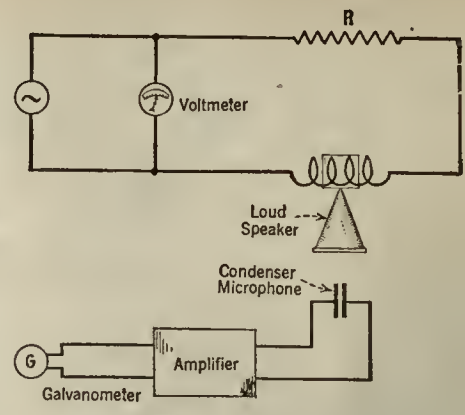


Fig. 5—System for measuring loud-speaker characteristics

Ten years ago I was working on static elimination in company with a first-rate radio engineer. His record since then has borne out that classification. What I recollect distinctly is that as we were walking home one day he said, "After all, the way to lick static is to use more power at the transmitter."

Two million kilowatts, say?

Safety for the Broadcasters

COMMENTING on an article in RADIO BROADCAST about the electrocution of one of the engineers at Daventry, Mr. Saul Bloch offers the following idea as a means of preventing such fatalities in broadcast stations:

"In setting up a transmitter why not build the following type of moving platform next to those parts of the apparatus which carry high tension currents?

"1. The platform should be located in such a manner that when anybody wishes to approach the high tension wires he will have to stand on the platform in order to be within reach of the wires;

"2. The platform should be set on some sort of device which would permit it to drop slightly below its normal level when the man steps on it;

"3. The platform should be so connected in the circuit that when it moves down with the weight of the man the high tension circuit would be automatically broken."

"To an engineer," adds Mr. Bloch, "this may not be feasible and may even be considered as an invention of Rube Goldberg's, but it is being offered in all sincerity."

While I do not consider this idea practicable I certainly feel that it deserves discussion, if only to keep the subject before the men who take the risks. My opinion remains as I have frequently stated it before—that there is no mechanical substitute, in working with high tension currents, for unremitting awareness of danger on the part of the operators and the caution that should result therefrom. A disconnect scheme like that proposed by Mr. Bloch could not be depended on to function infallibly. Automatic shut-down devices actuated by push-buttons and operating through relays sometimes fail to act. An open-circuiting platform would entail the same jeopardy. There are times, also, when the operator wants to get close to the set, while it is in operation, in order to observe a tube or some other part of the equipment. If he knows that the 10,000 volts are ready to jump on him he is as safe a foot from the conductors as ten feet away. The stuff will not leap at him; he has to get within an eighth of an inch before anything can happen. In the vast majority of cases where men have been killed or injured it has been because they forget that the current was on.

A CUBAN SHORT-WAVE RECEIVER

By FRANK H. JONES

WITH modern receiving equipment the radio fan in the United States finds it enjoyable to sit at home of an evening and listen to a musical program which is reproduced practically without distortion or electrical interference. However, the inhabitants of the tropics, and Cuba in particular, are not accustomed to this privilege. Owing to the prevalence of extremely strong static discharges, quality reception of American stations in the 200 to 500 meter wave band is a farce during most of the year. It is only during the middle of winter—from December 15 to February 15—that it is possible to derive any degree of pleasure from listening-in to programs originating in the United States.

Of course, most radio fans in Cuba are able to obtain good reception from their local station, PWX, which is located in the middle of the island, and they can always pick-up the signals of 6KW without difficulty. But these two stations do not transmit programs of the quality which the large American chains provide. Therefore, the only way open to the radio fan in the tropics to receive quality programs is to intercept the signals of the various short-wave stations which in many cases transmit the same program which is sent out on broadcast wavelengths, but even this method is not entirely satisfactory due to the extreme fading which seems to affect all high-frequency transmissions.

The writer has developed a duplex short-wave receiver which offers a practical solution to the tropical radio fan's problem. An abbreviated schematic diagram of circuit will be found in Fig. 1 on this page, and a description of the electrical features of the circuit is given in this article. However, before entering into a technical discussion, the value of the various high-frequency signals which may be received will be given further consideration.

Programs Available

THE writer, who is located in Tuinucu, Cuba, has been able to receive with satisfactory volume the signals of seven short-wave stations which transmit high-quality broadcast programs. These stations are: W2XAF, Schenectady, N. Y., on 31.48 meters; W2XAD, Schenectady, N. Y., on 19.56 meters; 5SW, Chelmsford, England, on 25.53 meters; W8XK, Pittsburgh, Pa., on 25.4 or 63.5 meters; CJRX, Winnepeg, Canada, on 25.6 meters; PCJJ, Eindhoven, Holland, on 31.2 meters; and Columbia's new station, W2XE, Richmond Hill, N. Y., on 58.5 meters. Of the above listed stations W8XK, W2XAD, and W2XAF usually transmit the programs of WEAF or WJZ, the NBC's Red and Blue network programs, while station W2XE sends out the programs of the Columbia chain. So, if one can receive these stations well, he is listening to the real pick of radio programs. A table giving the operating schedule of these stations will be found on page 298 of this issue.

In his endeavor to receive short-wave programs, the first serious problem encountered by the writer was that of fading, and the periods of fading were found to be much more frequent than on the long wavelengths. Also, it was discovered, that fading periods differ on different wave bands. This fact prompted the design of the receiver described in this article; it was thought that if the same program could be received on two different wavelengths with two different detectors, and the outputs of the two detectors feeding into the same audio amplifier, the fading periods of the two short-wave signals bearing the same program would tend to cancel out, leaving a more or less constant signal for the loud speaker to reproduce.

The unique short-wave receiving circuit described on this page will be of interest to radio experimenters living in the tropics where static on broadcast wavelengths is severe during most of the year. Mr. Jones points out that the same high-quality programs may be received with fidelity on short wavelengths. On these waves static is not as noticeable and fading may be overcome by mixing the signals of two stations which transmit the same program. A table on page 298 of this issue gives the operating hours and wavelengths of seven high-powered short-wave broadcasters which transmit chain programs. The hours during which two or more stations broadcast the same program are also indicated.

—THE EDITOR

It is interesting to note the way in which this principle may be employed to advantage by the radio listener. By listening-in on short wavelengths for an evening it will be found that frequently several stations transmit the same chain program simultaneously.

For example, W2XAD, on 19.56 meters, transmits WEAF's program to 5SW where it is rebroadcast on 25.53 meters for British listeners. Therefore, the 19.56-meter signal is received with one detector, the 25.53-meter signal is picked-up with the other detector, and the outputs of the two detectors, each of which bring the same program, are mixed in the audio amplifier. The result is a very satisfactory signal from the loud speaker.

There are several interesting features of the system described above. First, the loudspeaker volume is doubled as the audio components of the signals of the two detectors are added. Secondly, there is no increase in distortion as the signal from England arrives at practically the same time as the one from Schenectady—the time difference is only $\frac{35}{1000}$ second and this cannot be detected by the human ear. Thirdly, either one of two antennas, or both, may be used to pick-up the signals, and by switching from one to the other, or using one antenna for one detector and the other antenna for the other circuit, it is possible to find a combination which provides minimum static and interference. Of course, the two antennas should be erected at right angles to each other.

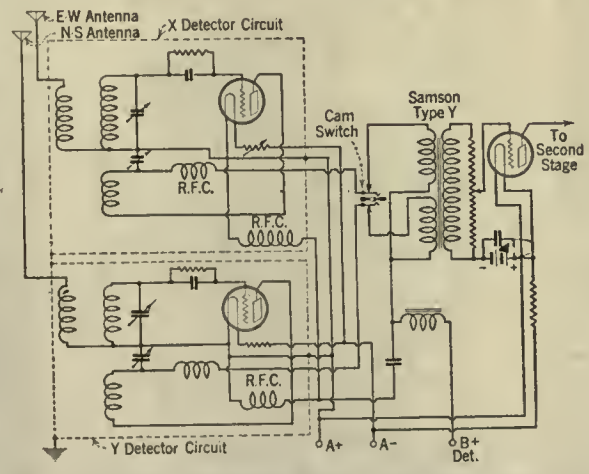


Fig. 1—Circuit diagram of the author's system for duplex reception of short-wave programs

Explanation of Circuit

RETURNING to the diagram of the detector circuits it will be noticed that the two detectors, X and Y, are isolated from each other and from the audio unit by r.f. choke coils and aluminum shielding. The next most interesting feature is the cam switch which governs the manner in which the detectors are connected with the double primary input transformer (Samson type Y interstage push-pull) of the amplifier. With the switch in the X position, only the X detector feeds its half of the primary of the transformer, with the switch in the Y position, the Y detector is connected with the other half of the primary of the transformer, and with the switch in the mid position both detector circuits feed into the double primary simultaneously.

The use of a double primary transformer is not absolutely essential to the success of the writer's system, but it provides most satisfactory results. In place of the double-primary transformer, it is possible to use an ordinary interstage transformer (not push-pull) by connecting the plate terminals of the two detector tubes to the "P" terminal of the transformer, and the positive B supply to the "B+" terminal of the transformer. An interstage push-pull transformer with three primary terminals instead of four (Samson make them) may also be used; in this case the plate of one detector is connected with one "P" terminal of the transformer, the plate terminal of the second detector is connected with the other "P" terminal, and the positive of the B supply is fed to the "B+" terminal of the transformer. However, the circuit shown seems to be less susceptible to low-frequency noises such as 60-cycle hum.

It is not necessary to give specific information regarding the other details of the receiver as they are more or less standard. The two detector circuits are identical, and may be similar to those used in your pet short-wave set. Following the input transformer, the a.f. amplifier is standard. The writer built the best possible amplifier as he wished to obtain good fidelity and this proved very much worth while.

TECHNICAL DATA

SOUND MOTION PICTURES

BY CARL DREHER

The Projection of Motion Pictures

NO ONE will learn, from a reading of this article, how to operate a motion-picture projector, and, if he did, it would be of little avail professionally in most localities unless, at the same time, the reader in question secured admission to the projectionists' union. The purpose of the article is the less ambitious one of explaining the principles involved in motion-picture projection, as part of a description of the most elementary sort of the mechanism in which those principles are embodied. A good many of the technical people working in movie studios, especially those on the sound end, know little about projection, just as most of the projectionists have only vague ideas about the camera and sound-recorder side of the business. This is unfortunate, since the studio and the theatre are closely tied together through the film itself, and the introduction of sound has raised the technical requirements all around.

The operating aspects of projection are set forth at length in several handbooks. The ones which have been used in the preparation of the present discussion are:

Richardson: *Handbook of Projection* in two volumes. Chalmers Publishing Co., 516 Fifth Avenue, New York, N. Y. 960 pages.

Cameron: *Motion Picture Projection*. Cameron Publishing Co., Manhattan Beach, N. Y. 1272 pages.

The sound motion picture industry is moving with such rapidity that even those in that field—as is Mr. Dreher, who writes regularly on the subject for RADIO BROADCAST*—have trouble in keeping abreast of developments. It is the purpose of these regular contributions to survey some of the highlights in the technical branches of sound picture work with the purpose of providing accurate technical information for those working in the field, for practising broadcasters whose daily work is perilously close to sound movies, and for all others who are interested.*

—THE EDITOR

PATH OF LIGHT

The elements of a motion-picture projection system are shown in Fig. 3. Except for the element of motion, these are basically the same as those of a magic lantern or stereopticon: a source of light, a transparent picture, and a lens system for throwing an enlarged image of the picture on a screen. A motion-picture projector is, in fact, simply an optical lantern equipped with means for moving a succession of pictures across the projected light to produce an illusion of motion.

In a theatre the source of light is generally an arc lamp fed from a direct-current source. Where less light is required a large incandescent lamp may be used. This is simpler and cleaner, but the intensity of the light available is limited. The source of light is housed in a sheet metal box, the *lamp-house*, which must be properly ventilated to carry off heat as rapidly as possible. Normally a flue is provided to carry away the gases of the arc. In back of the source of light there may be a reflector. The positive pole of the current supply is connected with the upper carbon, which may be cored. The crater of the arc thus forms on the upper carbon. As it is necessary to keep the arc on the optical axis of the train of lenses following, a small motor controller is usually installed to feed the carbons forward. The lengthening of the arc automatically actuates the motor through a solenoid. In an average theatre the arc will consume about 25 amperes at 110 volts. In very large houses 100-ampere arcs are found. A knife switch on the projector controls the current supply to the light.

A system of two or three large lenses concentrates the light of the arc on the film and the objective lens on the other side which forms the image on the screen. This may be in the form of two lenses with their plane surfaces outward and convex surfaces facing each other, as shown in Fig. 3. The combination is a *condenser*. The lens next to the source of light is called the *collector;* the lens nearest the objective is called the *converging lens*.

The lamp-house also contains a door, usually placed in front of the condenser, which may be used to intercept the light before it can reach the film. Generally this is operated manually by means of a handle. The term "douser" applied to it is self-explanatory.

The whole lamp-house is set on the back of the projector.

SAFETY DEVICES

The next element in the schematic arrangement of Fig. 1 is the *automatic fire shutter*.

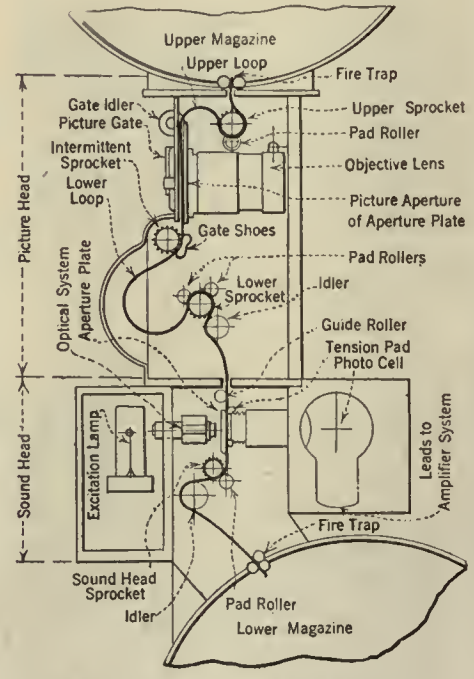


Fig. 1—Schematic diagram of mechanism in a standard motion-picture projector with sound adjunct

The heat of the light source in a theatre motion-picture projector is so intense that if the film stops moving it will catch fire. The operator may extinguish his arc in time to avoid this, but to prevent reliance being placed on a human element a centrifugally operated shutter is placed ahead of the film. At normal speeds this is kept open by the action of a governor, but as soon as the speed drops to a point where there is danger of ignition the shutter drops. The speed at which the shutter operates may be around 40 feet per minute, the normal silent projection speed being from 60 to 120 feet per minute, while sound pictures run at 90 feet per minute.

The *film* itself passes through the projector with the pictures upside down and the *emulsion* side toward the source of light. In the standard size it is $1\frac{3}{8}$" wide and 5 mils thick. Both margins are perforated so that the film may be dragged along by means of toothed wheels called *sprockets*. There are 64 perforations per foot, or four to a picture on either side, 16 pictures to the foot being standard. The *base* of the film is made from cotton soaked in a mixture of nitric and sulphuric acids to render it soluble, forming pyroxyline or nitro-cellulose. This is dissolved in a mixture of camphor, alcohol, and other materials, forming a viscous "dope," which is spread and dried on large drums with much complicated processing and finally cut up into strips of celluloid coated on one side with the light-sensitive emulsion of silver bromide in gelatine. The emulsion of *negative stock*, used in cameras, is more sensitive and less contrasty than that of *positive stock*, from which prints are made. Sound records, incidentally, are better made on positive stock.

The mechanism for taking the film through the projector will be considered in more detail later.

The light which passes through the film is brought to a focus in the *objective* or *projection lens*, where the rays cross so that the image is seen on the screen right side up. The projection lens generally consists of a system of four lenses, the two near the film forming a duplex lens, while the other two are cemented together to make a compound lens with the surface of greatest convexity toward the screen.

A rotating *shutter* completes the assembly. In Fig. 3 this is shown in front of the objective lens in an edgewise view. In this form it is a segmented disc with two or three blades to intercept the light. Other designs are possible, as well as other positions; the light may be interrupted before it reaches the film, and this has the advantage of reducing the heating of the film. The need for a shutter arises from the fact that the motion of the film is intermittent and it is desirable to allow the light to reach the screen only while the film is standing still before the lens. As is well known, the illusion of motion is secured through the psycho-physiological phenomenon of persistence of vision, sixteen pictures a second, or preferably more, blending into an optical impression of continuous motion. But if the light is not interrupted while the film is being moved, white streaks will appear on the screen owing to the sensitiveness of the eye to white objects in motion against a dark background. Hence a shutter is provided and timed to cut off the light during the intervals when the

successive pictures are being jerked into place. This periodic light interrupter has an auxiliary function, which is, by means of an added blade or two, to break up the stationary periods of projection and thus to eliminate flicker. These functions will be considered quantitatively later.

The *throw* or *projection distance* is measured, as shown in Fig. 3, from the objective lens to the screen, along the *axis of projection*, which is a straight line passing through the center of the photograph. the center of the screen image, and approximately through the center of the source of light. All the elements of the optical train, when in proper adjustment, are centered on the axis of projection.

MECHANICAL DESIGN

Fig. 1 gives a view of the projector mechanism from the right side, where all adjustments are made, and where the projectionist stands during operation. The film to be projected is placed in a length of 1000 or 2000 feet on a reel in the *upper magazine*, the beginning being on the outside of the roll, with several feet of *leader* before the action of the subject begins. The film issues through an opening or *valve* in the magazine and passes through a *fire trap*, an arrangement of rollers to smother a fire inside the head and prevent it from reaching the film inside the magazine.

The film is dragged out of the magazine by the *upper sprocket*, which is driven through gears on the other side of the head with uniform angular velocity. A *pad roller* presses the film against the sprocket by spring action. A short loop of film is then left, and the film passes through the gate, which consists on one side of a flat plate with an aperture against which the celluloid is held in a plane so that it is possible to get an accurate focus on it. The standard size of the aperture through which the light passes is, for silent film, 0.906″ by 0.6795″: when there is a sound track on the film the picture aperture must be correspondingly reduced in its long dimension. The pressure which keeps the film flat against the aperture plate is supplied by small metal bars called *tension shoes*, which are backed by *tension springs*. These also exercise braking force on the moving film, of which more will be said later. The position of the projection lens opposite the picture aperture is clear from Fig. 1.

The *intermittent sprocket* controls the motion of the film just below the gate. The film is pressed against it by means of a curved shoe, or a pad roller may be used as in the case of the other sprockets. The driving member of the intermittent mechanism is a circular cam, which actuates a "star," the motion of which is imparted to the intermittent sprocket. The design may be such that for a 360-degree movement of the driving member the sprocket goes through a 90 degree arc. It moves, then, one-quarter of the total time, corresponding to a 3:1 time ratio of stationary to moving time. If projection is at the rate of 90 feet per minute, corresponding to 24 pictures per second, the intermittent must move 24 times per second also, and while it is moving it must drag the film through the gate three times as fast as the continuously moving sprockets above and below the intermittent pass the film along. Between the lower sprocket and the intermittent there is a loop of film, longer than that between the intermittent and the upper sprocket. Through these loops the jerky motion of the film in the gate is made independent of the continuous motion elsewhere. There must be sufficient slack at these points so that when the film is jerked down through the gate the section between the upper sprocket and the gate will not be pulled taut, and, similarly, when the film is at rest in the gate the continuous motion of the lower sprocket must not tighten the film between the intermittent and lower sprockets. Both loops, while the projector is running, vibrate at a frequency equal to the number of pictures per second, owing to the periodic lengthening and shortening of the section of film in each loop. The regular alternation of rest and rapid movement of film in the projection mechanism, with slower, continuous motion above and below, is the design basis of the commercial intermittent type of motion-picture projector.

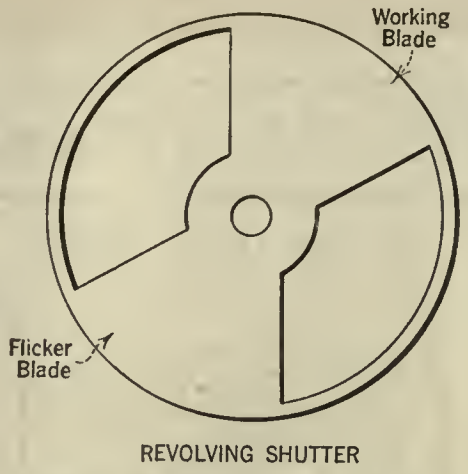


Fig. 2—Drawing shows type of shutter used for motion-picture projection

Mention was made above of the fact that the tension shoes in the gate exercise a braking action on the moving film. If the braking pressure is insufficient the film tends to "overshoot"—it does not stop, that is, at the instant that the motion of the intermittent sprocket ceases, but is carried on slightly by the momentum. This defect manifests itself by a tendency for the picture to move up on the screen. The tension must be set so that this will not occur at the highest speed at which the projector is run. The effect of too much tension, on the other hand, is rapid wear on the intermittent mechanism, the teeth of the intermittent sprocket, and the film itself.

OPERATION OF SHUTTER

Now that the action of the intermittent has been described the operation of the shutter may be analyzed in greater detail. Fig. 2 presents a view of a segmental disc type of rotating shutter, viewed from a point in front of the projector. The shutter in this case has two blades. One of these, usually slightly the broader, is known as the *working, cutting, obscuring, main, master*, or *travel blade*, which has the function of intercepting the light during the movement of the film across the picture aperture. The necessity for this has already been discussed. The second blade, known as the *intercepting* or *flicker blade*, interrupts the light during the rest or projection period and thus reduces or eliminates flicker by increasing the number of pictures per second thrown on the screen. Flicker is the visible alternation of light and darkness. It is visible when it is not sufficiently rapid. Sixteen pictures per second is enough to produce an illusion of motion, but not enough to overcome consciousness of the alternation of light and darkness. The addition of a second blade to the shutter increases the alternations to 32 per second, making the flicker less annoying. Higher projection speed obviously tends to decrease flicker by increasing the number of pictures per second and the periodicity of the light fluctuation. The frequency required for comfortable vision depends on the brightness of the screen, which is dependent on the intensity of the light source and the type of reflecting surface used in the screen. With a very bright screen a three-blade shutter (two flicker blades) may be preferable to the two-blade type. At 24 pictures per second (90 feet per minute), which is standard for sound pictures, the three-blade shutter gives 72 flashes of light on the screen each second, with intervening periods of darkness. This is sufficient to reduce flicker to a negligible point under normal conditions of bright lighting and high screen reflection.

The shutter must be timed (set in phase) so that the obscuring blade cuts off the light while the film is moving. This is taken care of approximately by a preliminary setting of the shutter so that it covers the projection lens almost all the time that the intermittent is moving. The residual light, called "travel ghost," which gets through under this condition and manifests itself as a series of white streaks in the picture, may be eliminated by a secondary adjustment which is provided on standard projectors.

It is standard practice to thread the projector in frame, that is, to insert the film so that one of the pictures coincides exactly with the aperture and appears in the proper position on the screen. In some machines a framing device is provided, consisting of a small incandescent bulb which is lighted during the threading process so that the projectionist may view the film in the aperture through a small door. Misframing results in parts of two pictures appearing on the screen at the same time, the frame line between them being in the aperture instead of coinciding with its upper or lower edge. This may be corrected by means of an adjustment while the machine is running. Even if the picture is properly framed at the beginning of the reel, a badly made splice may throw it out of frame.

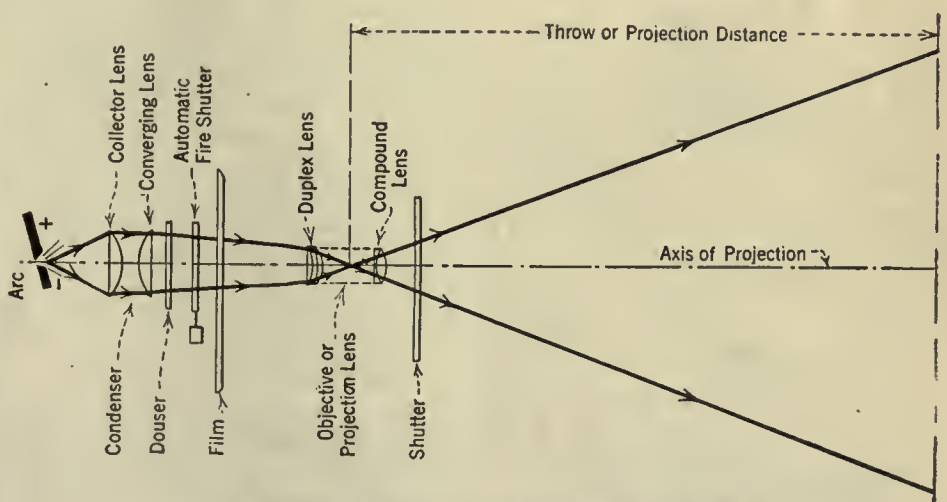


Fig. 3—Path of light in motion-picture projection

MEASUREMENTS ON DYNAMIC SPEAKERS

By FRANK C. JONES

THERE are two general types of loud speakers in use at present for radio reproduction. These are the electromagnetic drive and electrodynamic drive cone loud speakers. The latter is the most recent and will be considered in the following discussion because it gives a much wider frequency response than do other types.

The usual dynamic loud speaker consists of a moving-coil system and some form of magnetic field. The moving coil is attached to a small cone which acts as a diaphragm to set the surrounding air into motion. This coil moves back and forth in the magnetic field and the amplitude and frequency of motion depends upon the audio signal currents through the coil. The cone usually has two supports, one near the moving coil in the form of a fibre or aluminum spider frame, and the other at the front edge of the cone in the form of a thin leather ring. These two supports allow the cone to vibrate freely in a plunger motion back and forth.

The magnetic field generally consists of a field winding, an iron core, and a shell-return magnetic path. The power used by the field varies from 2.5 up to 20 watts for different types. Most of the magnetic field flux is used up in the air gap across the moving coil since this gap is fairly large. At least 0.010 inch clearance is allowed on each side of the coil and the coil itself is from $\frac{1}{32}$ to $\frac{1}{16}$ inch thick.

The Dynamic Unit

THE dynamic loud speaker is really a very complex machine when an attempt is made to analyze it electrically. At first sight, it appears that it functions in a simple fashion, i.e., the diaphragm is actuated by the moving coil which in turn moves in accordance with the audio-frequency currents flowing through it. This is true within certain limits but the question arises as to how much distortion is introduced for currents of different frequencies.

It is assumed ordinarily that a dynamic loud speaker is inertia controlled, that is, its diaphragm acts as a plunger. Then, for simple harmonic motion where the driving force alternates between +F and —F dynes, the amplitude can be expressed as

$$x = \frac{F}{\omega^2 M}$$

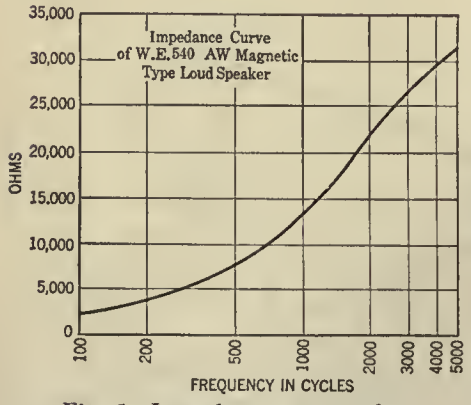


Fig. 1—Impedance curve of a standard magnetic-type loud speaker

At the present time a good moving-coil loud speaker in a three-foot-square baffleboard operated from a good amplifier provides fidelity par excellence. Mr. Jones, an independent investigator living in California, gives us some actual data on well-known speakers in this article, data which should appeal to anyone interested in "quality." The effect of cabinet resonance, the directional effects of dynamic speakers, and the use of filters are discussed and illustrated graphically. Incidentally, an article on the electrostatic loud speaker is being prepared for an early issue.

—THE EDITOR.

Where
x=amplitude
F=force in dynes (due to current in moving coil in the magnetic field
$\omega = 2\pi$ times the frequency
M=Mass of moving element in grams.

This equation shows that the amplitude varies inversely as the square of the applied audio frequency. According to Raleigh, *Theory of Sound*, the power radiated from one side of a large diaphragm is

$$P = \tfrac{1}{2}\rho V S \omega^2 x^2$$

and in the case of a small diaphragm

$$P = \frac{\rho S^2 \omega^4 x^2}{2\beta V}$$

P = power in ergs
V = velocity of sound
$\omega = 2\pi f$
x = amplitude of motion
β = solid angle of radiation
S = diaphragm area.
ρ = density of air
f = frequency in cycles

By large and small diaphragms are meant those whose outside diameters are larger and smaller, respectively, than the wavelengths of sound expressed in physical measure. These two equations show, therefore, that for a small diaphragm, the amplitude must vary inversely as the square of the frequency for constant sound output. For a large diaphragm the amplitude must vary inversely as the frequency.

For high audio frequencies, the wavelength becomes small enough to have the equation for the large diaphragm hold true, i.e., the amplitude varies inversely as the first power of the frequency. This means that the power output in sound will be so small at the high frequencies that the lower frequencies will be overemphasized. This occurs in some models of dynamic loud speakers, and may be made worse by cabinet resonance.

Operation at High Frequencies

THE two formulas are true for inertia-controlled diaphragms in which the whole diaphragm moves as a unit. This actually holds true for low frequencies with a small cone such as is used in a dynamic loud speaker. The cone shape gives the diaphragm very good rigidity. However, for higher frequencies, this does not hold true since the apex vibrates separately and flexural waves are radiated out to the edge of the cone. This is liable to cause standing waves along the diaphragm for the higher frequencies due to reflected waves from the edge of the cone. This occurs at certain frequencies and is quite apparent in the response curves for some loud speakers.

Because at high frequencies the loud speaker cannot be considered as inertia controlled there usually results a large increase of sound output for the higher frequencies. The combination of the two effects, inertia control and wave-motion control, generally causes a peak at about 3000 cycles per second for most commercial forms of these loud speakers. Beyond that point the plunger action or inertia control output drops off so rapidly that it is negligible and practically all of the sound output comes from the wave-motion action.

The motional resistance and impedance curves of the action of the moving coil and diaphragm also show that the output would be very small for the higher frequencies if it were not for this wave-motion action. Fig. 3 shows some impedance curves of two varieties of dynamic loud speakers. In both cases the moving coil has an appreciable inductance so its reactance increases rapidly for the higher frequencies. This reactive component is of very little use and serves to give a poor impedance match to the power tube. An example of the impedance of a magnetic type of loud speaker is shown in Fig. 1.

Motional Resistance Measurements

THE moving coil should consist theoretically only of a pure resistance, and the motional resistance portion of this would represent the useful part towards work done. This motional resistance is due to the acoustical load on the diaphragm and so is related to the useful sound output. It is possible to measure the motional resistance for all frequencies by means of an impedance bridge. First a resistance curve is taken with the cone free to vibrate and moving with an amplitude about equal to that obtained for normal sound output. Then the cone must be blocked securely, a very difficult job to do completely, and a second resistance curve made. The difference of values of these two curves gives a third curve of the motional resistance. These curves are interesting because they indicate the load

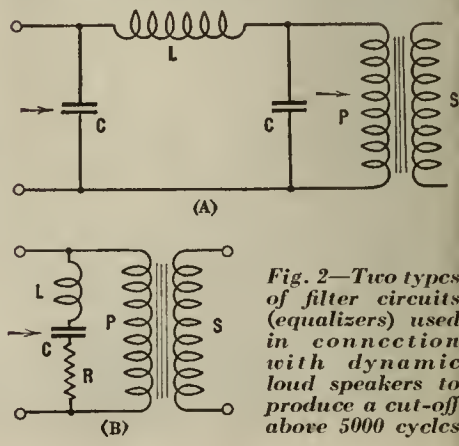


Fig. 2—Two types of filter circuits (equalizers) used in connection with dynamic loud speakers to produce a cut-off above 5000 cycles

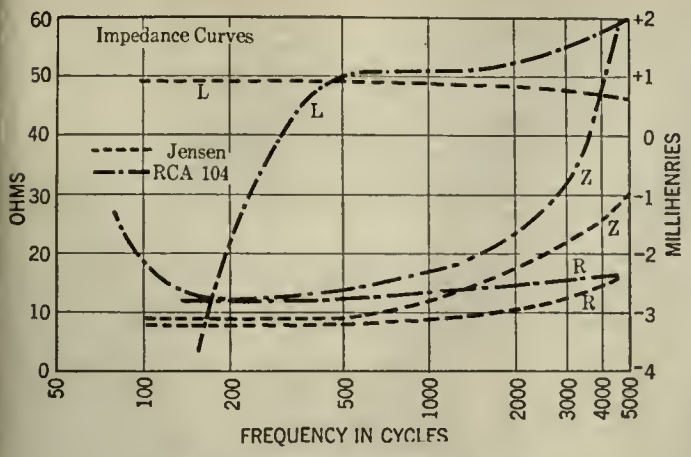


Fig. 3—Impedance curves of two popular dynamic loud speakers.

impedance which is offered to the power tube. Some dynamic loud speakers have a large motional reactance which becomes negative for some low frequencies with an abrupt peak at the natural resonant period of the moving coil and cone system. Usually this occurs at such a low frequency, from 20 to 70 cycles, per second, that it is not noticeable on radio reproduction.

Filter Systems

PRESENT-DAY models of dynamic loud speakers usually have some form of filter or equalizer as an integral part of them. The impedance of the moving coil is quite low, from 4 to 12 ohms for low frequencies, so a step-down transformer is used to obtain better undistorted power output from the power tube. In all cases the filter is connected across the primary or high-impedance side of the transformer. These filters or equalizers cut off above certain frequencies or cause a power loss at some frequencies.

The most general type of filter consists of a simple "Pi" section filter consisting of two 0.01- to 0.02-mfd. condensers and a 100- to 200-millihenry inductance as shown in Fig. 2A. This form of filter cuts off the frequencies above its natural resonant frequency and has practically no effect on the lower frequencies. It is called a low-pass filter because it cuts off above about 4000 cycles per second. Contrary to manufacturers' statements, these do not cut-off at about 5000 cycles, but all makes tested began to cut-off at about 3500 cycles. A 4000-cycle cut-off is very difficult to notice as far as speech is concerned but some of the brilliance is lost, especially for music.

Another form of filter or equalizer (diagram B of Fig. 2) consists of a resistance, inductance and capacitance in series connected across the primary of the step-down transformer. At the resonant frequency of this circuit the attenuation is greatest. By proportionating the values in this equalizer the "dip" may be made sharp or broad and deep or shallow to remove a resonant peak in the loud speaker output. This form of equalizer may be used to remove the peak mentioned before where the wave motion and plunger motion combine to cause an increased sound output. This peak and its removal by the last named method is shown in response curve A of Fig. 5.

The series-resonant filter is used in the Jensen dynamic loud speaker while the "Pi" filter is used generally on the Magnavox, Rola, and other popular makes of dynamic loud speakers.

By properly designing the shape and weight of the moving system it should be possible to eliminate equalizers and filters. A shallow cone, with an opening greater than 90°, will cause the wave motion to become effective at a lower frequency unless the stiffness and weight of the system are changed. Heavier paper causes an energy loss due to the added weight. It also affects the higher frequency due to increase of stiffness. The size of the cone also affects the frequency response due to the acoustic impedance which the air offers. Another effect is the directional properties at high frequencies due to the megaphone effect of the cone. The cone shaped diaphragm is not ideal but its advantages overshadow its shortcomings in present-day design.

That it is possible to overcome the usual peak at about 3000 to 4000 cycles by proper design was shown in a test on a new model Jensen speaker. This curve is shown and as can be seen the shift from plunger action to wave motion is gradual enough so that the response is nearly uniform. This was done by using a larger cone diaphragm which changes the weight and stiffness. Using a larger diaphragm means a good low-frequency response since for the same amplitude of motion there is of course a much greater amount of air set in motion. Conversely, for the same sound output the larger diaphragm does not have to move as far, which simplifies construction somewhat.

For low frequencies, 30 to 100 cycles per second, the amplitude of motion for good sound output is quite great. A motion of $\frac{1}{4}$ to $\frac{3}{8}$ inch is not uncommon. Such great motion causes crystallization of the rear spider support with breakage of these springs in time. With the larger diaphragm the motion is much less so the tendency to break is greatly lessened.

Baffles for the Dynamic

THE subject of baffles is difficult to handle since it must consider the effect of cabinet resonances, circulating air currents, standing-wave effects, and acoustics of rooms.

A source of sound emits waves of a spherical or hemispherical shape and these vibrations of air travel out to all parts of the room. Reflection and resonant effects take place, though generally the reflection properties are of major importance. The sound waves are reflected more or less from anything which they strike. If the walls and floor have drapes and rugs, the amount of absorption is, of course, much greater than in a bare room. Therefore, the reverberation is less, that is, the echo effect is small and so a note or tone of any frequency dies out more rapidly. The definition of music is also much clearer in such a room, and within certain limits, much more pleasant.

Another effect of excessive reverberation is the creation of standing waves of sound. In this case the reflected waves are of sufficient amplitude, and of proper phase for some frequencies, to cause points of maximum and minimum sound. This is easily noticed on organ music which is generally sustained long enough to allow a person to move a few inches or a few feet during some particular note. The presence of maximum and minimum areas of sound for some frequencies is quite pronounced in many rooms.

Reasons for Baffle

A DYNAMIC loud speaker with its small diaphragm will not produce tones of low frequencies unless a baffle of some sort is provided. The baffle should provide a path through the air such that the shortest distance from one side of the cone to the other is at least one quarter the wavelength of the lowest frequency desired. This does not prevent interference of the two sources of sound waves at the edges and near the baffle but it does stop the air circulation sufficiently to allow the loud speaker to reproduce the low tones. Considering the velocity of sound in air to be about 1100 feet per second, a baffle for tones as low as 75 cycles per second can be calculated easily.

$$\frac{1}{2} \times \frac{1100}{75} = 3\frac{2}{3} \text{ feet} = \text{diameter of baffle}$$

This, of course, can be in the form of a square $3\frac{2}{3}$ feet on a side. Thus to reproduce actually a tone of 30 cycles a baffle 9 feet square would be necessary. The wall or ceiling of the room may be used for the purpose when such a baffle is desired.

If frequencies below the "cut-off" of the baffle are impressed on the loud speaker, the resulting tone is made up mostly of higher harmonics. Tests by ear apparently show quite a bit of the fundamental tone but this is nearly all due to the modulating property of the human ear, since it combines the harmonics in a manner similar to the first detector or "mixer" tube in a super-heterodyne receiver. For example, if the ear hears two tones one of 120 and one of 180 cycles, there is apparently a strong 60-cycle tone present, which, of course, is not apparent to electrical recording systems. Fortunately very little music is transmitted below 80 to 100 cycles per second so a baffle of 3 feet effective length is sufficient for present-day needs.

When a flat baffle is used there are no

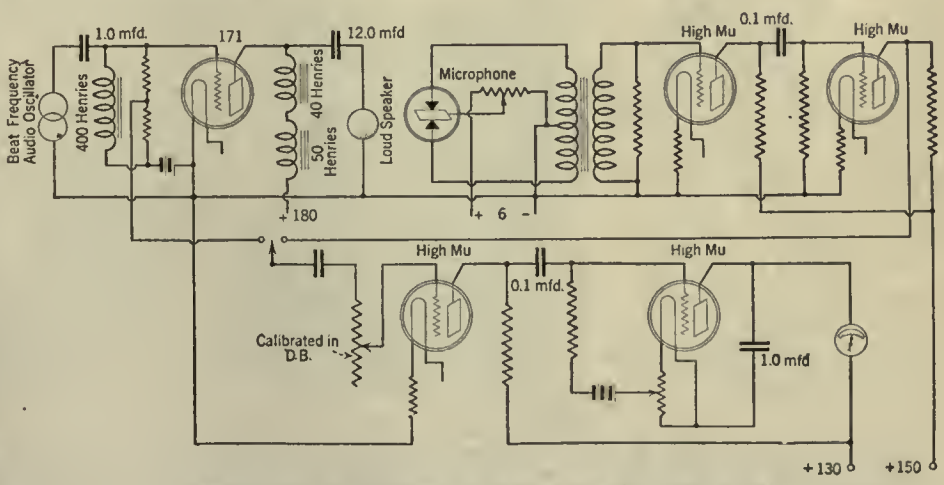


Fig. 4—The circuit used by the writer for measuring the characteristics of dynamic-type loud speakers.

resonant effects hut as soon as the sides are bent around, as in a cabinet, bad resonance occurs. Part of this resonance is due to the sides vibrating and part due to the natural period of the cavity. Making the cabinet of heavy wood helps reduce the resonating effect due to the sides vibrating. That this effect of cabinet resonance is very bad can be shown experimentally. The effect on music and speech is to change the quality greatly. It becomes booming in nature because the resonance is generally at low frequencies, and, in addition, the air chamber attenuates the high frequencies.

Response Measurements

MEASUREMENTS were made by means of a W. E. 387w transmitter and calibrated amplifiers over the audio-frequency band in an effort to learn something about cabinet resonance. The circuit arrangement used is shown in Fig. 4 in which a special beat-frequency audio oscillator was used as a source of sound. This audio oscillator had a range of from less than 30 cycles up to about 15,000 cycles and was, of course, continuously variable. Particular care was taken to minimize standing waves of sound in the room. The most practical method is to have the "mike" less than a foot from the loud speaker so that the direct sound wave is much stronger than the reflected waves.

Numerous response curves were run with the "mike" in different locations. Some trouble was had from room resonance and reflecting surfaces since either the loud speaker or the "mike" had to be moved for the different runs. Even with these effects it is quite evident that cabinet resonance is pronounced as shown in curve B of Fig. 5. A larger cabinet generally has a lower resonant period, but because of audio amplifier deficiencies, it may not be very noticeable.

Padding the inside of the cabinet with felt does not help much since felt is not an efficient absorbing material for low frequencies. Therefore, felt padding may attenuate the high frequencies more and tend to make the quality even more drummy in character. Felt padding helps occasionally in damping the sides to prevent vibration. Lining the cabinets with acoustic celotex or some such material should help greatly. Mounting the entire loud speaker unit in thick felt seems to remove the cabinet resonance but this cuts down the sound output nearly half. Only the front can emit sound in this case so a larger power tube is necessary to prevent overloading in the audio amplifier for the same sound output.

Effect of Small Cabinets

THE harmful effect of small cabinets on the higher frequencies is shown vividly in the curves C of Fig. 5. The solid curve was taken with the microphone about 15 centimeters in front of the loud speaker, the dotted curve was taken with the microphone at the same distance to the rear and the dot-dash curve was made with the microphone on one side. The dot-dash curve shows the effect of cabinet resonance since the "mike" was near one of the vibrating surfaces. The sudden drop at low frequencies is probably due to interference of sound waves emitted from the back and front of the loud speaker.

The dotted curve D of Fig. 5 shows the effects of cabinet resonance and the attenuation of the high frequencies. Evidently the cabinet cavity acts like a condenser in absorbing more energy on the higher frequencies. It is like a horn loud speaker in which there is a large air cavity between the diaphragm and the throat of the horn. It is quite a well-known fact that such a cavity attenuates the high frequencies greatly. If the air chamber or cavity is large enough with respect to the diaphragm, such as with a console cabinet, this attenuation of the high frequencies is of much less importance. If a small cabinet must be used, drilling a few large holes in the sides should help reduce both cabinet resonance and high-frequency attenuation. These holes would prevent the small cabinet from acting as a horn, but the effective baffle size would be diminished somewhat so the very low notes would be down a little in level.

Large cabinets such as those used to completely house the radio receiver may reduce the resonance to a minimum by using a screen back for the cabinet and by not having any shelves inside of the cabinet. The use of a couple of strips of acoustic material, such as type BB Celotex, fastened to the sides or sides and top inside of the cabinet should make this form of cabinet practically as good as a flat baffle.

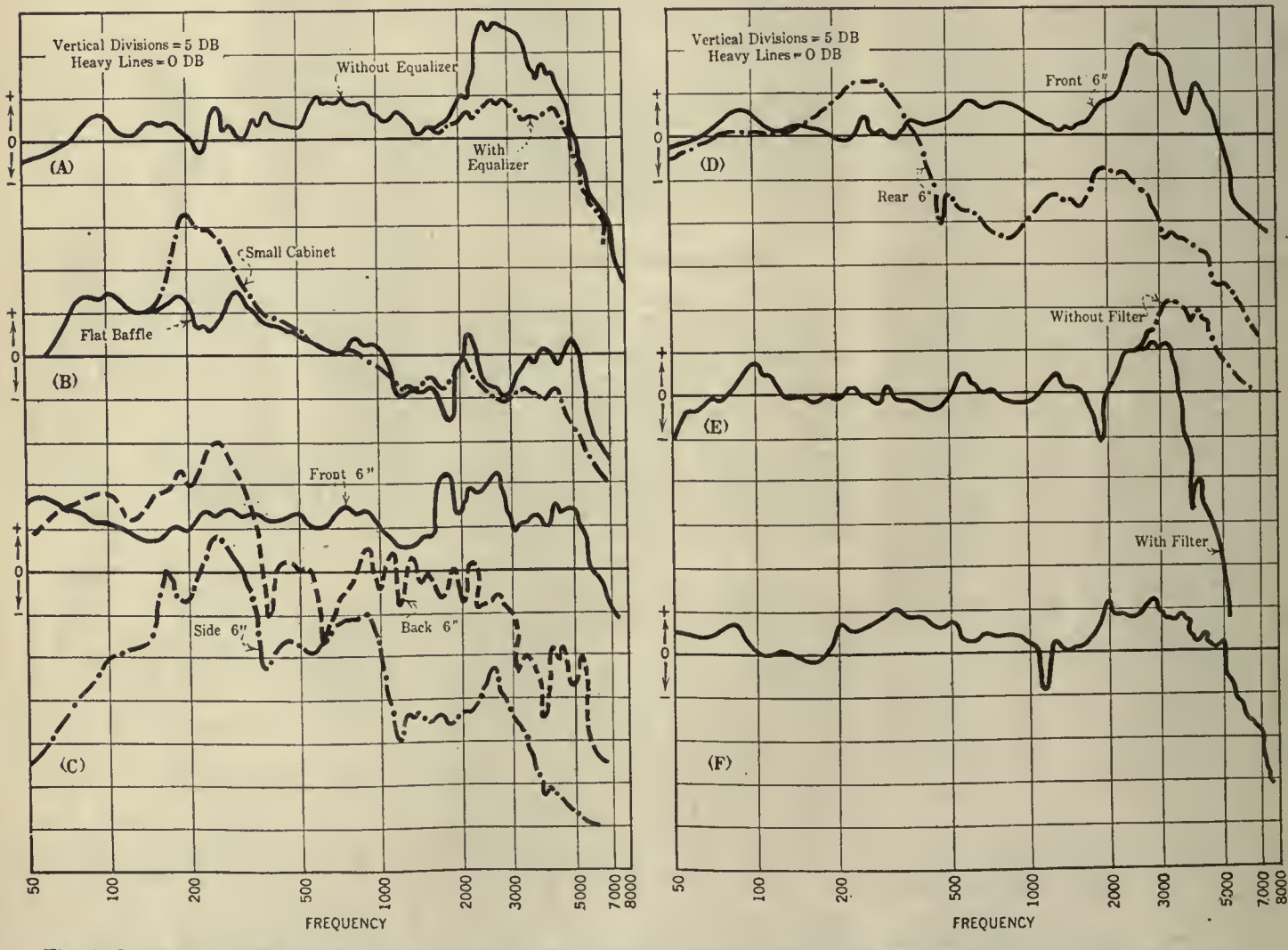
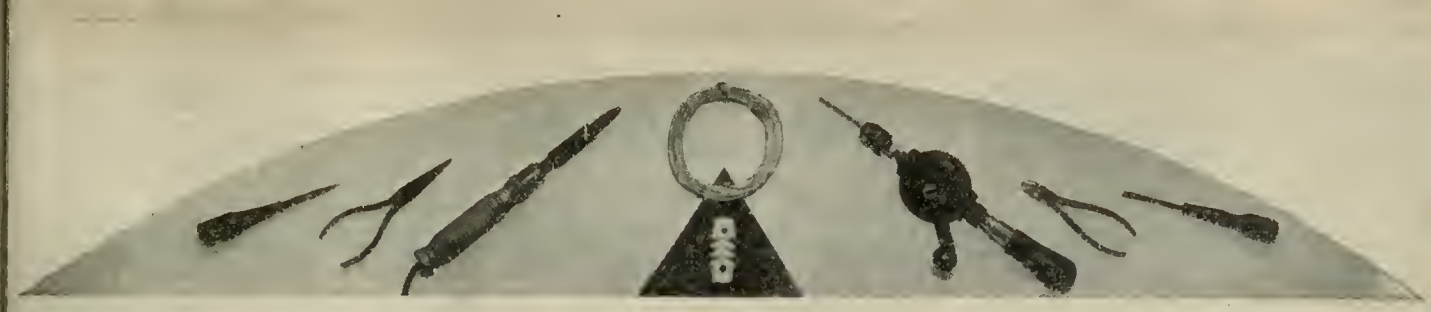


Fig. 5—Response curves of several dynamic-type loud speakers measured under different conditions. Curve A, Jensen loud speaker; curve B, Jensen loud speaker with different baffles (measured five feet in front of loud speaker); curves C, dynamic loud speaker in a small cabinet; curve D, small-cabinet-type dynamic loud speaker; curve E, Magnavox dynamic loud speaker; curve F, Jensen loud speaker with large cone and no filter or equalizer.



THE SERVICEMAN'S CORNER

With this issue of RADIO BROADCAST, *"The Serviceman's Corner" stretches into its natural stride. The purpose of this department is to publish everything and anything of genuine interest to the radio serviceman that can be briefly and thoroughly covered. Subjects justifying longer treatment will be covered in complete articles elsewhere in* RADIO BROADCAST. *Contributions, payable at our usual rate, will be welcome from engineers, manufacturers, servicemen, and dealers who have been intimately associated with any of these problems.*

It is requested that the contributor write us on his professional stationery, enclosing with his letter copies of his business cards and business literature if any.

—THE EDITOR.

RADIO Interference from House Plumbing: Two extraordinary but similar cases of radio interference have come to my attention. Although both conditions arose in the operation of short-wave receivers, the trouble may be affecting ordinary receivers, and telling of the experiences here may enable others to clear up an obscure source of trouble. In the first instance, a microphonic trouble developed in the receiver. The noise was terrible. The effect was suggestive of a loose connection. Sometimes a violent rapping on the set produced little effect, while placing an object on a distant table produced an explosion. Every connection from antenna to ground on a cold-water pipe was thoroughly overhauled. The trouble would reappear after each discovery and removal of its supposed cause. Matters reached a desperate state. As a final test, the set was put in operation and a 40-foot extension cord attached to the head set. The set was in the dining room and the floors of the dining room and kitchen were explored by rapping with a stick from point to point, like a blind man and the resulting static was carefully studied. A lone point on the floor, remote from the set, was found to be the most "sensitive." The extension was then carried through the floor to the cellar and the exploring transferred to the pipes hung from the floor overhead. Some were quite sensitive but they were not coupled with the ground connection.

The trouble was quite by chance traced to the metal stopper of a laundry tub. This stopper fitted loosely in the drain outlet and was attached by a brass chain to the cold water faucet. This proved to be a most sensitive microphone affected by vibrations conveyed to it from pipes hung overhead. It acted as a variable short circuit in the pipe ground system, changing the electrical constants of the system. Pulling out the plug and hanging it over the side entirely cleared this vexing interference.

Later an annoying but less overwhelming noise was traced to a variable contact between two pipes in the cellar that crossed each other. A little wedge of wood placed between them remedied this trouble. Probably many similar cases of interference exist which have not been traced down. This is particularly likely to be true of those who are now acquiring short-wave receivers. If trouble from loose connections cannot be found in wires in the attic, it is time to be suspicious of pipes in the cellar!

—C. A. BRIGGS,
Washington, D. C.

A simple method of determining if a noisy receiver is suffering from the trouble described by Mr. Briggs is to run fifty feet of wire almost anywhere, and use this as a counterpoise in place of the ground. Also, a simple cure might be a permanent counterpoise or six feet of iron pipe driven into the earth.

Servicing Magnavox Receivers: William K. Aughenbaugh, of Altoona, Pa., has run across several Magnavox receivers that would not function when the original tubes were replaced with R. C. A. or Cunningham tubes. The difficulty, he points out, can be remedied by short circuiting the coil of wire that will be found under the cardboard at the bottom of the set—near the front panel. Also the pin on the volume-control rheostat should be removed or bent so that the rheostat can be adjusted to the full "on" position if necessary.

Finding tube-locations: I was recently called on to install a new a.c. set. Not finding any installation instructions or data on proper location of tubes, I hit upon a useful method of locating the proper socket for the proper tube.

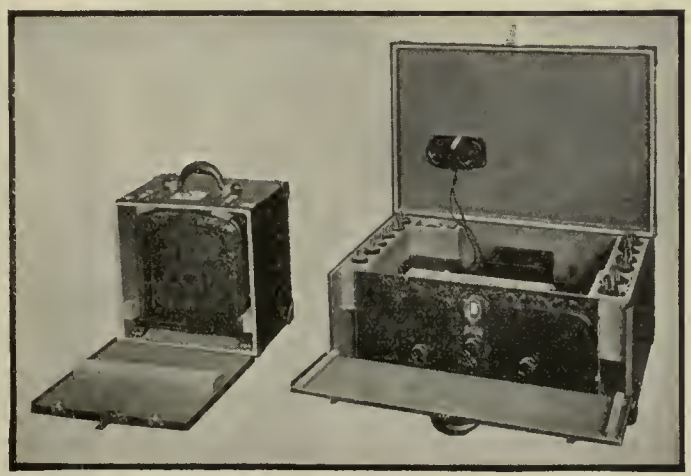


Fig. 1—Portable radio receiving apparatus that suggests a useful adjunct to the serviceman's equipment for determining general receiving conditions

No mistake can be made about the 280 or the Y-227, especially since the latter has five prongs. The set in question required four 226's, one 227, two 171's and one 280. Putting a 226 in a 171 socket won't do the 226 any good. I took a 171 and put it into the first socket next to the 227. I was sure about the location of the 227. Not seeing the filament light, I assumed it to be a 226 socket. In this way, by trying all the other sockets, I found which were the 226 sockets and which the 171.

FRED BERKLEY, Astoria, Long Island.

Polarity Incorrectly Stamped: I just serviced a Radiola No. 20. The owner of this set was using a 22.5-volt B battery as a C battery, connected correctly. I tested the set as usual. It would receive only locals, and these not at all well. Closer inspection, with a voltmeter, showed that the C battery was incorrectly stamped, the stamping being reversed for positive and negative. This is the second time in my eight years of servicing sets that this same thing has come to my attention.

GEORGE A. HARTMANN, Howell, Indiana.

Terminal reversal has also happened within the experience of the editor. A check of the socket and tube connections with the usual plug-in testing outfit would show this up as a very high plate current through the tube having the reversed grid bias.

Servicing Cheap Receivers: L. R. Arnold, of the Richards Radio Company, Providence, R. I. comments on the difficulties of servicing inexpensive receivers. These are often characterized by fairly good reception on local stations, but are insensitive to distant stations and stations covered by the upper section of the tuning dial.

These receivers can often be improved, as far as sensitivity is concerned, by running all r.f. tubes, with the exception of the first, from 135 volts through a bypassed variable resistor, using the additional knob as a sensitivity and volume control.

A Portable Receiver To Check General Conditions: The Kolster Radio Company provides its dealers with a portable demonstration set possessing several points of interest that recommend similar outfits for the serviceman. The complete apparatus is pictured in Fig. 1, and consists of two carrying cases, one holding the receiver, tubes and power supply, and the other the loud speaker. A portable receiver of somewhat similar design is of inestimable value to the serviceman in solving the more general problems of poor reception. The inability of a receiver being serviced to receive certain stations can be checked against a standard receiver, the characteristics of which are well known to the serviceman, to determine whether it is the location or the receiver that is at fault.

An outfit of this sort proved itself worth while to the department editor in the case of a batteryless installation in a d.c. district of New York City. Noisy reception in this particular apartment removed radio from the entertainment class. However, by using a portable receiver, operating entirely from independent battery sources, it was easily ascertained that the pickup was conductive through the lines. The receiver was rewired for battery reception (a desperate remedy) and has been giving satisfactory service ever since.

An Unusual Problem: The following incident came to my attention while servicing an Atwater-Kent battery receiver equipped with an A-power unit, and perhaps a little information about it might help a brother service man.

The set was playing along nicely when I arrived, but a moment later the thing stopped dead. After about 30 seconds the set gradually began to play and soon was up to its full volume. As nothing like this had happened before installing the power unit, of course, this was blamed. A careful check of both the A- and B-power unit circuits failed to reveal anything. A wire from the power rheostat in the A-power circuit seemed to be a little loose, but installing a new power rheostat didn't remedy the trouble.

By carefully questioning the owner of the set I discovered that some time before a very similar trouble had developed in the set when it was operating from batteries. The music had died down but hadn't stopped entirely and by working the filament switch the full volume of the set could be brought back. This led to the inspection of the filament switch. Sure enough there was the trouble. This is how I doped it out. The filament switch with a slight jar or other disturbance would cause a poor connection in the filament circuit. This, in turn, would cause the voltage in the A-power unit to rise due to the reduced load. The condenser in this particular unit (a Hartford with an electrolytic condenser and Tungar full-wave rectifier) would blow as soon as 8 volts or more was pushed into it. It took the condenser perhaps three seconds to heal and the remainder of the thirty seconds to charge up again. After repairing the switch this trouble disappeared entirely.

Alton R. Bowen, Pleasantville, N. J.

All In a Day's Work: Here are two difficult problems which I solved more or less by chance. The trouble was similar in each case and may aid in solving related troubles found by brother servicemen.

The first, a Freed Eisemann model 57, had been working very satisfactorily. One day on turning it on it was found to have lost its volume even on local stations. On checking it with an analyzer, the amplifier and power potentials were found to be considerably less than normal. In checking the power pack I found it o. k. I turned the set upside down and turned it on and noticed a minute curl of smoke as I pulled the wire running from the plate of the power tube to the jack. On closer inspection, I found the insulation of this wire was leaking and, as it was cabled with a ground wire, it practically caused a short circuit. When these wires were separated and the plate wire replaced (as it was burned badly) the set acted normally again.

The other was a Fada battery model which had lost its pick-up and even locals tuned broadly with no great kick. This set checked perfect. When I had it out, however, I noticed that where two wires went through the metal parts of the frame circles of corrosion had formed. By replacing these wires with new insulation where possible and by entire new wires in places where this was impossible, and rebalancing the set, normal reception was obtained.

In both these cases the wire involved was covered with a material similar to black cotton and impregnated with wax. It is not so good!

George W. Brown, South Boston, Mass.

The D. C. Problem: Supplementing your editor's remarks about the portable receiver and artificial "static" in d.c. districts, Arthur R. Gerling, of Kellogg and Bertine, New York, writes:

During my eight years of selling and servicing radio receivers in the wealthiest d.c. district in the United States, I have acquired a knowledge of what the *élite* want in the way of radio entertainment and reception, and also

Radio Service

For Particular People

Now is a good time to have the Radio looked over, tested, and put into first-class condition.

A radio receiver is a very delicate piece of apparatus and no matter how well constructed should have attention from time to time to maintain it in order for best results.

Often a little work of this kind will make a marked improvement in quality of reception.

Batteries, Eliminators, Tubes, Aerial should all be in proper order.

We are technically trained for this work, have the most modern tools, testing outfits, and appliances for performing this work in a workmanlike manner, at reasonable prices. A postcard or telephone call will receive prompt attention.

Endorsed by
National Radio Institute,
Washington, D. C.

William V. Lowe
Box No. 387 Tel. 3527-M
Fitchburg, Mass.

Fig. 2—A neat specimen of radio service-sales literature that brings returns for William V. Lowe, of Fitchburg, Mass.

the bug-a-boos that sometimes prevent us from giving them just what they want.

These folks whom I have chosen to call the *élite* would be quite satisfied—for the most part—with just the same kind of reception that their chauffeurs get out in the Bronx (where a.c. current is supplied). In many cases even this is denied them—why? First, because they are burdened with d.c. current with its many disadvantages known to all servicemen. Second, the management of the apartment houses in which they dwell often have stringent rules regarding the erection of antennas, and usually forbid them entirely—quite a reasonable attitude. Third, the numerous d.c. motors always found in large apartments—elevators, refrigerators, exhaust fans, water pumps with their armatures spitting fire and interference with every revolution. These are a few of the things that the serviceman has to think about when installing the present-day d.c. set, plus the natural loathing of the "madame" to have wires stretched here and yon about her drawing room, boudoir—or what have you.

The several sets now being put out by leading manufacturers are successful in only a comparatively small percentage of cases, and these very often because of the industry of the serviceman making the installation as regards filtering motors—known to interfere—putting filter banks in the d.c. line—experimenting with antennas, etc.

Is the manufacturer really interested in helping to solve this d.c. problem by putting out a set that will cut down d.c. interference to a minimum, or must the serviceman continue to rub along as best he can under the circumstances?

My answer to the d.c. question is: A superheterodyne using a loop—disappearing when not in use—201A-type tubes—d.c. operated—console cabinet with a self-contained dynamic loud speaker. Price range $350.00 to $500.00. What is your answer? Solve it and the residents along Park Avenue will forever be in your debt.

[By the way, the portable used by the editor was exactly this].

Neat Connections with Bell Wire: It is possible to use ordinary bell or annunciator wire for hook-up and for external wiring purposes without having the work marred, as far as appearance is concerned, by frayed ends.

If first the outer cover is unwound as far back as desired, then the inner covering, which is wound in the opposite direction, is unwound to the same point, and the two loose ends tied together and clipped short, there will never be any ragged ends hanging loose.

J. H. Bond, Dallas, Texas.

Testing Audio-Frequency Transformers: When going on service jobs I always carry a carbon microphone button with me, which can be shunted across the primary of the first audio transformer in series, with a six-volt battery. If, on speaking into it, the voice comes through well, the audio channel can be eliminated as the source of trouble.

Bernard J. Cannon, Pittsburgh, Pa.

[Another simple way of accomplishing the same test is to connect a loud speaker across the grid leak of the detector tube, and speak against the diaphragm. The unit from an old horn-type loud speaker may be included conveniently in the service kit for this purpose. It is, as Mr. Cannon suggests, the simplest test for the audio channel—*Editor*].

Defective Transformers: The usual tests for an open primary will not locate a microphonic transformer winding, which is the cause of a great deal of trouble down here in Florida. I have run across several cases of transformer trouble that tested o.k. with a battery and milliammeter, but were defective in operation, due, probably, to the dampness of climate. When suspecting trouble of this nature, I connect a 4.5-volt C battery across the primary of the transformer and a pair of telephone receivers across the secondary. A defective primary will generally show up, as a loud scratching, after a few seconds. The effect, of course, is stepped up by the transformer.

C. Washburn, Jr. Jacksonville, Fla.

Noise in the volume control: Here is a suggestion for remedying a difficulty which has turned up in some instances. If a set had not been used for some time and the weather has been damp, slight oxidation may occur at the point of the volume-control contacts. A condition of this kind will cause some noise when the volume control is adjusted. *Fada Sales* points out that, although such a condition may not always be apparent, it is easily fixed by moving the contact arm back and forth until the slight oxide coating has worn away.

Watch for bad contacts: Two simple sources of improper contact which may cause trouble are worth mentioning. Receivers equipped with loop antennas connecting to the receiver through a plug and jack arrangement may develop noise due to dirty contacts. This trouble is quickly stopped by rubbing the plug with a bit of fine sandpaper. Contact prongs in the house-lighting plug circuit connecting the receiver to a convenience outlet may become slightly bent so that the contact in the outlet is not tight. Noise resulting from

this cause is removed by bending the prongs to assure a tight contact.

The Case of the Broken Vase: "A telephoned service call" writes D. F. Greer, Coatesville, Pennsylvania, "informed me that while the set tuned properly, it lacked volume. I assumed that it was probably a case of poor tubes, open transformer, or similar ailment. On testing the set, antenna and ground were o.k. and routine tests showed no opens, no shorts, tubes good, plate and filament voltages correct, proper C voltages, and still the set did not deliver a "kick." A new speaker was substituted with no change. I was on the point of removing the set to my shop for a bench test when I accidentally discovered the difficulty. In testing the B power unit, I had clipped the negative lead of the meter on the negative post and the positive lead at the time lay in my left hand. I gazed disgustedly at the set and toyed abstractedly with the extension cord of the loud speaker. There was a deflection in the voltmeter (the cord had been tested for continuity), and at the same time a tingling sensation in my hand. Then the truth dawned. The loud speaker was being shunted by moisture in the cord. I could not understand what caused the dampness until one of the maids confessed she had knocked over a vase containing cut flowers and the water had seeped into the cord. This experience illustrated to me the value of a high-resistance voltmeter.

Antenna-Ground, connections: While there are several devices made for the purpose of bringing the antenna and ground wires into the house, the use of an ordinary convenience receptacle makes a neat job and one which is uniform with other receptacles and wiring in the house. I have found that the owners of higher-priced sets prefer this manner of entrance rather than the use of window strips and manufactured receptacles. A porcelain tube is used through the brickwork to insulate the antenna lead-in. The wires are then pulled through the knock-out in the rear of the receptacle and the ends clamped under the screws inside the box. A length of double-conductor and receptacle plug then connects the set to the outlet. Be sure to cut the hole in the baseboard to fit the box and not the outlet plate. Fig. 4 shows this method.

—D. L. Love, Greensboro, N. C.

Items of Interest

CONTRIBUTIONS on the routine of servicing, the general equipment, and tools employed are piling in on the service editor's desk in response to our recent request for such material. Just what we are going to do with this—outside of the fact that *it will be used*—we don't know. It is possible that the material will prove of sufficient interest and length to justify a separate article—or perhaps we shall make a symposium of the various contributions—or, again perhaps, we shall pick the best points of all contributions and give them to you as a digest.

At any rate we are still open for suggestions on the routine of servicing and the simplest, yet complete, equipment with which to do it.

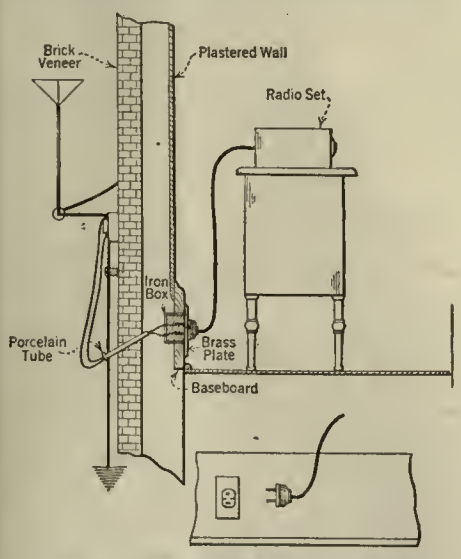


Fig. 4—A neat method for bringing antenna and ground wires in the house

FRANCIS H. ENGEL, Radiotron Engineer, with the R. C. A., sends along the following suggestions in reference to tests on rectifiers and power tubes suspected of suffering from old age:

(1) The loss of emission in a rectifier tube (which is the usual cause of failure) is quite often accompanied by an increase in alternating-current hum. The most practical and simplest method of determining whether or not the rectifier tube is defective is to remove the tube in question and substitute in its place a new tube of known good quality.

(2) The average life of the 281-type rectifier is greatly in excess of 1000 hours when operated under maximum rated conditions. Individual tubes may fall short of this figure but the large majority of them will exceed it.

(3) Regarding a test for defective output tubes the same scheme as outlined above for the rectifier tube would seem best.

Many servicemen have written us asking for suggestions as to the best book available on the background of radio theory. We don't know any such book because each inquirer wants a book with some special emphasis to suit his particular needs. Most of our correspondents want a book on radio circuits, particularly dealing with receiving circuits, which does not devote major attention to the general theory of electrical circuits. There is such a book, indeed there are several. How Radio Receivers Work, *by Walter Van B. Roberts and published by* Radio Broadcast, *Garden City, N. Y. at $1 net contains precisely the simple, clear analysis that is so welcome when it is found. Other useful books are listed on page 295 of this issue.*

(4) Another test which a serviceman should make when looking for trouble in the rectifier unit of a receiving set is to test for d.c. voltage across the output terminals of the filter and voltage divider. Knowing, from experience, the normal value he can readily tell by his meter reading whether or not the rectifier tube is performing satisfactorily.

Literature That Sells Service: The radio service business, for the greater part, concerns a commodity that sells itself. When a radio set actually goes wrong, the average person turns to the serviceman and it requires no salesmanship to convince him that his set needs repairing. But sales literature—circulars and cards describing the advantages of some particular serviceman or company—can go a long way toward building up a profitable service business.

Such literature acts in several ways. It reminds the radio owner that it is foolish to wait until his set actually goes bad,—until he misses entertaining programs—before calling in the serviceman. It also impresses on his mind the name and address of a reliable serviceman available in case of trouble. Thirdly it may call his attention to subtle difficulties existing in his set of which he was only vaguely aware.

Fig. 2 shows a card circulated by William V. Lowe, Certified Radiotrician, of Fitchburg, Mass., that gives a good idea of what can be done in the way of progressive servicing.



Fig. 3—A simple antenna clamp which is easy to install.

The possibilities of drumming up trade in this manner are enormous. Special circulars could be prepared, prior to important broadcasts, suggesting the inspection services of an expert at a special price. The average set owner should be educated into having his equipment examined at regular intervals—in the same way that the intelligent man goes to his dentist. Stock circulars can be prepared for distribution in the late summer suggesting that now is the time to have receivers gone over thoroughly in preparation for the coming radio season.

Good radio service sales literature might turn the summertime into a profitable radio season.

"The Serviceman's Corner" is particularly interested in circulars, letterhead and cards of this nature, and will pay a special price for those reproduced.

Arthur Rogers, New York City serviceman, has been building up sales on electric phonograph pick-ups by following up his old customers. He circularizes the owners of receivers he made several years back, adding to this list all recent service jobs on old equipment. He suggests modernizing these receivers by the installation of power amplifier apparatus and new speakers. The phonograph pickup naturally follows.

"The Serviceman's Corner" pays for live sales tips.

What should the serviceman charge? What is an equitable price for an inspection?—for an hour's work? How should the serviceman figure his charges? Should the profit on parts lessen his charges for time? "The Serviceman's Corner" will welcome an exchange of ideas on this subject.

¶An antenna clamp which makes installation quick, and much neater than is often possible has been brought out by the F. G. Manufacturing Company, 1117 Peoples Bank Building, Indianapolis, Indiana. This clamp requires no nails or braces to affix it to the roof, or chimney. A sample has been examined in the Laboratory and found very satisfactory. The picture, Fig. 3, shows how the device looks.

IMPORTANCE OF IMPEDANCE RELATION

By C. T. BURKE

Engineering Department, General Radio Company

IT IS recorded that a lecturer on sanitation, speaking in a portion of the country which shall from motives of policy, be nameless, upon reaching the inevitable question period was somewhat taken aback by the query "What's sanitation?" Lest the writer find himself in a similar predicament he hastens to define impedance, which he is going to endeavor to explain briefly in this article. The first part of this article is devoted to the general subject of impedance and the latter part of the article to its application to audio transformers.

Impedance is that quality in an electrical circuit which impedes or limits the flow of current, and determines the value of the current that flows when a given pressure (voltage) is applied against the obstruction. It should not be necessary to point out that, if we are connecting an electrically operated device in a circuit, the impedance of the device is of the utmost importance, since it regulates the amount of current which is delivered to it from the source. A device of very great impedance approaches an open circuit in effect, that is, little current flows from the generator to the load. On the other hand, if a short circuit (very low impedance) is placed across the generator, all the available voltage will be used up in forcing the large current through the internal impedance of the generator.

The power supplied to the load depends neither on current nor voltage alone; it is proportional to the product of current and voltage, that is, power equals volts times amperes. Fig. 3 shows the variation of current, voltage, and power for a source of 5000 ohms impedance (for example, a tube with a plate impedance of 5000 ohms, such as a 210 or 112A) and generating 100 volts, as the load impedance is varied. The current is at maximum when the output or load resistance is zero under which conditions the current is equal to the voltage, 100, divided by 5000 ohms which gives 20 milliamperes. The voltage available across the load is equal to

$$\text{Voltage across the load} = 100 \text{ volts times } \frac{\text{Resistance of load}}{\text{Resistance of load plus internal resistance of generator (5000 ohms)}}$$

The voltage across the load, therefore, rises as the load impedance is increased and will be at maximum when the load impedance is infinitely high. The power in the load, however, rises to a maximum where the load is 5000 ohms, or equal to the source impedance. This relation is always true; that is, the maximum transfer of energy occurs when the source (generator) impedance and the load impedance are equal. This is a universal rule applying to batteries, rotary generators, and converters, as well as to vacuum tubes.

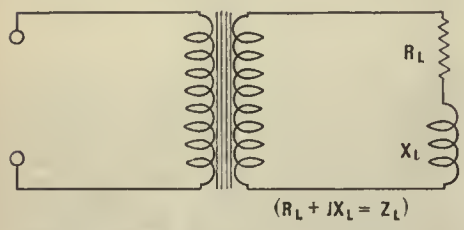


Fig. 1—Diagram of a transformer with load.

We are pleased to present this article by Mr. Burke in which he endeavors to clear up some misconceptions regarding impedance, especially as it affects the operation of audio transformers. Impedance is a characteristic possessed by every unit used in a receiver and few things in radio are more important than a clear understanding of what impedance is and how it affects the operation of various devices.

—THE EDITOR.

Conditions in Tube Circuits

IN COMMUNICATION circuits, the impedance of the circuit elements is often necessarily high, so that the current flow even under short circuit will not cause damage. Under these circumstances, with vacuum tubes it is possible to realize the theoretical maximum output of the device, obtained when the load impedance equals the generator impedance, and the so-called "matching" of impedances becomes important. That is, in connecting two circuits or devices together, it becomes important to have the impedance of the circuit in which the power originates (the source) equal to the impedance of the load (or "sink"). For a concrete example, a power tube of 5000 ohms impedance will deliver maximum power to a load of 5000 ohms impedance.

The importance of exact matching of impedance has undoubtedly been over-emphasized. In the power curve of Fig. 3 it will be noted that, while the maximum power to the load occurs with a load resistance of 5000 ohms, the load resistance can vary from 2600 to 10,900 ohms, a range of about 4 to 1, with only ten per cent. reduction in load power. Owing to a peculiarity in the behavior of vacuum tubes, the maximum *undistorted* output will be delivered to a load of twice the impedance of the tube, i. e., 10,000 ohms for a 5000-ohm tube, and in designing a circuit this relation is usually aimed at.

The impedance of a device is determined generally by certain considerations in its design which cannot be altered conveniently to obtain the optimum impedance relation when the device is worked out of a source of a certain impedance. The remedy for this situation is fortunately quite simple, involving only the use of the so-called impedance adjusting transformer. The remainder of this article is devoted to a discussion of this important device.

Impedance Adjustment

IT WILL be remembered that impedance was defined as the opposition which a circuit offered to the flow of current, in other words the factor which determines the flow of current from a source of definite voltage and internal impedance. If, then, a load impedance may be so affected as to cause the same current to flow in from the source as would another impedance, it is, so far as the source is concerned, equivalent to the latter impedance. If the load impedance is less than the source impedance there are two methods of increasing it, by means of a series impedance, and by means of a transformer. The series impedance method does not generally accomplish the desired result. Under the conditions in which we are principally interested, i. e., a vacuum tube feeding a loud speaker, the series impedance is not effective. While the "matching" thus accomplished does increase the power output of the tube, it does not increase the input to the load, since the added power is dissipated in the extra series resistance. Similar reasoning will dispose of the suggestion of the use of a parallel impedance to reduce the load impedance. There is left as a possible means of impedance adjustment, the transformer.

The action of a transformer is to step-up or -down an alternating current or voltage. Since the transformer is not a source of power, the power must be the same on both sides except for the losses in the instrument. Power being proportional to the product of current and voltage, this product must be the same on both sides of the transformer. i. e. the current is stepped-up in the same ratio as the voltage is stepped-down, and vice versa. This ratio of transformation is the ratio of turns in the two windings (approximately).

Consider the loaded transformer of Fig. 1.

The definition of impedance may be stated algebraically as: $Z = \frac{E}{I}$, i. e.,

$$\text{impedance} = \frac{\text{voltage}}{\text{current}}$$

Then if $Z_{i.e.}$ is the equivalent impedance of the transformer and load (the impedance which would permit the same current to flow as flows with the loaded transformer):

$$Z_{i.e.} = \frac{E_1}{I_1} = \frac{NE_2}{I_2} = \frac{NE_2Z_L}{E_2} = N^2Z_L$$

where

$Z_{i.e.}$ — equivalent impedance of load from primary of transformer
N — turns ratio $= E_1/E_2$
E_1 — voltage across primary
I_1 — primary current
I_2 — secondary current
E_2 — secondary voltage
Z_L — load impedance

That is, the equivalent impedance of a transformer of a turns ratio of N, loaded with

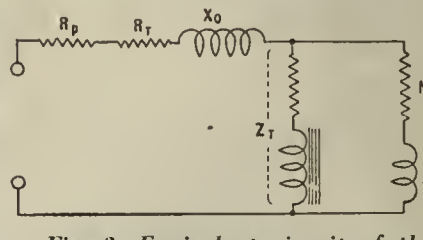


Fig. 2—Equivalent circuit of the loaded transformer. The circuit of Fig. 1 may be replaced by this series-parallel network

an impedance Z_L, is N squared times Z_L, or the effect of the transformer is to multiply the load impedance by the square of the turns ratio which may be a fraction or an integer depending upon whether the high or the low side of the transformer is loaded.

In the foregoing discussion, the turns ratio of the transformer is assumed to be the only transformer characteristic entering the relation. This ideal condition does not actually exist and, in designing or selecting an impedance adjusting transformer, other factors must be considered. There are, of course, the power losses which invariably accompany the passage of power through a conversation. These, however, are small in a well-designed transformer. Most important, however, is the impedance of the transformer itself.

In discussions of impedance-adjusting transformers, the statement is often made that the primary impedance of the transformer should equal the impedance of the source, and its secondary impedance equal that of the load. At best this is a careless statement. The effective impedance of the loaded transformer is determined by the impedance of the load over the frequency range for which good efficiency is maintained. The complete equivalent circuit of the loaded transformer is shown in Fig. 2.

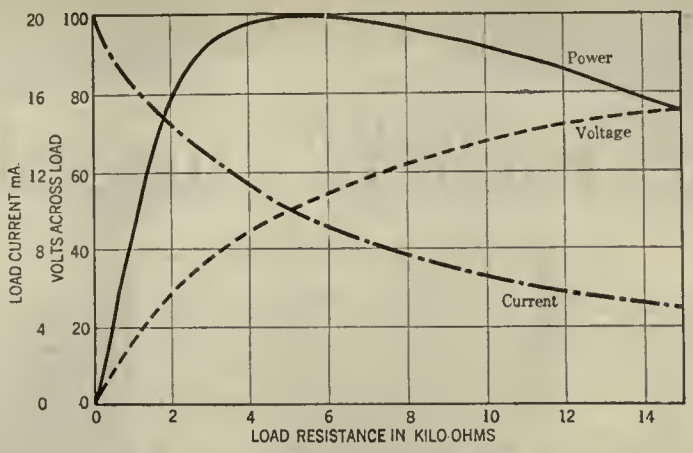


Fig. 3—Variation of voltage, current, and power as the load is varied. Values were computed on the basis of a 5000-ohm tube impedance and a resistance load

The series impedance, R_t and X_o, represents the loss in voltage due to transfer losses and leakage reactance. The shunt impedance, Z_s, is equivalent to the primary open circuit impedance of the transformer, to which one would expect the term transformer impedance to apply. This impedance has no definite value unless a frequency is specified, i. e., it varies with frequency. The fact that this impedance was ignored in the original discussion gives the clue to its proper value—it must be so high as to take no appreciable current from the source. The useful frequency range of the transformer is the range of frequencies over which this impedance is high enough to prevent appreciable current flow through it. At any frequency at which the transformer is useful, this impedance must be, not equal to, but several times the impedance of the source.

An impedance-adjusting transformer should have a turns ratio equal to the square root of the ratio of the impedances to be coupled. The input impedance of the transformer with the secondary open circuited should be several times that of the source at all frequencies in the range to be covered.

Table of Wavelength Allocations

The following table gives the wavelength allocations which were adapted by the International Radiotelegraph Conference at Washington, D. C. The data show the type of service permitted in wavelength bands between 5 and 30,000 meters (60,000 and 10 kilocycles per second). This radio allocation plan, of course, is used in all civilized countries of the world, as it was adopted at an international conference.

Frequencies in kilocycles per second (kc/s)	Approximate wavelengths in meters	Services
10– 100	30,000–3,000	Fixed services.
100– 110	3,000–2,725	Fixed services and mobile services.
110– 125	2,725–2,400	Mobile services.
125– 150[1]	2,400–2,000[1]	Maritime mobile services *open to public correspondence exclusively*.
150– 160	2,000–1,875	Mobile services.
160– 194	1,875–1,550	(*a*) Broadcasting. (*b*) Fixed services. (*c*) Mobile services. The conditions for use of this band are subject to the following regional arrangements: All regions where broadcasting stations now exist working on frequencies below 300 kc/s (above 1000m) } broadcasting. Other regions { Fixed services. / Mobile services. Regional arrangements will respect the rights of other regions in this band.
194– 285	1,550–1,050	(*a*) Mobile services. (*b*) Fixed services. (*c*) Broadcasting. The conditions for use of this band are subject to the following regional arrangements: Europe { (*a*) *Air* mobile service *exclusively*. / (*b*) *Air* fixed services *exclusively*. / (*c*) Within the band 250–285 kc/s (1200–1050m). Fixed service *not open to public correspondence*. / (*d*) Broadcasting within the band 194–224 kc/2 (1550–1340m). Other regions { (*a*) Mobile services except commercial ship stations. / (*b*) Fixed *air* services *exclusively*. / (*c*) Fixed services *not open to public correspondence*.
285– 315	1,050– 950	Radio beacons.
315– 350[2]	950– 850[2]	*Air* mobile services *exclusively*.
350– 360	850– 830	Mobile services *not open to public correspondence*.
360– 390	830– 770	(*a*) Radio compass service. (*b*) Mobile services, on condition that they do not interfere with radio compass service.
390– 460	770– 650	Mobile services.
460– 485	650– 620	Mobile services (*except damped waves and radiotelephony*).
485– 515[3]	620– 580[3]	Mobile services (distress, call, etc.).
515– 550	580– 545	Mobile services *not open to public correspondence (except damped waves and radiotelephony)*.
550– 1,300[4]	545– 230[4]	Broadcasting.
1,300– 1,500	230– 200	(*a*) Broadcasting. (*b*) Maritime mobile services, waves of 1365 kc/s (220m) exclusively.
1,500– 1,715	200– 175	Mobile services.
1,715– 2,000	175– 150	Mobile services. / Fixed services. / Amateurs.
2,000– 2,250	150– 133	Mobile services and fixed services.
2,250– 2,750	133– 109	Mobile services.
2,750– 2,850	109– 105	Fixed services.
2,850– 3,500	105– 85	Mobile services and fixed services.
3,500– 4,000	85– 75	Mobile services. / Fixed services. / Amateurs.
4,000– 5,500	75– 54	Mobile services and fixed services.
5,500– 5,700	54– 52.7	Mobile services.
5,700– 6,000	52.7– 50	Fixed services.
6,000– 6,150	50– 48.8	Broadcasting.
6,150– 6,675	48.8– 45	Mobile services.
6,675– 7,000	45–42.8	Fixed services.
7,000– 7,300	42.8–41	Amateurs.
7,300– 8,200	41–36.6	Fixed services.
8,200– 8,550	36.6–35.1	Mobile services.
8,550– 8,900	35.1–33.7	Mobile services and fixed services.
8,900– 9,500	33.7–31.6	Fixed services.
9,500– 9,600	31.6–31.2	Broadcasting.
9,600–11,000	31.2–27.3	Fixed services.
11,000–11,400	27.3–26.3	Mobile services.
11,400–11,700	26.3–25.6	Fixed services.
11,700–11,900	25.6–25.2	Broadcasting.
11,900–12,300	25.2–24.4	Fixed services.
12,300–12,825	24.4–23.4	Mobile services.
12,825–13,350	23.4–22.4	Mobile services and fixed services.
13,350–14,000	22.4–21.4	Fixed services.
14,000–14,400	21.4–20.8	Amateurs.
14,400–15,100	20.8–19.85	Fixed services.
15,100–15,350	19.85–19.55	Broadcasting.
15,350–16,400	19.55–18.3	Fixed services.
16,400–17,100	18.3 –17.5	Mobile services.
17,100–17,750	17.5 –16.9	Mobile services and fixed services.
17,750–17,800	16.9 –16.85	Broadcasting.
17,800–21,450	16.85–14	Fixed services.
21,450–21,550	14 –13.9	Broadcasting.
21,550–22,300	13.9 –13.45	Mobile services.
22,300–23,000	13.45–13.1	Mobile services and fixed services.
23,000–28,000	13.1 –10.7	Not reserved.
28,000–30,000	10.7 –10	Amateurs and experimental.
30,000–56,000	10 –5.35	Not reserved.
56,000–60,000	5.35–5	Amateurs and experimental.
Above 60,000	Below 5	Not reserved.

[1] The wave of 143 kc/s (2,100m) is the calling wave for mobile stations using long continuous waves.

[2] The wave of 333 kc/s (900m) is the international calling wave for air services.

[3] The wave of 500 kc/s (600m) is the international calling and distress wave. It may be used for other purposes on condition that it will not interfere with call signals and distress signals.

[4] Mobile services may use the band 550 to 1,300 kc/s (545–230m) on condition that this will not cause interference with the services of a country which uses this band exclusively for broadcasting.

NOTE.—It is recognized that short waves (frequencies from 6,000 to 23,000 kc/s approximately—wavelengths from 50 to 13m approximately) are very efficient for long distance communications. It is recommended that as a general rule this band of waves be reserved for this purpose, in services between fixed points.

our readers suggest . .

This department of RADIO BROADCAST *is utilized each month for the presentation of miscellaneous short radio articles which are received from readers. These abbreviated manuscripts describe "kinks," radio short cuts, and economies that the experimenter runs across from time to time and that can be made clear in a concise exposition. Although some of these notes have been submitted by engineers and professional writers, the editors particularly solicit contributions from the average reader. All material accepted, including photographs, will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas*

—THE EDITOR.

Reducing Static

A SIMPLE and effective way to reduce heavy static crashes and other interference such as howls from radiating receivers to the signal level has been tried out by the writer on a number of receivers with gratifying results.

A neon glow lamp, such as is sold by electrical-supply houses for use as pilot lights on 110-volt lines, is the "magic lamp" which effectively reduces static to ineffectual "plunks," and cuts the ear-splitting howl of radiating receivers to a less offensive squeal that does not rise in volume above that of the incoming signal.

The neon glow lamp, known as T14 and rated at $\frac{1}{10}$ watt, costs 60 cents. It has a screw base, containing a resistance compound which prevents excessive current flow when used on standard light circuits. Carefully cut this screw base off with tin snips and remove the resistance compound, being cautious not to break the delicate bulb or the fine lead-in wire. Solder No. 30 copper wires to the leads. Bend a piece of light metal around the glass bulb so as to form a mold for a base. Drop in hot sealing wax or rosin. This will harden into a base which will protect the tube and the delicate terminals.

The "static-spiller" is now ready to be connected in shunt with the loud speaker as suggested in Fig. 1.

The signal volume should be adjusted to suit the average requirements. At this volume setting the neon tube will not light at all, or only at rare intervals. When static is received if the surge is equal or smaller in amplitude than the incoming signals it will pass through unaffected by the neon tube, but it will be fairly innocuous. The crashing static that makes radio reception impossible is greater in volume than the received signal and therefore "spills over" through the shunting neon tube. When bad static is being received the crashes are visible each time they occur, the tube flashing brightly.

When the squeal of a blooper comes through the tube lights, holding the squeal down to the level of the received signal.

R. F. STARZL, Le Mars, Ia.

STAFF COMMENT

Mr. Starzl's idea should be reasonably effective in many cases. It is *not* a static eliminator. It is merely a device that has a limiting effect on volume. If the device is set to operate above a certain arbitrary signal level, the effect of any disturbance above this limit will be reduced.

It will be desirable to adjust the neon-lamp circuit so that it spills over at the correct intensity. If it spills over at too low a volume a variable resistor, such as a universal range Clarostat, should be placed in series with it.

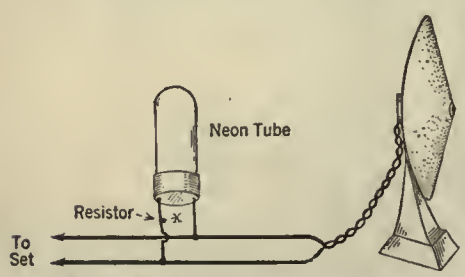


Fig. 1—A neon tube connected as shown above is an effective static reducer

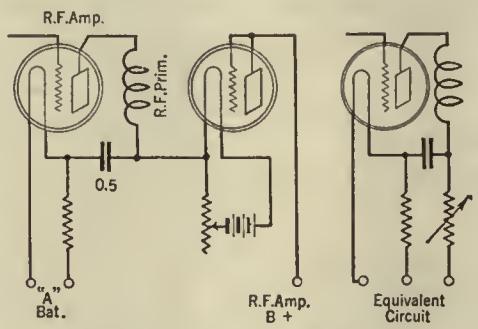


Fig. 2—The vacuum-tube circuit shown above is an excellent variable-range high resistor

A Variable-Range High Resistor

THE vacuum tube can be used as a variable high-range resistor for a variety of radio purposes, by taking advantage of the fact that its internal resistance varies with the filament emission. With plate and grid elements of the tube connected together, either filament leg may be used as one terminal of the resistor, and the common grid-plate connection as the other. The filament is controlled by a rheostat, which, in turn, varies the resistance of the plate-filament circuit. Using a 199-type tube a resistance range of from about 3000 ohms to infinity can be secured. The actual lower limit will vary with the voltage applied across the device.

The principal advantage of this arrangement is that it provides a silent, velvet variation in resistance. It may be used most successfully as a regeneration or oscillation control in receiving circuits, as suggested in Fig. 2. The use of a 199-type tube is recommended because, in many instances, it will be necessary to use a separate filament-lighting source. The resistor, of course, is operable only in d.c. circuits (such as the plate circuit of a receiver), and the plus side of the line must be connected to the plate-grid terminal.

RALPH VAN KEUREN, Beloit, Michigan.

A Good Coil Cement

AN EXCELLENT dope for coating solenoid coils, and for giving the necessary rigidity to spiderwebs and other self-supporting coils, may be made by dissolving one ounce of parrafin in one pint of high-test gasoline. This solution may also be used as a substitute for boiling in parrafin in almost any radio impregnation job.

S. W. OLDERSHAW, Waterbury, Conn.

Ghostly At Least

I HAVE found that my radio set can be enjoyed by everyone in the house by means of a very simple device. I attached a long cord to my loud speaker, and passed it through the same hole that I use to bring my battery wires up from the cellar. Then I place my loud speaker directly in front of the opening where cold air is taken into the hot-air furnace. When I turn on my radio set, the pipes from the furnace serve as carriers, transmitting the music into all rooms of the house. Oftentimes a guest is quite mystified to hear this perfectly transmitted music coming out of the register.

JACQUE LONGAKER, Buffalo, N. Y.

STAFF COMMENT

The idea is novel—useful to an extent, and replete with humorous possibilities. But we should hesitate to second our contributor's characterization of the reproduction as "perfectly transmitted." Hot-air heating pipes hardly have the acoustic properties of an ideal loud speaker.

An Economical Voltage Divider

THE 2 candle-power 110-volt carbon lamps, purchasable at almost any five and ten cent store for ten cents, make excellent resistor units for radio purposes. Each lamp has a resistance of about 2000 ohms.

I have found them particularly applicable to the requirements of a voltage divider in power-supply units. A power source having a maximum potential of 180 volts will require from six to eight lamps for a "bleeder" arrangement. These may be mounted easily by placing them in holes, one inch in diameter, drilled in thin wood or a bakelite strip. After the lamps have been mounted they are connected in series by soldering directly to the screw bases. Employing eight lamps, any voltages between 0 and 180 may be had in 22.5 volt steps. A typical arrangement is suggested in Fig. 3. As usual, each voltage tap should be bypassed to B negative.

C. H. GALBRAITH, Boston, Mass.

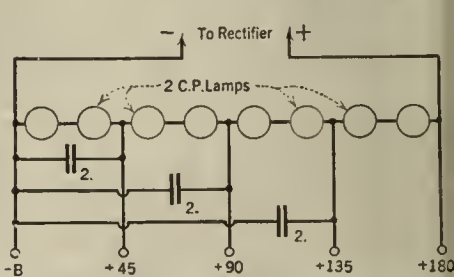


Fig. 3—A simple inexpensive voltage divider for a B power-supply unit.

A HOME-MADE THERMIONIC MILLIAMMETER

By G. F. LAMPKIN

IT IS more than ordinarily difficult for the radio worker to measure alternating currents around or below 25 milliamperes. A necessity for determination of currents in this range usually leads to a contemplation of vacuum thermo-couples and d.c. microammeters. Full-scale ranges of 100 milliamperes can he had rather reasonably in self-contained thermogalvanometers; but because of the current-squared crowding of the scale, readings below 25 milliamperes cannot be reliably taken.

It is useful, then, to know that a vacuum tube can bc fitted up rather simply to measure alternating currents from some 5 milliamperes upwards. A 199-type tube, a one-milliampere d.c. meter, and a 30-henry choke are the chief accessories necessary to measure currents in the above mentioned range. In the range from 35 milliamperes to as high as desired only the tube, d.c. meter, and appropriate shunts are needed.

Calibration of a home-made meter usually necessitates the use of a standard meter for the same kind and range of current. In this case, however, only a 0-100 d.c. milliammeter is required, and it can be improvised from the 0-1 meter if necessary.

Design of Meter

THE principle utilized in the thermionic meter is the change in emission current of a tube due to change in filament-heating current. Fig. 1 is the circuit diagram. The 0-100 milliampere meter is not a permanent part of the set-up, but is used only to obtain the initial filament-current, plate-current characteristic. Fig. 2 shows this curve for a typical 199-type tube. Appreciable emission is not had until some 35 milliamperes flow in the filament. It is evident 5 or 10 milliamperes of a.c. alone would have no effect whatsoever in producing emission current.

The scheme, then, to measure alternating currents in this lower range is *to pass an initial d.c. through the filament, and on this current superimpose the a.c. which is to be measured.* The a.c. alternately adds to and subtracts from the steady filament current. If the temperature of the filament could instantaneously follow these current fluctuations, the plate current would swing up and down the emission-current curve of Fig. 2. However, because of heat capacity, thermal lag, frequency of fluctuations, and such, the temperature of the filament cannot follow the heating-current fluctuations. What happens is that the temperature takes up a new value dependent on the new root-mean-square value of the heating current. The average value of the current, of course, does not change—but the average value plays no part in determining the filament temperature. The r.m.s. value of the steady initial current is simply its d.c. value. The new r.m.s. value caused by the combination of the a.e. with the d.c. can be calculated by:

$$I_{r.m.s.} = \sqrt{(I_{d.c.})^2 + (I_{a.c.})^2}$$

This change in heating value of the filament current is evidenced by a change in the d.c. plate current. By suitable calibrations, and fortunately by calculations, the magnitude of the superimposed a.e. can be determined from plate-current readings.

The author of this article, who is no stranger to the readers of RADIO BROADCAST, *has used the meter described to measure the overall frequency characteristics of receivers, the currents into loud speakers, the a.c. in power-supply chokes whose inductance was being measured, and, as he says, once one has an instrument that will measure accurately small values of a.c., many other uses will be found for it. It is much less expensive than a combination thermo-couple and microammeter—and repairs are less costly, too.*

—THE EDITOR

In the set-up of Fig. 1 the 30-henry choke is necessary to insure that the a.c. takes its intended path through the tube's filament. The filament battery has a low a.c. resistance, and were it not for the choke it would bypass the larger part of the a.e. The usual d.c. resistance value of a 30-henry choke is approximately 300 ohms, which makes necessary a filament battery of 22½ volts. The filament battery should be of the heavy-duty B type, for it must supply a current of 40 or 50 milliamperes. A 400-ohm rheostat or potentiometer is used for filament control. The filament battery could be made to serve also as a B battery, by returning the anode connection to the positive terminal. However, the comparatively heavy load which the battery must supply tends to cause a rather rapid drop in voltage; and, although the battery remains entirely suitable for A supply, the changed plate voltage leads to inaccurate results. For this reason, another battery is used to supply the plate voltage. One additional battery, a 4½-volt unit which supplies bucking-out current for the plate meter, is also used.

When obtaining the emission characteristic of Fig. 2, readings are taken up to one milliampere plate current, the full-scale range of the meter. Then a 50-ohm rheostat, which is connected across the plate meter, is adjusted until the deflection is exactly half its original value. This will require a shunt of approximately 39 ohms on a Jewell meter. Readings up to 2 milliamperes are taken, because the curve in this region is necessary for calculating calibration points.

The sensitivity of the thermionic meter depends on what part of the tube's filament-current, plate-current characteristic is worked. It may be seen that a given change in r.m.s. filament current at a low initial current, say 38 mA., will produce only a fraction of the plate-current change that would be caused at a higher initial current 60 mA., for example. The resistance in the circuit diagram of Fig. 1 through which bucking-out current is fed to the plate meter is fixed. The only control is the 400-ohm filament rheostat.

The procedure in using the meter is to close the battery switch and adjust the filament rheostat until the plate meter reads zero. This will happen when the emission current equals the bucking-out current supplied through the 4½-volt battery and fixed resistor.

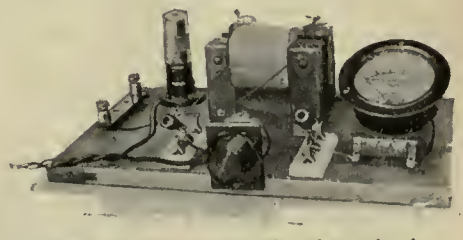
Thus the size of the fixed resistor automatically determines what initial emission current must flow and accordingly what part of the filament-plate current characteristic is to be used. If the value of the fixed resistor is low, the bucking-out current will be large. To produce an equally large emission current a high initial filament current will be necessary, and the resultant sensitivity of the meter to a.c. will be good. However, extreme values of initial filament and emission current are detrimental to the tube's life and the accuracy of calibration and so should be avoided.

The calibration curves of Fig. 3 were made by measuring the superimposed 60-cycle current on the tube's filament, and taking the corresponding plate-current readings. With a 2500-ohm resistor in the bucking-out circuit, the initial plate current, which was required to equal the bucking-out current, was 1.6 milliamperes; and the superimposed a.c., which gave a one-milliampere plate current range, was 3 to 18 milliamperes. Greater sensitivities can be had by working higher on the emission curve, i.e., with smaller values of bucking-out resistance, but such is not advisable. A 10,000-ohm fixed resistor and an initial plate current of 0.4 milliamperes gave a range of 6 to 23 milliamperes a.c. (curve 2 of Fig. 3). With the bucking-out circuit opened, and the plate current adjusted to an initial current of 0.02 milliamperes, the a.e. maximum was 35 milliamperes (curve 1.). The calibration on the latter range departs much farther from the linear than does the one for 6–23 milliamperes. The lower range calibration works over a more restricted and a straighter part of the emission characteristic, so that it does not show the sharp bend present in the 15–35 milliampere curve.

It is important to note that there must not exist a d.c. path in the circuit which carries the to-be-measured a.e. A d.e. path would draw current from the filament battery of the tube and disarrange the zero setting. In



Parts required for construction of a 35-mA. thermionic millammeter



View of the author's thermionic milliammeter set-up

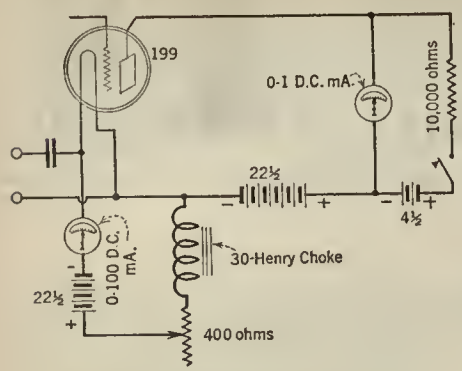


Fig. 1—Schematic circuit of thermionic milliammeter

such cases it would be necessary to insert a condenser in the a.c. leads to the tube. The size of the condenser is determined by the impedance which it is permissible to insert in the circuit carrying the a.c. The resistance of the thermionic meter alone to the a.c. is approximately 50 ohms.

Calibration by Calculation

THE check between calculated and calibrated points agrees within 3 per cent. and this shows that it is not necessary to have 20- or 40-milliampere a.c. meters at hand to calibrate the thermionic meter. From the known data as to initial filament-current and emission characteristic it is perfectly feasible to get good calibrations by computation. The procedure followed for the 6–23 milliampere curve (curve 2 Fig. 3) was first to measure the bucking-out current through the 10,000-ohm resistor. This was 0.4 milliamperes. From the emission curve of Fig. 2, 0.4 milliamperes corresponds to 46 milliamperes, the initial filament current. This is $I_{d.c.}$ in the formula above. Then values of superimposed $I_{a.c.}$ were assumed—say 7, 10, 14, etc. milliamperes—and the resulting r.m.s. values figured. For instance, for 10 milliamperes of assumed a.c.,

$$I_{r.m.s.} = \sqrt{(46)^2 + (10)^2} = \sqrt{2116 + 100} = 47.1 \text{ mA.}$$

Going back to the emission curve, 47.1 milliamperes in the filament gives 0.52 milliamperes plate current. Although 0.4 milliamperes already flow in the plate circuit, the meter reads only .12 mA. because of the bucking-out current. Thus the meter reading of 0.12 milliamperes corresponds to 10 milliamperes of superimposed a.c. In the case of the 15–35 milliampere curve (curve 1, Fig. 3) there was no bucking-out current. The initial plate current of 0.02 milliamperes meant a filament current of 36 milliamperes. The combination with an assumed value of 33 milliamperes a.c. gives:

$$I_{r.m.s.} = \sqrt{(36)^2 + (33)^2} = \sqrt{1296 + 1089} = 48.8 \text{ mA.}$$

The plate current for 48.8 milliamperes filament current is 0.75 milliamperes. Thus when the plate meter reads 0.75 mA., 33 mA., a.c. flows through the filament.

Both the filament battery and the bucking-out battery circuits on the meter set-up can be opened, and a.c. alone used to heat the filament—in which case currents from 35 milliamperes up can be measured. If lower current ranges are not necessary, the thermionic meter becomes simplicity itself. The raw materials required are only the tube, the one-milliampere meter, and a 22½-volt B battery. There are no restrictions as to d.c. path in the circuit in which current is measured. The wave shape of the current is immaterial—on any sort of wave the meter reads the r.m.s. value. Shunts may be used to extend the range indefinitely upward. The fact that a filament-current change of only 35 to 50 milliamperes gives full-scale change on the plate meter is both an advantage and a disadvantage. The limited a.c. range allows an open and easily read scale so that currents can be determined accurately. It also means, however, that an inconvenient number of shunts must be used to give overlapping ranges.

A possible alternative is to connect the grid of the tube to one side of the filament. By doing this the rate of increase of plate current with filament current is cut down, and a range of approximately 35 to 60 milliamperes results. In other words, the minimum readable current is 58 per cent. of full-scale value as compared with 70 per cent. when the grid is tied to plate. However, this alternative method makes the plate current dependent in a greater measure on the plate voltage, so that changes in plate voltage damage the accuracy more than in the case of grid-plate connection.

In Fig. 4 are given sample calibrations for the tube (grid connected to plate) when carrying a.c. alone, with and without shunts. These calibrations may be made with either d.c. or a.c. and then be used to measure any sort of a current.

[*Editor's Note:* Mr. Lampkin has indicated but briefly the uses to which such an instrument as he describes can be put. Anyone who has worked in the laboratory where small

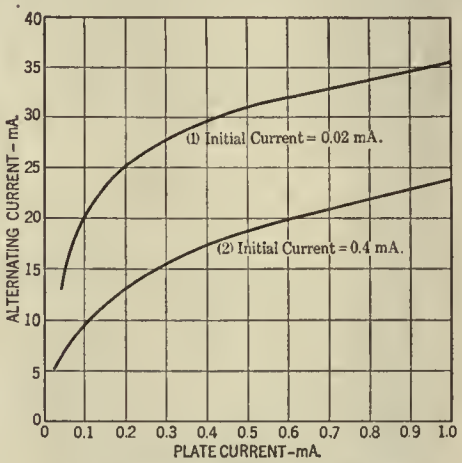


Fig. 3—Calibration curves of thermionic milliammeter

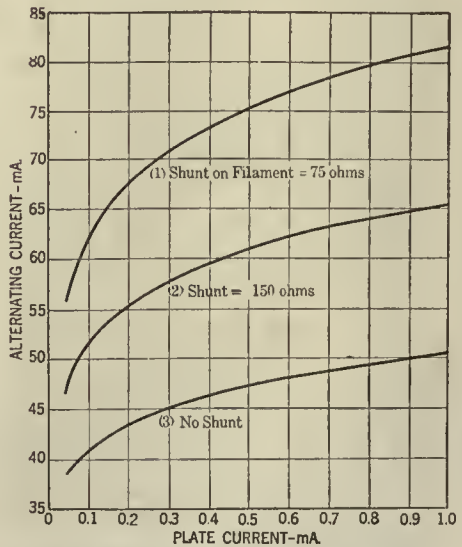


Fig. 4—Calibration curves of thermionic milliammeter with two values of filament shunts.

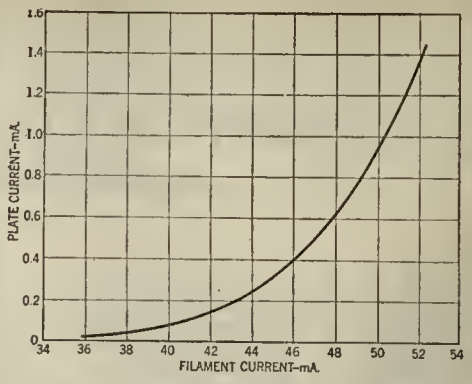


Fig. 2—Filament-current, plate-current characteristics of 199-type tube with 22½ volts on plate and grid

a.c. potentials must be measured, either at low or high frequencies, will appreciate the advantages of this combination of tube and d.c. meter.

As an example, let us try to measure the impedance offered to a 60-cycle current by a 30-henry choke coil. There are various methods, all of which are more or less complex. This impedance, however, is largely inductive reactance, and, if we knew the current through the coil at a given a.c. potential across it, this reactance could be calculated. From this calculation would come the value of inductance and impedance in which we are interested. At 30 henries, and with an a.c. potential of 110 volts, the current through the coil will be about 10 milliamperes. Now a thermo-couple that will measure currents of this value costs about $25 and requires a sensitive d.c. microammeter in order to read the rectified current. This meter will cost not less than $35 and probably will amount to $100. Therefore, in order to measure this small current of 5 to 10 milliamperes, equipment worth over $100 is required.

The device described by Mr. Lampkin will measure this current easily and at much less cost than by the use of a thermo-couple and indicating meter. It is only necessary to put an initial current through the filament of the tube and then to add the current going through the choke. The differential of filament current will cause a differential in plate current which can be read on an inexpensive d.c. meter. After the tube and meter are calibrated, or when the values of plate current corresponding to certain values of filament current have been calculated, the meter is immediately useful. The change in plate current caused by the change in filament current can be obtained from a curve similar to those given on this page.

Other uses for the device have been indicated in the box on the preceding page.

In all of the cases where a.c. and d.c. both flow through the device under measurement, care must be taken to prevent the d.c. current from flowing into the tube filament. This is a simple matter and requires only a large fixed condenser through which the a.c. will pass but which offers a very high opposition to the flow of d.c.

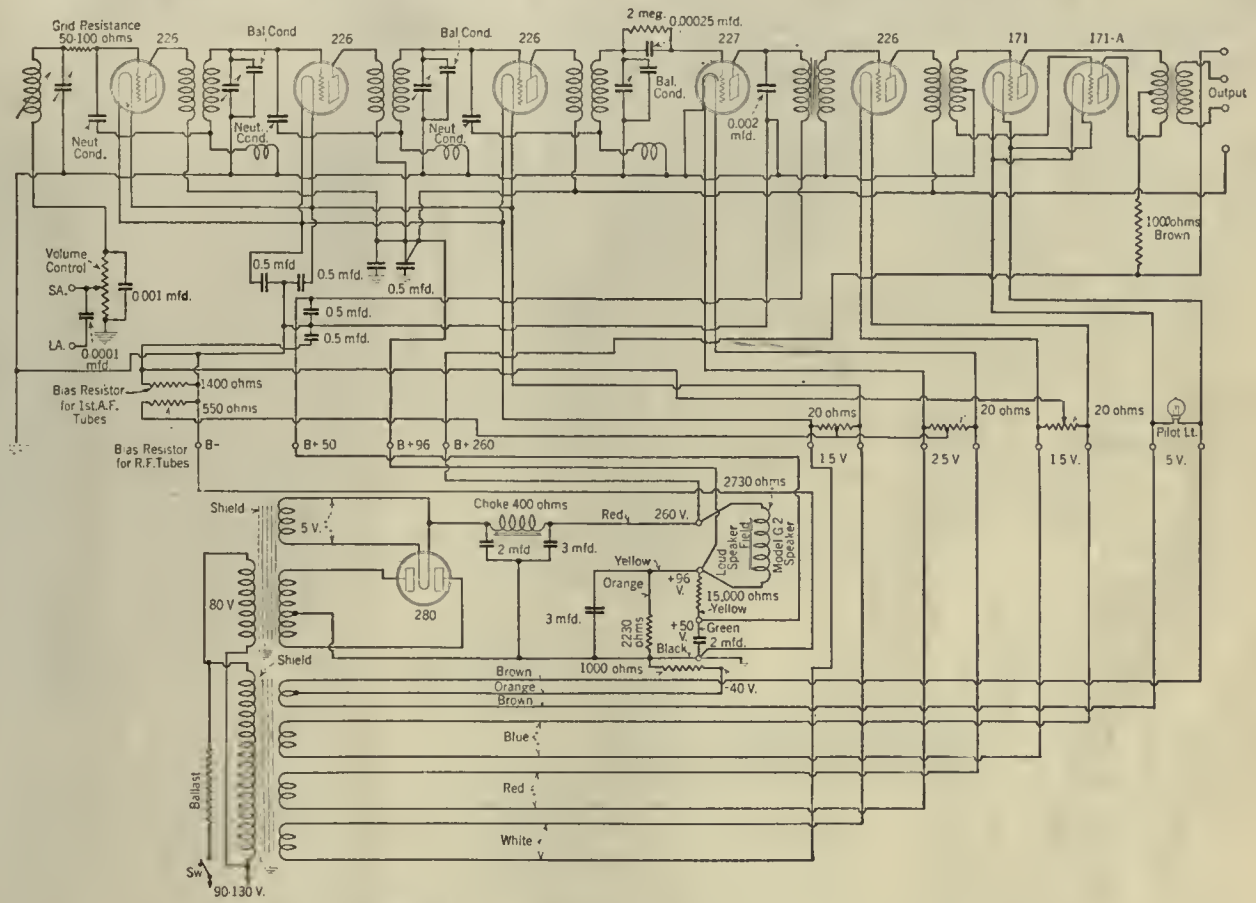
This milliammeter is one that can be built and operated by any home experimenter or any laboratory worker. The requirements are simple, a d.c. meter reading about one milliampere, a 60-milliampere filament tube, and a little patience at calculating what plate current will be read when a given a.c. current is added to the filament current.

As the author points out the resistance of the voltmeter to the a.c. currents which it is designed to measure is of the order of 50 ohms. The effect of this resistance on the circuit in which this a.c. currents flow must be taken into account, but in general such an addition will not upset the circuit condition.]

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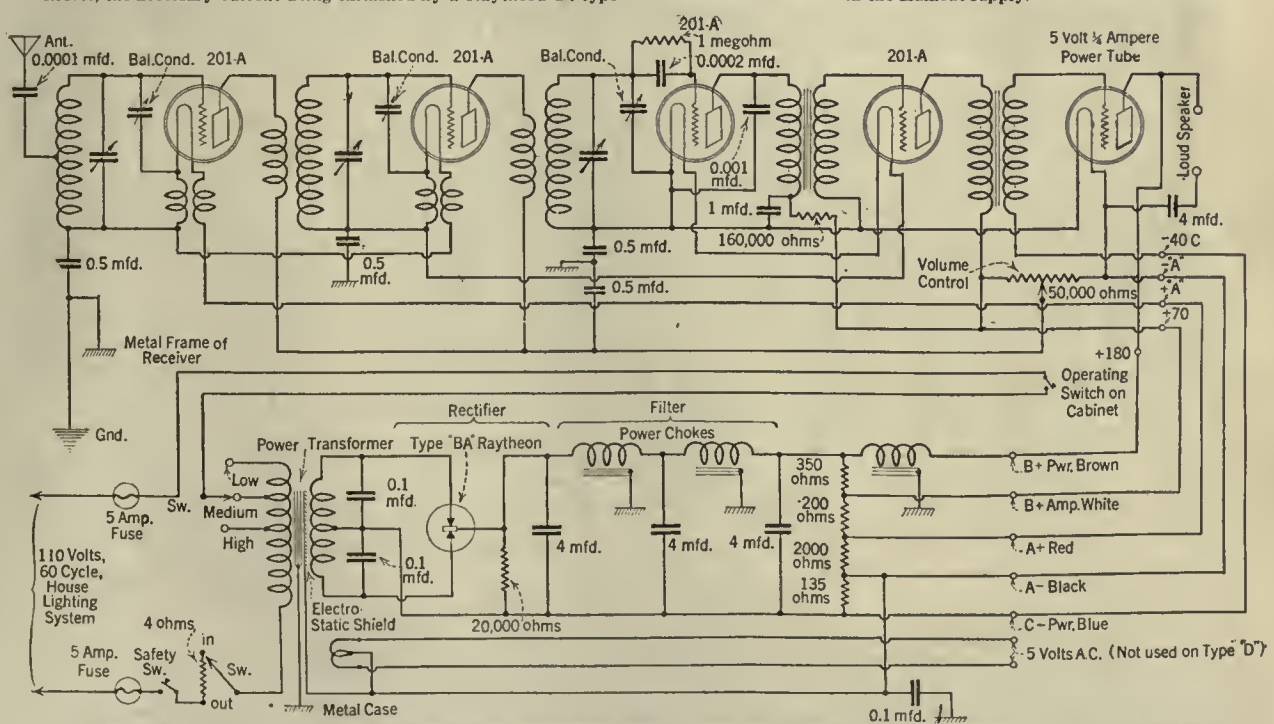
THE MAJESTIC MODEL 70-B RECEIVER

This seven-tube Majestic receiver consists of a three-stage tuned radio-frequency amplifier, a detector and a two-stage transformer-coupled audio-frequency amplifier, the output circuit of which is push-pull using two 171A-type tubes. The power unit supplies A, B, and C potentials to the set and also provides field current for a Majestic model G-2 dynamic loud speaker.



THE FEDERAL TYPE D (60 CYCLE) RECEIVER

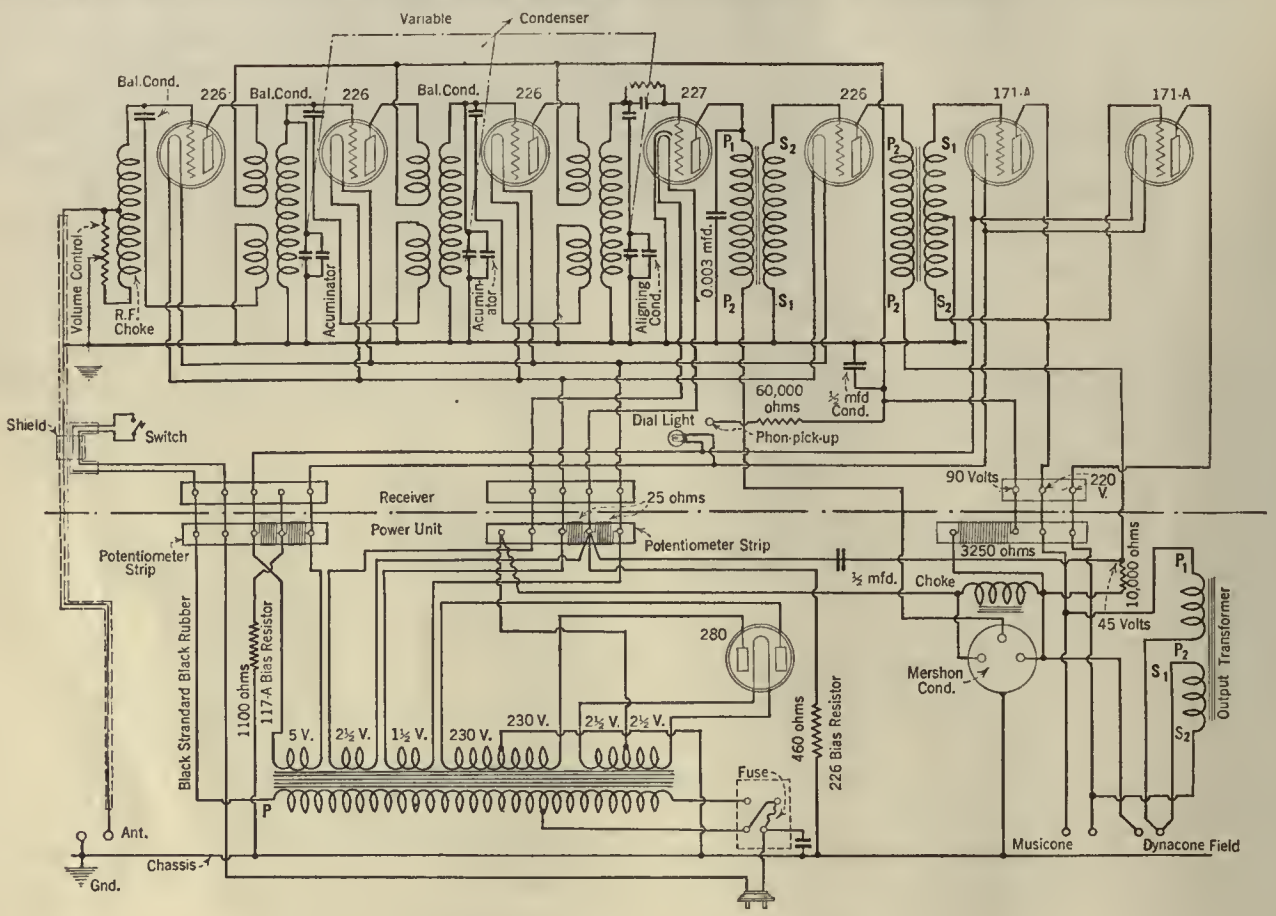
This interesting receiver manufactured by the Federal Radio Corporation uses four 201A- and one 171A-type tubes in a series filament circuit, the necessary current being furnished by a Raytheon BA-type rectifier. It should be noted that the filament circuits of the r.f. amplifier tubes contain r.f. choke coils to prevent common coupling in the filament supply.



The data which was given in the description of the receiver in previous "Set Data Sheets" has been lettered on the above diagram.

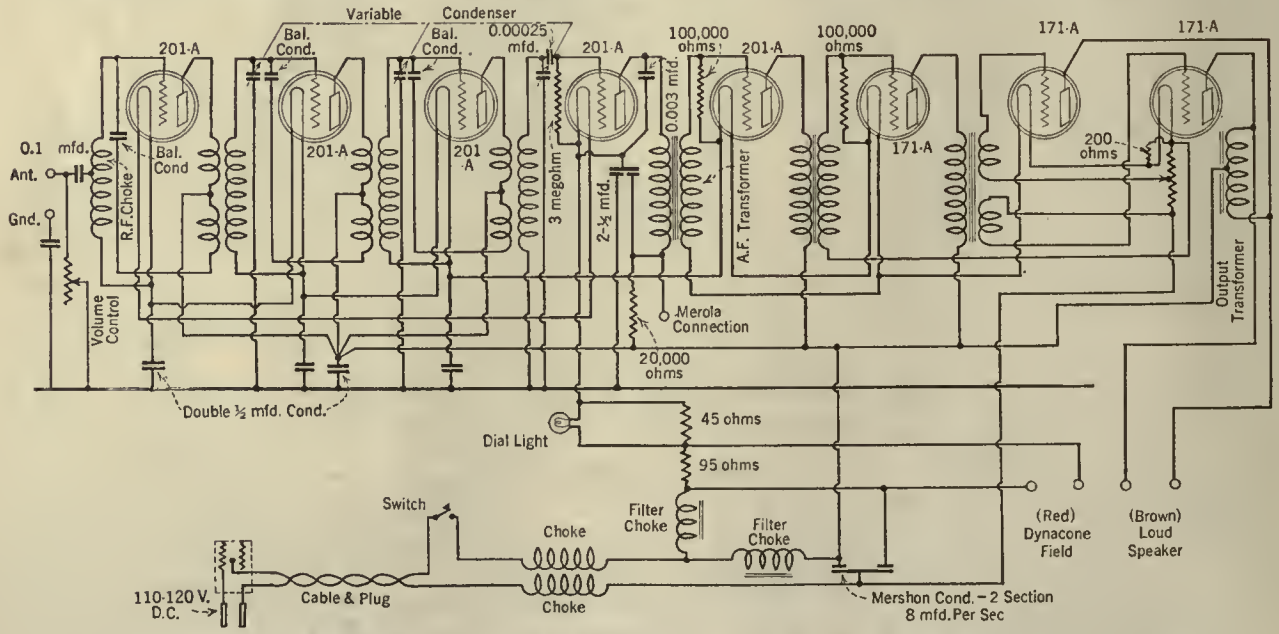
THE CROSLEY MODEL 704-B RECEIVER

This popular model in the Crosley line is a complete a.c. set. The Hazeltine neutrodyne circuit is used in the r.f. amplifier to prevent oscillation. The circuit of the power supply is designed to furnish field current to a Crosley Dynacone loud speaker although any type of loud speaker may be used with the set. The output circuit is push-pull.



THE CROSLEY MODEL 705 RECEIVER

This light-socket-operated receiver is designed for use in districts where the only power supply available is 110 volts d.c. The set uses five 201A- and three 171A-type tubes in a series-filament circuit. The two push-pull 171A-type tubes in the output are supplied with about 90 volts so the available a.f. output is 100 milliwatts per tube giving a total of 300 milliwatts.



The data which was given in the description of the receiver in previous "Set Data Sheets" has been lettered on the above diagrams

A HIGH-POWER OUTPUT TUBE—THE 250

By K. S. WEAVER
Westinghouse Lamp Company

Public Library Kansas City, Mo.

THE 250-type power tube was developed to fill a definite place in the field of radio reception, that of a tube which would deliver a large output to a loud speaker without appreciable distortion and with a grid swing or input signal strength readily obtainable with available apparatus.

The tube as finally developed has been found to meet this requirement well. A filament of the coated type is used which insures an ample electron emission with a moderate filament power consumption. The plate resistance is inherently low, a plate voltage of only 450 being required for full power output.

The general characteristics of the tube were determined according to its intended use as a power amplifier. Consequently it is not well adapted for use as an oscillator or voltage amplifier. The use of a coated filament together with the low amplification factor, which were found to be very desirable features, are not ideal from the standpoint of oscillator tube design, although the tube can be used as an oscillator in certain cases.

Before going into the details of the development of the 250 it may be of interest to consider some of the factors which have made the production of tubes of high power output desirable.

A very few years ago about the only kind of loud speaker in general use was of the horn type operated by a vibrating metallic diaphragm. The characteristics of this type of loud speaker were such as to accentuate greatly the higher frequencies and to suppress the lower frequencies. Recent developments, however have made it possible to reproduce frequencies well below 100 cycles with practically normal relative intensity.

A general idea of the relatively large amount of power that the output tube must handle in order to reproduce the lower frequencies adequately may be secured by examination of a curve in the paper "An Analysis of the Voice-Frequency Range" by I. B. Crandall and B. MacKenzie, *Bell System Technical Journal*, July, 1922. This curve shows in a striking way that in normal speech the power associated with the low frequencies is enormously greater than that associated with the high frequencies.

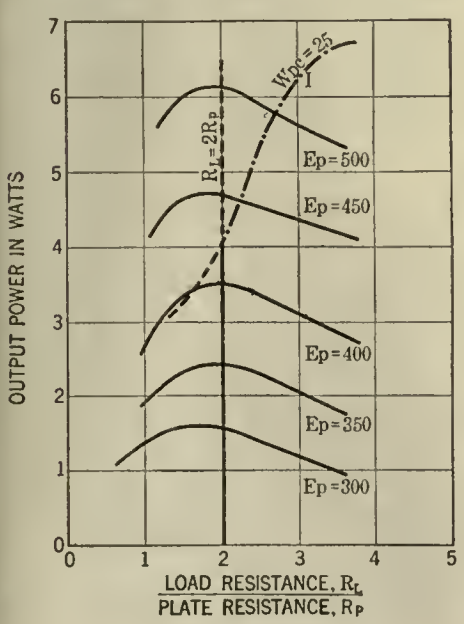


Fig. 1

The same general relation may be observed readily by the use of an oscillograph or a milliammeter inserted in the output circuit of a receiving set. Low notes at intensities which are not particularly striking to the ear are seen to have amplitudes many times greater than those of the higher notes. This effect is evident whether speech, vocal music, or instrumental music is being studied.

A little thought will show that the use of tubes designed for low power output in sets equipped with transformers which pass the low notes will, unless the output of the set be very much reduced, result not only in bad distortion of the low notes, but also in many cases the complete obliteration of the high notes.

Table I shows the power output, grid swing and other characteristics of the tubes which have been developed from time to time in order to meet the growing demand for a larger power output.

Analysis of Various Types

OF THE tubes listed the 199- and 201A-types are general purpose tubes, the others were designed primarily as output tubes. The 112A, however, while distinctly an output tube, has a high amplification constant which makes it useful as a voltage amplifier and detector as well. The 210 also has a fairly high amplification constant which facilitates its operation as an oscillator; but as a power output tube, although the plate voltage is high, the grid swing is only 35 volts and the power output is low compared with that of the 250.

The power output of the 250 is about ninety times as great as the output of the 201A which originally was used as the output tube of most storage-battery-operated sets at the time when the horn-type loud speaker was common.

Most people readily appreciate the advantages of increased volume when it has been demonstrated that this can be obtained without distortion.

With the relatively poor fidelity of reception that was formerly obtained, people having a well-developed sense of musical harmony, generally preferred to use low volume due to their unconscious objection to the distortion at full volume. In many cases it was contended that the music was too loud although it was the distortion accompanying high volume which was the real source of the objection. With the best equipment now available most people, after becoming accustomed to the fact that good volume may be obtained without distortion, prefer to have their sets adjusted for a more normal volume.

Development of the 250

AT THE time work was started on the development of this tube it was decided to limit the plate potential to 450 volts; and in order to keep the physical dimensions within limits that would permit the use of the standard UX base the plate was limited to a size which was estimated to be able to dissipate 25 watts without an unduly high temperature rise; the blackening of the plate makes a larger heat dissipation possible, due to the resulting increase in thermal emissivity. It was further estimated that with one stage of audio-frequency voltage amplification, using equipment now available, a grid swing of 80 volts peak could be obtained.

With these factors fixed as a starting point, several tubes were made up having amplification constants ranging from 2.5 to 8.3.

A set of static characteristic curves was then taken for each tube and from these was calculated the maximum undistorted power output that could be obtained, using in each case the optimum value of load impedance and grid bias. The plate current in all cases was limited to 55 milliamperes, the value corresponding to a heat dissipation of 25 watts. The maximum second-harmonic distortion permitted in these calculations was five per cent., a value which has been assumed generally to be inappreciable in effect on reproduction.

The methods of calculating the maximum power output from a set of static characteristic curves have been described in detail by others ("Design of Non-Distorting Power Amplifiers" by E. W. Kellogg, *Proceedings* A.I.E.E., Feb., 1925, and "Output Characteristics of Amplifier Tubes" by J. C. Warner and A. V. Loughren, *Proceedings* I.R.E., Dec., 1926); a brief outline of the procedure will be sufficient here.

For a moderate plate voltage at which the heat loss at the plate is below the maximum allowable, the best load impedance is equal to twice the tube impedance. That this is true has been shown theoretically by W. J. Brown ("Symposium on Loud Speakers," *Proceedings of London Physical Society, 36*, Part III, April, 1924) and was verified experimentally by Hanna, Sutherlin, and Upp preceding their development of the 250.

An actual determination of the proper load impedance and grid bias for maximum power

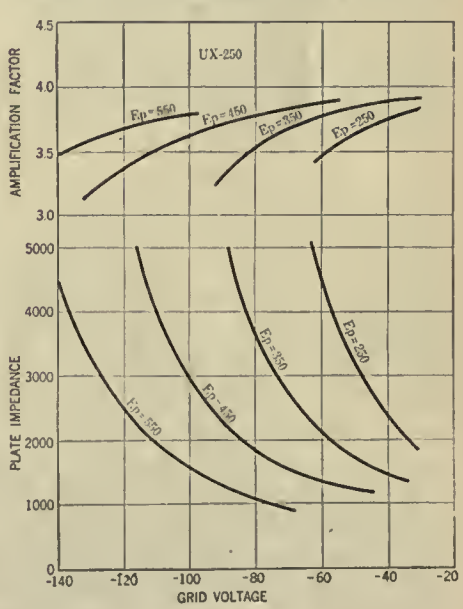


Fig. 2

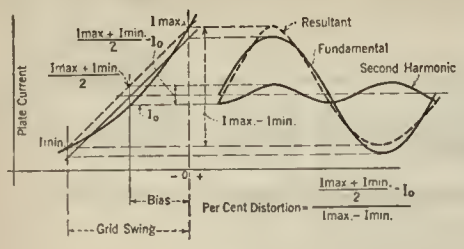


Fig. 3

output at a given plate voltage involves a considerable amount of cutting and trying, due in part to the fact that the tube resistance varies with plate current. The most straightforward procedure is probably that of taking points on the plate-current curves, at the desired plate voltage, corresponding to several values of plate current and determining for each the load impedance that will give the maximum power output without excessive distortion, Fig. 6.

The power output in watts for any dynamic curve is given by:

$$W = \frac{(I\ max - I\ min)\ (E_b\ max - E_b\ min)}{8}$$

The minimum plate current is that where the negative grid swing is equal to the fixed grid bias.

When this nas been done it will be found that the ratio of the load resistance to the plate resistance, R_l/R_p becomes less as the plate current is increased or the grid bias is decreased; and that the maximum power output is obtained at a point where the ratio is equal to approximately two.

If, however, the plate current at this point is greater than the maximum allowable, the output corresponding to the maximum plate current must he used, the load impedance being in this case greater than twice the tube impedance.

Fig. 3 illustrates one step in the procedure, that of determining the second-harmonic distortion due to the curvature of the dynamic characteristic. The formula used is—Distortion equals $\frac{\frac{1}{2}(I\ max + I\ min) - I_o}{I\ max - I\ min}$ and gives the amplitude of the second harmonic component as a decimal of the amplitude of the fundamental.

Fig. 1 shows the relation between the power output ohtainable at various plate voltages and the load impedance. The curve marked $W_{DC} = 25$ shows the limiting values as determined by a plate dissipation of 25 watts. This curve also shows that when the plate current becomes the limiting factor, a load resistance greater than twice the tuhe impedance should be used. For example, at $E_p = 500$ the load resistance should he 2.8.

In Fig. 4 are summarized the results of the work done on the tubes of different amplification constants. Curve 1 shows how the maximum undistorted power output varies with amplification constant, the dotted portion indicating how the output would increase if the plate dissipation were not a limiting condition. Curve 2 shows the corresponding grid swing required in peak volts.

It will he seen that the grid swing required to operate the tube at full output becomes rapidly greater as the amplification constant decreases. Also it will be noted that the power output reaches a maximum and then decreases. Both of these conditions are due to the fact that at low values of amplification constant the grid becomes less effective in controlling the electron llow to the plate. This results is an excessive eurvature of the plate-current characteristic which gives a correspondingly limitcd working range when the maximum distortion permitted is fixed at a low value.

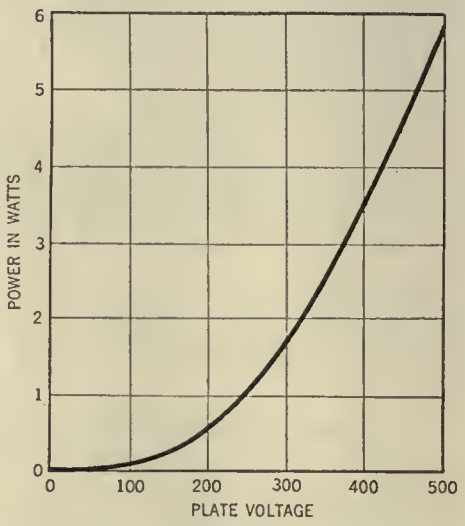


Fig. 5

Table I—Power Output of Various Tubes

TYPE TUBE	Ep	Eg*	MU	Rp	FILAMENT	OUTPUT MILLIWATTS
199	90	−4.5	6.6	15,500	(Thoriated)	7.6
	90	−7.15		18,000	(Tungsten)	17.5
120	135	−22.5	3.3	6600	(Tungsten)	105.
201A	90	−4.5	8.0	11,000	(Tungsten)	14.
	135	−9.0		10,000		55.
112A	180	−13.5	8.0	4700	Coated	275.
171A	135	−27.	3.0	2200	Coated	330.
	180	−40.5		2000		720
210	425	−35.0	7.5	5100	(Thoriated) (Tungsten)	1550
250	350	−58.5	3.8	1900	Coated	2450
250	300	−67.5		1800		3500
250	450	−80.0		1800		4600

**To negative end of filament.*

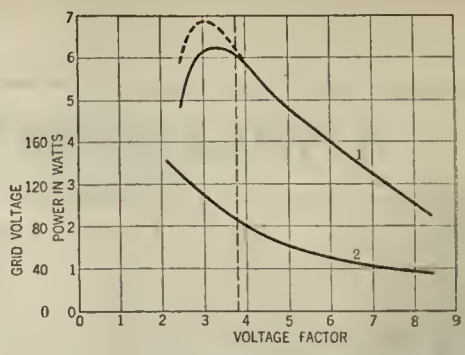


Fig. 4

Fig. 5 shows the relation between maximum undistorted power output and plate voltage. Over a limited range the power output may be taken as proportional to the square of the plate voltage.

Figs. 2 and 7 show the static characteristic curves.

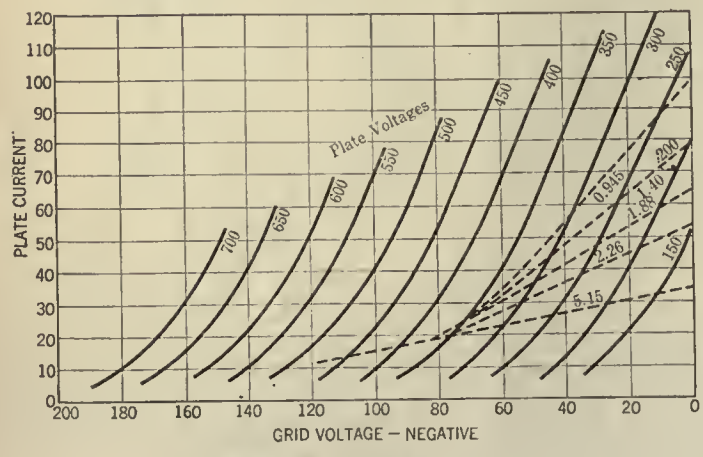
The dotted curves of Fig. 7 correspond to a filament voltage of 7. The maximum undistorted power output is in this case 4.27 watts, a grid swing of 78 volts being required. It will be seen that there is little loss in maximum power output or in sensitivity when the tube is so operated, and it is, in fact, frequently preferable to operate the tube slightly below normal filament voltage in order to protect it from over voltage due to line fluctuations when, as is usually the case, it is operated on alternating current. Careful control of filament voltage will help materially in securing satisfactory operation and long life.

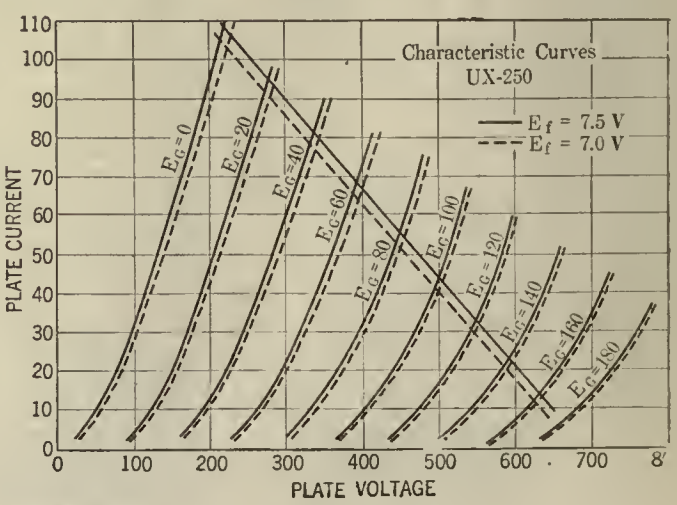
The inter-electrode capacities are: from grid-to-plate 9 mmfd., from grid-to-filament 7 mmfd., and from filament-to-plate 5 mmfd.

Operation of the 250

THE 250, requiring for full power output a grid swing of 80 volts, has been designed to be operated from a detector followed by one stage of audio-frequency amplification.

By the use of a high plate voltage on the detector, and the plate-current method of detection the intermediate stage of audio-frequency amplification may be omitted. This will tend to improve the quality, due to the elimination of one audio transformer, as well as to the improved detector action when plate-current detection is used. This, of course, will require rather high radio-frequency amplification preceding the detector. The power supply for use with an amplifier employing a 250-type output tube should use two 281-type half-wave rectifier tubes in a full-wave circuit.





Above: Fig. 6 Right: Fig. 7

IN THE RADIO MARKETPLACE

News, Useful Data, and Information on the Offerings of the Manufacturer

Two New Tubes

AT LEAST two new tubes will be released during 1929; one is a new power tube which will (according to information given by Philco to their jobbers, at a recent meeting in Philadelphia which we attended) be made available sometime during the first quarter of the year and the other is an a.c. screen-grid tube which will be released sometime during the second quarter. Probably one or both of these tubes will be used in some of the sets that manufacturers will bring out in the fall. Further data regarding these two tubes will be found on page 300 in "Strays from the Laboratory."

Freshman Price Reduction

ON JANUARY 17, the Chas. Freshman Company announced a price reduction on all cabinet models of the Freshman line. The new list prices of the various models are as follows: Q-16, $99. QD-16, $129. N-12, $149. N-17 $195. These prices do not include tubes.

How to Sell Battery Sets

SALES suggestions of wide use to those interested in the market for battery-operated receivers have been made by the National Carbon Company, makers of batteries and receiving sets. A survey made under their direction developed the fact that there are more than 10,000,000 homes in the United States that are not wired for electricity and cannot use a.c. sets. Of this astounding number, very few are not potential customers for radio sets.

Many dealers have allowed this large market to escape their notice because of the justified popularity of the a.c. set. The National Carbon Company have formulated a plan to help dealers sell this large market. The principal points in their plan are:

1. The dealer is asked to ascertain from his local chamber of commerce, bank, or other authority, the approximate limits of his trading area.
2. He is asked next to consult either the United States census or county maps for the approximate population of his trading area.
3. Dealer then divides this total population by 4.3, which will give him the approximate number of families. This will be the total potential market for both a.c. and battery-operated sets.
4. Following that, he ascertains from his electric light and power company how many of these homes are wired. (This is, the number of residential meters in his area.)
5. Dealer subtracts the number of wired homes from the total number of families and he has the approximate number of homes which cannot use a.c. radio sets. This represents his market for the modern battery-operated set.

It is suggested that dealers order their stock of a.c. and battery-operated sets accordingly.

Some interesting information turned up as a result of the survey. Washington, D. C., is regarded as one of the most urban communities in the country. A large part of the District of Columbia is built up as a city. Yet there are no fewer than 28,300 homes in the District unwired for electricity and potential markets for battery sets. Ohio has 342,000 unwired homes; Kentucky 418,700; Pennsylvania 852,500; North Carolina 514,900. The total for the entire United States is 10,559,510. In many states it is estimated that the battery market is 70 per cent. of the total.

In this section of RADIO BROADCAST *is grouped a great deal of information of value to the dealer and serviceman, to the professional set-builder, and to the many others who find themselves doing one thing or another in the radio industry. This month we present a compact but complete report on a popular receiver for home and custom set-building, tabulated data in an interesting and useful form for the dealer and serviceman and a great deal of other carefully selected miscellaneous information of definite interest. A careful reading of these pages will help you to keep abreast of what is going on.*

—THE EDITOR.

Roger Wise With Majestic

ROGER M. WISE, for many years chief engineer of E. T. Cunningham, Inc., has left that organization and joined the Grigsby-Grunow Company of Chicago, manufacturers of Majestic radio sets and loud speakers. A tube manufacturing division, it is said, will be added to the other manufacturing activities of Grigsby-Grunow.

New Receivers Announced by Fada

RECENTLY Fada announced several new receivers containing such features as push-pull amplification and dynamic loud speakers in the console models. The new Fada 16 is an eight-tube set using five 227-type tubes, two 171A-type tubes, and a 280-type rectifier tube. The circuit consists of three stages of tuned r.f., detector and two-stage audio amplifier, the last stage being push-pull. Fada 32 uses the same circuit and tubes as the 16, but differs in the fact that it is housed in a console with a built-in dynamic loud speaker. The Fada 18 is a d.c.-operated set designed to fulfil the needs of those living in districts supplied with direct current. This set uses five 112A tubes and two 171A tubes in a circuit similar to the model 16. Other items in the Fada line are the model 72 radio-phonograph combination, the model 4 magnetic speaker, the models 14 and 15 dynamic loud speakers.



The eight-tube Philco console model receiver—one of their new line

Federal Series-Filament Sets

THE models F-10 and F-11 Federal Orthosonic receivers are designed for either a.c. or d.c. operation and they use ordinary ¼-ampere tubes in a series-filament circuit, all the necessary A, B, and C potentials being supplied by a Raytheon BA-type rectifier. The four r.f. stages and the first audio stage employ 201A-type tubes. The detector is a 112A-type tube and the power stage uses a 171A-type tube. The order of the tubes in the series-filament arrangement is first r.f., second r.f., third r.f., fourth r.f., detector, and finally second a.f. The set is completely shielded and carefully neutralized. If the set is to be supplied from d.c., i.e., a storage battery and a B-power unit, it is simply necessary that the tube filaments be connected in parallel instead of in series.

New Philco Console Receiver

THE New Philco line for 1929 features a console set selling at the low price of $157. The set is entirely a.c. operated and contains eight tubes including a rectifier. Into the console is built a dynamic-type loud speaker. There are two other models in this line, the Highboy selling for $275, without tubes, and the Lowboy selling for $215. All of these sets use the same circuit, consisting of a neutralized tuned r.f. amplifier followed by a two-stage audio amplifier with push-pull in the output. The Philco Company feel that these sets will require a minimum of servicing but have nevertheless arranged the design of the set so that all connections may be reached easily so that any servicing which may be necessary can be done quickly and efficiently.

Polymet to Make Coils

THE Polymet Manufacturing Company of New York has announced the purchase of the Coilton Electric Manufacturing Company of Easton, Pa. Polymet is now in a position to supply filter blocks, condensers and resistances, and, with these added facilities, coils for power transformer, audio transformers, moving-coil loud speakers, power packs, etc., are being manufactured.

Jensen Auditorium Loud Speaker

AN auditorium-type dynamic loud speaker is being manufactured by the Jensen Radio Manufacturing Company. This loud speaker will be made in three models differing only in the method of field excitation. The a.c. model will have a field coil with a resistance of 2250 ohms and it will consume a current of 90 mA. at a potential of approximately



The new Majestic model 71 is a completely shielded seven-tube receiver. The cabinet is of "post-colonial" design and the built-in loud speaker is a dynamic type

200 volts; the field current will be supplied by a full-wave rectifier system using the 280-type rectifier tube. The 220 d.c. model has the same field as the a.c. model but it is intended that the field will be supplied from 220-volt d.c. service mains—in this model a transformer and rectifier are of course unnecessary. The type 110 d.c. model is to be supplied from 110-volt d.c. mains. The field resistance is about 600 ohms and the field current, therefore, is about 180 mA. It should be noted that the power consumed by the field in each case is about 20 watts. The cone has a diameter of 12 inches.

A Super-heterodyne Kit Set—The Tyrman "80"

ALL radio receivers in use to-day fall into one of two broad classes, that group in which the signal is amplified at the frequency at which it is received and a second group in which the signal is amplified at some frequency other than that at which it is received. In the first class are the tuned r.f. sets and in the second class fall all the superheterodyne sets. Fancy names have been attached to individual makes of receivers in both classes, but in principle and general design they remain essentially the same.

Here we describe a super-heterodyne that has been designed to utilize to best advantage the fundamental characteristics of this type of circuit, and secondly, which has been designed to take full advantage of the a.c. screen-grid tube to obtain the greatest sensitivity consistent with satisfactory selectivity and fidelity.

The Tyrman Imperial "80" employs a first detector, oscillator, and three stages of intermediate-frequency amplification using a.c. screen-grid tubes and operating at a frequency of 480 kc. The i.f. amplifier is followed by the second detector and a two-stage transformer-coupled a.f. amplifier. The power tube is a type 250 which is part of the B supply. Interchangeable coils are provided so that the set may be used for both broadcast and short-wave reception.

In the design of the i.f. amplifier a very complete set-up of laboratory instruments and equipment was necessary to measure accurately the efficiency of the a.c. screen-grid tubes at frequencies of about 500 kilocycles. The efficiency of the screen-grid tube operating as an impedance-coupled amplifier was the basis of comparison as to gain per stage while the characteristics of a band-pass filter was the goal for selectivity.

The actual gain of an impedance-coupled screen-grid amplifier is in the order of 36—a satisfactory figure—but the width of the bottom of the curve is too broad for good selectivity.

In order to obtain the maximum efficiency from a screen-grid tube it was found necessary to tune the plate circuit with a low-loss coil and condenser combination. An interesting thing was noticed with regard to the relative amplification obtainable from a screen-grid tube with various LC ratios. A one-inch diameter coil form was used with a variable condenser. The first measurements were made with approximately .0005 mfd. of capacity tuning the one-inch diameter coil. Only enough turns of wire were used to have sufficient inductance to tune to 500 kilocycles.

With a coil of 140 turns of No. 30 enamel wire on a one-inch diameter form tuned with .0005-mfd. capacity, a gain per stage of only fifteen was obtained. A coil of 325 turns of No. 34 enamel wire was tuned with a few micromicrofarads to the same frequency and a gain of thirty-six to forty was obtained. This data was the basis of all further work on Tyrman intermediates.

Finally experimental work was begun upon tuned primary and secondary circuits. The first results were discouraging because of the general characteristics of coupled tuned circuits which produce double-peaked curves. This led to the measurement of loosely coupled tuned circuits. It was found that by just barely coupling the two circuits a result as shown in the curve insert (A) of Fig. 1. could be obtained. Then by carefully designing the LC ratio of both the primary and secondary circuits an actual amplification in the order of twenty-five to thirty per stage was possible.

To improve the selectivity of the first-detector circuit regeneration was employed. Some of the r.f. currents in the plate circuit of the first detector were fed back to the lower end of the antenna coil by a small semi-fixed condenser, C_1, which is adjustable from the top of the set by a screw driver. Once set it should not be necessary to readjust it unless antenna or tubes are changed.

BIASING RESISTOR

In designing the rest of the circuit, provision was made for obtaining grid-bias voltage for

The Radio Dealer's Note Book—No. 1 Interference Filters

ACCURATE summaries of useful information are constantly of value to those radio folk who deal with the public. This sheet, the first of many such on various subjects to follow, sets down collected information on interference-prevention devices. The dealer or serviceman can remove this part of the page for his notebook or he can have it photostated in any number of copies.

The electrical noises from oil burners, battery chargers, heating pads, sign flashers, vacuum cleaners, dental motors, electric thermostats, sparking brushes on motors, etc., can be amplified and detected by a modern sensitive radio receiver almost as well as it can amplify and detect the signals from broadcasting stations. The latter is a desirable program, the former is certainly undesirable. As receivers have become more sensitive the problem of eliminating interference due to electrical appliances has become a pressing question of constantly increasing importance.

If general electrical interference cannot be eliminated by attaching some gadget to the receiver—the interference must be eliminated at the *source*. Fortunately, however, there are now available a large variety of devices designed for use at the source of interference and their installation is a simple problem.

We have listed in the table all the interference devices on which we have data available at this time. From the table some idea of the wide variety of devices available can be obtained but it is not possible here to point out the many uses to which they can be put, or the manner in which some of the manufacturers have arranged the devices so that they can be installed easily and quickly.

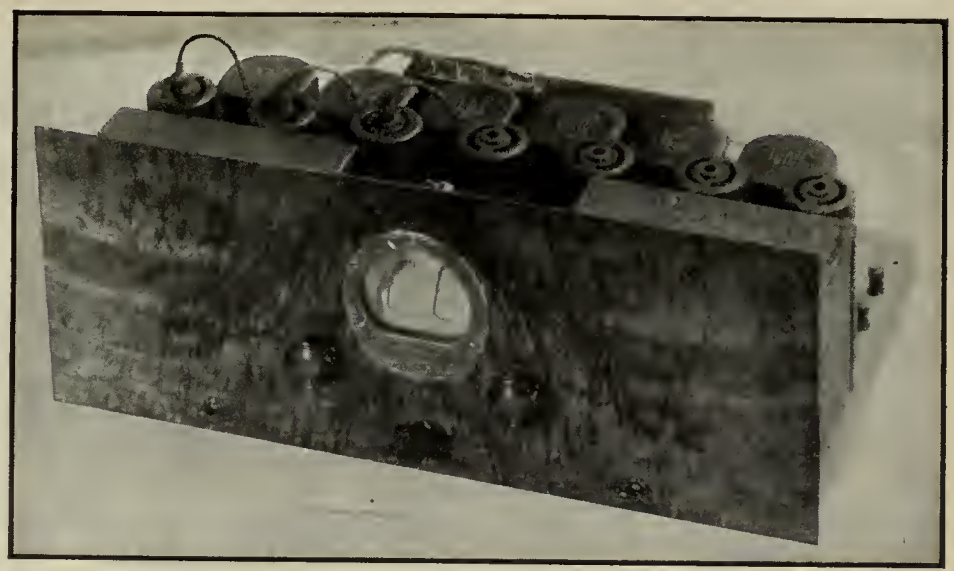
The problem of installing interference preventors is the job of the dealer and serviceman and data on these devices should be in the hands of all those who do servicing. As a service to readers, the Editors have arranged that servicemen may receive complete information on all the devices listed in the table by simply writing to the Service Department of RADIO BROADCAST and requesting the data on interference devices. We would suggest that in all cases a card or letterhead be enclosed with the request to identify the writer as a serviceman or dealer.

Manufacturer	Type No.	Price	Line Voltage*	Wattage Rating
Potter Mfg. Co	103-03	$ 2.25	110	
	104-04	3.00	110	
	105-05	3.75	110	
	303-03	3.00	220	
	304-04	3.50	220	
	305-05	6.50	220	
Dubilier Condenser Corp.	1	5.00	220	
	2	7.50	220	
Tobe Deutschmann Co.	Junior	3.50	110	500
	11	10.00	110	1000
	22	15.00	220	2000
	23		220 3 phase	2000
	55	20.00	550	
	56	25.00	550 3 phase	
	60	20.00	600 d.c.	
	110	15.00	110	400
	131	20.00	110	1000
	132	25.00	110	2000
	133	30.00	110	3000
	134	35.00	110	4000
	135	40.00	110	5000
	221	20.00	220	1000
Dongan Electric Mfg. Co.	D-207	7.50	110	
	D-215	5.00	110	
Aerovox Wireless Corp.	IN-24	6.50	125	
	IN-44	9.00	220	
Therm-A-Trol Mfg. Co.		3.00	110	
Advance Electric Co.	Clarostat	7.50	110	

*Line voltages are a.c. unless otherwise specified.

each tube. The use of heater-type tubes permitted the employment of individual grid-bias resistors which were connected between the cathodes and ground.

The volume control had to be independent of frequency and should not detune the set or spoil fidelity. The best place for such a control is before the second detector and by experiment it was decided the best method was to increase the grid bias on two of the screen-grid tubes by varying the biasing resistor, R_1, connected between the cathode and ground. This resistor had to be so designed as to be able to give a small amount of bias at its minimum-resistance position and the value of resistance had to increase at a uniform rate until maximum resistance was attained in order to get sufficient grid bias at minimum-volume position or maximum-resistance position. It was found that when the grid bias upon a 222-type or screen-grid tube was 1½ volts the amplification was greatest, and, as the grid bias was further increased or decreased, the amplification began to decrease. The volume control was, therefore, designed to have a value of minimum resistance which kept the grid bias on the two intermediate-frequency screen-grid tubes at about 1½ volts—the best value.



Front view of the Tyrman Imperial "80" receiver

THE AUDIO SYSTEM

The audio of the Tyrman "80' was designed especially for the 227-type tube and the frequency characteristic of the audio amplifier is sufficiently wide to give the utmost in fidelity in conjunction with the 250 power amplifier and a good loud speaker.

Bypass condensers are an essential part of the Tyrman "80." It was found necessary to bypass individually each of the bias resistors. This tended to eliminate the possibility of coupling through a common grid circuit. A filter block consisting of six 1-mfd. condensers is provided for bypassing the 150- and 50-volt B supplies and for bypassing the audio circuit.

It was found necessary to incorporate a special filter, consisting of a resistance and a capacity, in the first audio circuit. Without this filter it was found that at times instantaneous huge drains imposed upon the power pack by the 250 tube (due to overloading) caused plate modulation of the detector circuit and resulted in "motorboating."

POWER PACK

The power pack for the Tyrman "80" was designed with three ideas in mind, first, low hum, secondly, plenty of available output, thirdly reliability. The power pack has a transformer which can be overloaded one-hundred per cent. without causing serious trouble. Normally, it operates at a temperature far below the normal temperature at which transformers of this type are usually operated. The voltages delivered by the secondaries are such that line voltage can vary from 100 to 130 without causing trouble with the set or the tubes. The filament or heater potential is set at 2.1 volts and, although the tubes will operate at 1.9 volts and also at 2.3 volts, this point was found to be the most desirable for average conditions.

In order to obtain the amount of current necessary for good regulation and for operating the dynamic-speaker field directly from the power pack, it was necessary to use two 281-type rectifying tubes but this was more than compensated in the increased reliability of the power pack. The Tyrman "80" power pack can be used to energize any 100-volt dynamic-speaker field which does not require more than 45 milliamperes.

The mechanical or chassis design of the Tyrman "80" makes it a pleasure to wire the set because no wiring is necessary above the subpanel. The fact that all of the grid circuits are returned directly to ground eliminates a great number of wires in the set and also prevents the possibility of interstage feed-back due to parallel wiring.

The parts for this receiver are sold only in kit form by the Tyrman Electric Company. The total cost of a complete set of parts for the receiver and power supply is $199.50.

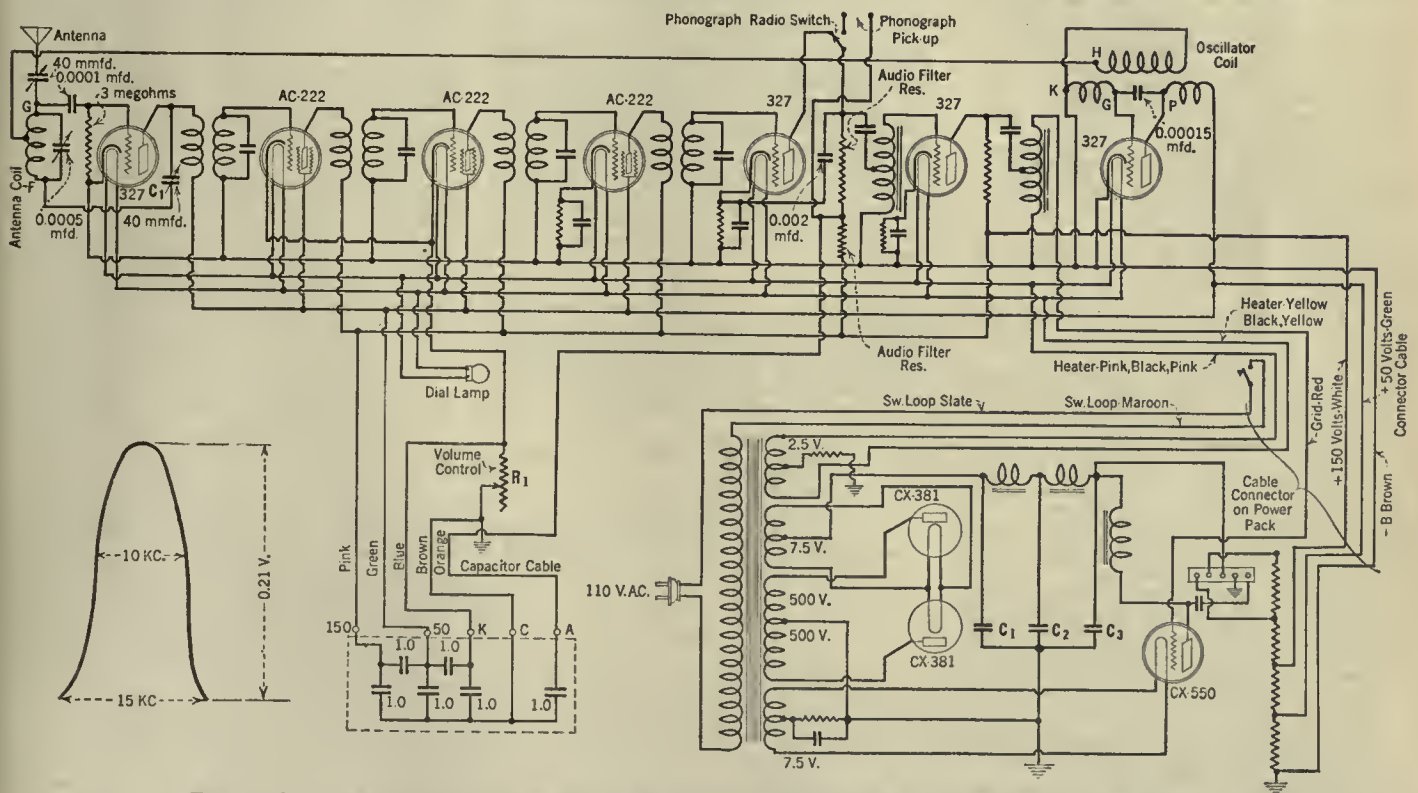


Fig. 1—Complete schematic diagram of the Tyrman Imperial "80" super-heterodyne receiver. Insert A: frequency characteristic of i.f. amplifier stage.

MANUFACTURERS' BOOKLETS

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

1. Filament Control—Problems of filament supply, voltage regulation, effect on various circuits, and circuit diagrams of popular kits. Radiall Company.

5. Carborundum in Radio—Pertinent data on crystal detectors with hook-ups, and information on the use of resistors. The Carborundum Company.

12. Distortion and What Causes It—Hook-ups of resistance-coupled amplifiers with standard circuits. Allen-Bradley Company.

17. Bakelite—A description of various uses of bakelite in radio, its manufacture, and its properties. Bakelite Corporation

22. A Primer of Electricity—Fundamentals of electricity with reference to the application of dry cells to radio. Constructional data on buzzers, automatic switches, alarms, etc. National Carbon Company.

23. Automatic Relay Connections—A data sheet showing how a relay may be used to control A and B circuits. Yaxley Manufacturing Company.

30. Tube Characteristics—A data sheet giving constants of tubes. C. E. Manufacturing Company

32. Meters for Radio—A book of meters used in radio, with diagrams. Burton-Rogers Company.

33. Switchboard and Portable Meters—A booklet giving dimensions, specifications, and shunts used with various meters. Burton-Rogers Company.

37. Why Radio is Better with Battery Power—What dry-cell battery to use; their application to radio, wiring diagrams. National Carbon Company.

46. Audio-Frequency Chokes—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. Samson Electric Company.

47. Radio-Frequency Chokes—Circuit diagrams illustrating the use of chokes to keep out r. f. currents from definite points. Samson Electric Company.

48. Transformer and Impedance Data—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use. Samson Electric Company.

53. Tube Reactivator—Information on the care of vacuum tubes, with notes on reactivation. The Sterling Manufacturing Company.

56. Variable Condensers—A bulletin giving an analysis of various condensers together with their characteristics. General Radio Company.

57. Filter Data—Facts about the filtering of d. c. supplied by means of motor-generator outfits used with transmitters. Electric Specialty Company.

58. How to Select a Receiver—A common-sense booklet describing what a radio set is, and what you should expect from it, in language that anyone can understand. Day-Fan Electric Company.

67. Weather for Radio—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. Taylor Instrument Companies.

69. Vacuum Tubes—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit; list of American and Canadian broadcast stations. Radio Corporation of America.

72. Plate Supply Systems. Technical information on audio and power systems. Bulletins dealing with two-stage transformer amplifier systems, two-stage push-pull, three-stage push-pull, parallel push-pull, and other audio amplifier, plate, and filament supply systems. American Transformer Company.

73. Radio Simplifier—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. Crosley Radio Corporation.

76. Radio Instruments—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. Jewell Electrical Instrument Company.

78. Electrical Troubles—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. Burton Rogers Company.

81. Better Tuning—A booklet giving much general information on radio reception with specific illustrations. Primarily for non-technical set-builders. Bremer-Tully Manufacturing Company.

88. Super-Heterodyne Construction—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. The George W. Walker Company.

89. Short-Wave Transmitting Equipment. Data and wiring diagrams on construction of all popular short-wave transmitters, operating instructions, keying, antennas; information and wiring diagrams on receiving apparatus; data on variety of apparatus used in high-frequency work. Radio Engineering Laboratories.

90. Impedance Amplification—The theory and practice of a special type of dual-impedance audio amplification. Alden Manufacturing Company.

95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. International Resistance Company.

98. Copper Shielding—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. The Copper and Brass Research Association.

99. Radio Convenience Outlets—A folder giving diagrams and specifications for installing loud speakers in various locations at some distance from the receiving set, also antenna, ground and battery connections. Yaxley Manufacturing Company.

101. Using Chokes—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. Samson Electric Company.

102. Radio Power Bulletins—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the B11 or B rectifier tubes. Raytheon Manufacturing Company.

104. Oscillation Control with the "Phasatrol"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. Electran, Incorporated.

Two Books of Interest to Readers of Radio Broadcast

Radio Broadcast Laboratory Information Sheets (*Nos. 1-190*)

How Radio Receivers Work

By Walter Van B. Roberts

Ask any newsdealer for *Radia Broadcast Data Sheets* or both books may be obtained by writing to Radio Broadcast, Garden City, N. Y.

Price $1.00 each

105. Receiving and Transmitting Circuits. Construction booklet with data on 25 receivers and transmitters together with discussion of low losses in receiver tuning circuits. Aero Products Company.

108. Vacuum Tubes—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. Arcturus Radio Tube Company.

112. Heavy-Duty Resistors—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. Warn Leonard Electric Company.

113. Cone Loud Speakers—Technical and practical information on electro-dynamic and permanent-magnet type cone loud speakers. The Magnavox Company.

114. Tube Adapters—Concise information concerning simplified methods of including various power tubes in existing receivers. Alden Manufacturing Company.

115. What Set Shall I Build?—Descriptive matter, with illustrations, of fourteen popular receivers for the set-builder. Herbert H. Frost, Incorporated.

118. Radio Instruments, Circular "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. Weston Electrical Instrument Corporation.

In sending the coupon below, make sure that your name and address are included and are plainly written. Also make sure that the listing of booklets from which you choose is that of the latest issue of the magazine, as Radio Broadcast cannot guarantee the delivery of booklets not listed in its current issue.

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120. The Research Worker—A monthly bulletin of interest to the engineer and home builder. Each issue contains special articles on radio design and construction with special emphasis on resistors and condensers. Aerovox Wireless Corporation.

123. B Supply Devices—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. Electran, Inc.

124. Power Amplifier and B Supply—A booklet giving several circuit arrangements and constructional information and a combined B supply and push-pull audio amplifier, the latter using 210-type tubes. Thordarson Electric Mfg. Co.

125. A. C. Tube Operation—A small but complete booklet describing a method of filament supply for a.c. tubes. Thordarson Electric Mfg. Co.

126. Micrometric Resistance—How to use resistances for: sensitivity control; oscillation control; volume control; regeneration control; tone control; detector plate voltage control; resistance and impedance coupling; loud speaker control, etc. Clarostat Mfg. Co.

129. Tone—Some model audio hook-ups, with an explanation of the proper use of transformers and chokes. Sangamo Electric Co.

130. Screen-Grid Audio Amplification—Diagrams and constructional details for remodeling old audio amplifiers for operation with screen-grid tubes. Thordarson Electric Mfg. Co.

131. The Mershon Condenser—An illustrated booklet giving the theory and uses of the electrolytic condenser. Amrad Corporation.

132. The National Screen-Grid Short-Wave Receiver—Constructional and operating data, with diagrams and photographs. James Millen.

133. The National Shield-Grid Five—A circuit diagram with constructional and operating notes on this receiver. James Millen.

134. Remler Service Bulletins—A regular service for professional set-builders, giving constructional data, and hints on marketing. Gray & Danielson Mfg. Co.

135. The Radiobuilder—A periodic bulletin giving advance information, constructional and operating data on S-M products. Silver-Marshall, Inc.

136. Silver Marshall Data Sheets—These data sheets cover all problems of construction and operation on Silver-Marshall products. Silver-Marshall, Inc.

139. Power Unit Design—Periodical data sheets on power unit problems, design, and construction. Raytheon Mfg. Co.

140. Power Unit Problems—Resistance problems in power units, with informative tables and circuit diagrams. Electran, Inc.

141. Audio and Power Units—Illustrated descriptions of power amplifiers and power supplies, with circuit diagrams. Thordarson Electric Mfg. Co.

142. Use of Volume and Voltage Controls. A complete booklet with data on useful apparatus and circuits for application in receiving, power, amateur transmitter, and phonograph pick-up circuits. Central Radio Laboratories.

143. Radio Theory. Simplified explanation of radio phenomena with reference to the vacuum tube, and data on various tubes. deForest Radio Company.

144. Low Filament Voltage A. C. Tubes. Data on characteristics, and operation of four types of a.c. tubes. Arcturus Radio Tube Company.

145. Audio Units. Circuits and data on transformers and impedances for use in audio amplifier plate and output impedances and special apparatus for use with dynamic speakers. Sangamo Electric Company.

146. Receiver Circuit Data. Circuits for using resistances in receivers, and in power units with descriptions of other apparatus. H. H. Frost, Inc.

147. Super-Heterodyne Construction. Construction and operation of a nine-tube screen-grid superheterodyne. Set Builders' Supply Company.

151. The Secret of the Super. Constructional and operation data on the Lincoln 8-80 One-Spot Super. Lincoln Radio Corporation.

152. Power Supply Essentials. Circuits and data on power-supply devices, and descriptions of power apparatus. Polymet Manufacturing Company.

153. The Everready Fidelity Curve. An analysis of the frequency range of musical instruments and the human voice which shows how these tones are reproduced by a receiver with an audio range of 60 to 5000 cycles. National Carbon Company.

154. Amplifier and Power Supply Construction Manual. A booklet giving descriptions, circuit diagrams, and lists of parts of several popular amplifier and power supply circuits. Acme Wire Company.

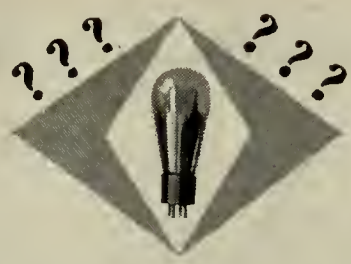
155. The Custom Set-Builder—A four-page monthly bulletin containing information of interest to servicemen and custom set-builders. Clark and Tilson, Inc.

156. Photo-Electric Cells—A booklet describing the applications, theory and characteristics of photo-electric cells. The G-M Laboratories, Inc.

157. Uses of Electrical Meters—Set of blueprints showing correct use of meters in laboratory and testing circuits. Weston Electrical Instrument Corporation.

158. The Truvolt Divider. A circular describing ten popular power-pack circuits. Circuits, lists of parts, and pictures are also included. Electrad, Inc.

159. Radio Course of Instruction. A series of five lessons designed to teach boys the principles of radio design and construction. Junior Radio Guild.

WHAT IS A  GOOD TUBE

THREE years ago a series of articles was published in RADIO BROADCAST as a result of a serious investigation of the characteristics of the radio vacuum tubes then on the market. Nearly one hundred tube manufacturers sent samples of their products to the Laboratory to be tested. Many of these manufacturers have since demonstrated the fact that they had no business in the tube market —their names are forgotten. At that time, radio listeners and dealers did not have the means of finding out the characteristics of the tubes, and probably knew little about what the characteristics meant if they had been able to obtain them. No one knew how long a tube was supposed to last, least of all the ultimate user. Then the market for radio receivers was rising rapidly, but was still small. And so the data collected in the Laboratory and published in this magazine not only gave the possible users an idea of how to judge good tubes, but how to use them intelligently, and—if they desired—simple methods of measuring their characteristics as well.

To-day the picture is different. There are perhaps a dozen reputable manufacturers of tubes for receivers and power apparatus—and yet the market for tubes has increased to a degree never dreamed of by the forefathers of radio. The tubes made by these manufacturers are more uniform in their characteristics, have longer lives, and look and act more like their brothers from other factories. The tube business is "shaking down;" it is becoming more a matter of engineering and less of cut-and-try. The names of tube manufacturers we still see on tube cartons are the names of people who have learned by experience how to make a good tube.

Now the question is, "*What is a good tube?*"

The data presented in the following pages is an attempt to answer that question. It is presented for the benefit of radio dealers and servicemen whose responsibility to the users of tubes is great. These men are in intimate contact with radio listeners and must daily answer the question, "What tube do you recommend?" The data should be interesting to the ultimate user of the tube too, for he ought to know what to expect and when his expectations have or have not been realized. The more the serviceman-dealer knows about the tubes he sells, the better he can satisfy the demands of the user who wants long life more than he wants a cheap price.

The data are in a form so that they can be clipped from the magazine and filed in a note book. We suggest each sheet be mounted on a heavier sheet in the notebook. This information represents the latest obtainable data on the best-known tube manufacturers and until something startling occurs in the tube business, something entirely unforeseen, the data presented here will be representative of what these better known manufacturers are building into their tubes.

Answering the question "What is a good tube" involves two factors, the electrical characteristics of the tube and the factor of economics. How long will the tube last?

The characteristics of general- and special-purpose tubes have undergone no radical changes in a year or more. Whether or not this is fortunate, we are not prepared to state. It is true that every reputable manufacturer who is interested in his future is doing his best to build good tubes, tubes whose characteristics are good when the user purchases them, and good for a long time afterward. The uniformity in the characteristics, as shown by comparing the data in the following pages, was not true three years ago. Then there was a wide disparity between the characteristics of one tube as compared with a similar type made in another plant. Now a 201A-type tube is a 201A-type tube no matter who makes it.

Standard Tube Types are Similar

DIFFERENCES among the products of the tube manufacturers are differences of construction, differences of material, differences of packing for shipment, etc. The electrical characteristics are much the same no matter what the name of the tube. But the differences in mechanical construction, in pumping, and in the choice of materials used are the differences that determine life, the second criterion by which one may judge a good tube.

The first factor, the electrical characteristics of tubes, involves the manufacturer alone. The second involves both the manufacturer and the user. The best of tubes will blow up if the proper wires of the receiver are crossed, or if a screw driver in the experimenter's or engineer's laboratory or in the serviceman's shop falls into the power supply by accident. The best tube will have short life if its filament or plate is overloaded with voltage. The electrons which make the radio wheels go round are tireless workers, but their supply is limited. The best tube will suffer with fatigue if it is forced to work under conditions for which it was not designed.

Generally speaking, tubes from one of the manufacturers represented in the following pages should last as long as from any other, and, although there may have been a time when manufacturers deplored the fact that their tubes lasted too long, it is true now that every manufacturer must make his tubes as good as is possible. Competition takes care of that.

And yet all the responsibility for long tube life does not rest with the manufacturer. The serviceman who recommends the tube, the dealer who sells it, and the user who employs it must share this responsibility. The dealer-serviceman's share is particularly great for it is he who knows whether or not the set-owner is operating the tubes of his set at voltages recommended by the manufacturer. It is he who must tell the user not to raise the filament and plate voltages until the last "ounce" of signal strength or "DX" is extracted from his radio.

Importance of Correct Voltage

A TUBE manufacturer is much more familiar with his product than anyone else can be, and when the tube manufacturer sets the voltage limits which his tubes can stand, the user has no right to assume a new set ratings for himself and to expect the manufacturer to replace tubes which seem to have premature failure of emission. In other words, if the correct filament or heater voltage of a certain tube is 2.5 volts, the experimenter should not use 3.0 volts nor should he use 2.0 volts and expect long healthy tube life.

Let us consider the case of a power tube, a full-wave filament rectifier, for example. It seems natural to suppose that it will last much longer if we don't overload the filament and such is true. But let us reduce the voltage across the filament, burn it at a lower temperature, and see what happens. All tubes lose emission as they get old. Rectifier tubes have a certain lower emission limit beyond which they cannot hope to keep up with the drain of electrons imposed not only by the receiver, but by the filter and voltage divider as well. Once the tube emission falls below this figure, the voltages supplied to a receiver begin to fall, a.c. hum begins to come up—because the wave-form of the rectified current is no longer halves of sine waves, but has a flat-topped form, hard to filter—and the regulation goes bad because of the increase in effective resistance of the rectifier and hence of the plate-voltage supply system.

When such a tube is operated below its rated temperature the supply of electrons is not as great as when the temperature is raised. This means that the useful life of the tube is decreased, because the lower limit in emission is reached sooner. The tube is still good, and probably would continue to supply plenty of voltage if its temperature were increased—but the only safe and economical method is to supply the heating voltage that the tube needs throughout its life.

How can the user tell a good tube from a bad one? He must first of all buy a tube whose name is known to him. It is safe to state that a purchaser of tubes gets exactly what he pays for, and if he wants freedom from replacement worries, he should purchase a tube whose name is one he is sure of, one that is nationally advertised and sold, and backed by a manufacturer who has a reputation for making good products out of glass, nickel, and electrons.

A purchaser cannot tell by looking at a tube whether it is good or not. He must rely either on the tube maker's reputation or upon the advice of his dealer or serviceman. It is certain that the latter must not trick the former into buying "just as good" products on the supposition that they can get away with it. A dealer who has a monopoly on the radio sales in his community might sell the tubes that cost the least and had the shortest life, but he could be sure that someone would soon furnish his customers with better tubes—even at a higher price, and that his short-sighted policy would get its merited result.

There is a practice in "gyp town" of showing a prospective customer how good a tube is by stepping on a foot switch which boosts the plate voltage while the tube is being tested. Of course, the plate current will be high, and the customer thinks is he receiving a high-emission product. The chances are he is getting somebody's shrinkage.

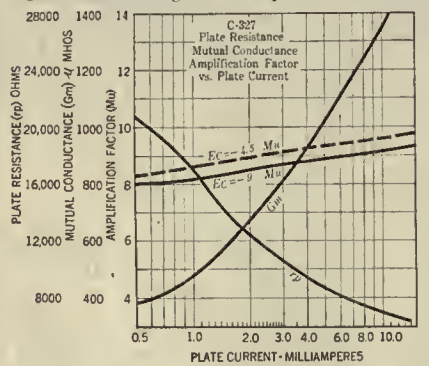
The answer is to buy tubes from well-known dealers, who safeguard their customers as well as themselves. If tubes get weak, as indicated on a reputable dealer's or service organization's tester, within a short time, look at the name. In the majority of cases it is one you never heard of.

From the dealer's standpoint, the rules for successful tube sales are but three—1. Sell only well-known tubes, 2. Insist that your serviceman install these tubes so that the voltage will be correct, 3. Make sure that the purchaser operates the tubes according to the conditions the manufacturer recommends.

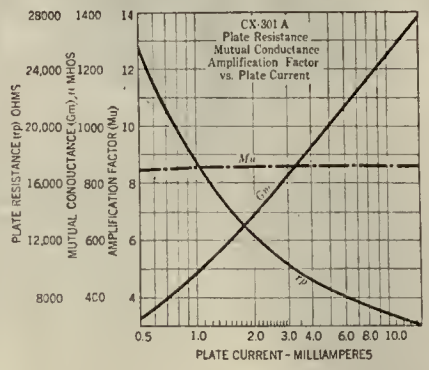
From the user's standpoint, there are three rules, 1. Buy a well-known tube, 2. Buy it from a well-known dealer, 3. Operate the tube at correct voltages.

THE complete chart of average characteristics of Cunningham Radio Tubes shown below has been arranged for convenient reference. In the section under the heading "Amplification" is a tabulation of the resistor values required to furnish the C voltage, or grid bias, when this voltage is obtained from the plate voltage source. The resistor values required when the filament is operated from d.c. differ from those required when the resistor is connected to the mid-tap of the filament winding or potentiometer used with a.c. operation, being higher in the latter case. When the plate current of more than one tube flows through the same resistor a lower value must be chosen. The values shown for a.c. operation are the proper ones to use when a single tube is operated from a filament winding, so that the plate current for that tube alone flows through the resistor.

The difference in grid bias required for d.c. and



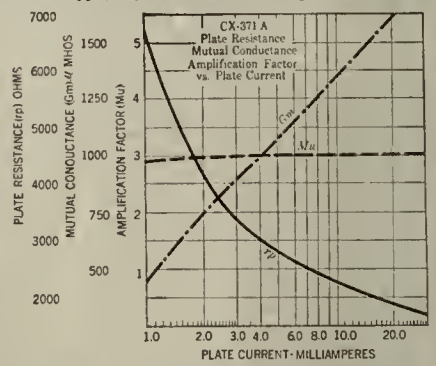
a.c. operation arises from the fact that with battery operation the plus C is returned to minus A, while with a.c. operation the plus C is returned to the filament mid-tap, so that the actual voltage on the grid is reduced to the extent of one-half of the drop across the filament (the filament voltage). In the case of type CX-371A this amounts to 2.5 volts, so that while the bias required for battery operation at 180 volts plate is 40.5 volts; with a.c. operation this becomes 43 volts.



Curves showing amplification factor (Mu), plate resistance (rp), and mutual conductance (Gm), are shown for types CX-301A, C-327, and CX-371A. In these illustrations the horizontal axis is not plate voltage, but plate current, and in order to show the values at low plate currents, graphs with a logarithmic scale have been used. Assuming that the filament is in good condition (as may be determined by an emission test), it is probable that the amplification factor is slightly above or below the value indicated on the curve as the average value. This small variation will not affect the operation of the tube, but will result in the plate current being slightly below average if mu is above average, and vice versa. If the plate current is read under operating conditions, and the value of plate resistance is found from the curves, this value will be found to be quite close to the true reading obtained on a bridge measurement. This is particularly true of Cunningham tubes because the passing limits for each type are so close that all erratic tubes are rejected.

With batteries, all voltages are fixed and do not vary with plate current, while with a.c. operation the B and C voltages both vary with plate current. It is, therefore, more convenient to measure only the plate current to determine the operating point, rather than to attempt a measurement of B and C voltages. The readings of the latter are apt to be affected by the current taken by the voltmeter, even when the high-resistance types are used.

Attention should be called to the filament voltage for power amplifier and rectifier tubes. In view of the high voltages and the larger currents involved, operation of such types at voltages under 5 per cent. below the rated values is apt to result in the impairment of operating characteristics, and in some cases to lead to overheating of the tubes due to increased internal resistance. Conservative operation of such types will be secured if the tube is operated in the range between rated voltage and a value 5 per cent. lower. It is true, of course, that normal life will be obtained over a wider range of filament voltages, and also that when the plate voltage used is well below the maximum value specified for that particular type, a greater reduction is permissible.



In operating type C-327 as a detector, an average value of 2.25 volts will insure satisfactory tube performance. When this tube is used as an amplifier it should be operated at a higher voltage, and the range of 2.25 to 2.6 volts is recommended.

The rating of the CX-380 rectifier tube will be of particular interest to experimenters who prefer full-wave rectification. The increase in transformer rating from 300 volts per anode to 350 volts per anode will permit sufficient voltage to be obtained, with a low-resistance filter, to operate the CX-350 at a plate voltage of 250 to 300 volts.

AVERAGE CHARACTERISTICS OF CUNNINGHAM RADIO TUBES

GENERAL									DETECTION			AMPLIFICATION							
													AMPLIFIER C VOLTAGE (GR10 81A5)						
													O.C. FILAMENT OPERATION		A.C. FILAMENT OPERATION				
TYPE	USE	FILAMENT SUPPLY	RHEOSTAT RECOMMENDATION NOTE 1	FILAMENT TERMINAL VOLTAGE	FILAMENT CURRENT AMPERES	BASE	MAXIMUM OVERALL HEIGHT	MAXIMUM OVERALL DIAMETER	GRID LEAK MEGOHMS	DETECTOR B-BATTERY VOLTAGE	DETECTOR PLATE CUR (mA.)	AMPLIFIER B-VOLTAGE	C VOLTS	RESISTOR OHMS See Note 2	C VOLTS	RESISTOR OHMS See Note 3	AMPLIFIER PLATE CURRENT	A.C. PLATE RESISTANCE (OHMS)	MUTUAL CONDUCTANCE (MICROMHOS)	VOLTAGE AMPLIFICATION FACTOR	MAXIMUM UNDISTORTED OUTPUT (MILLIWATTS)
C-11 & CX-12	Detector Amplifier	Dry Cell 1½ V. Storage 2 V.	4 to 6 Ohms	1.1	0.25	C-11 Special	4½"	1 3/16"	2 to 5	22½ to 45	1.5	90	4.5				2.5	15,500	425	6.6	7
						CX-12 Lg. Std.	4 1/16"	1 7/16"				135	10.5				3.5	15,000	440	6.6	35
C & CX-299	Detector Amplifier	Dry Cell 4½ V. Storage 4 V.	50 to 750 ohms	3.3	0.063	C-299 Sm. Bay't	3½"	1 3/16"	2 to 5	22½ to 45	1.5	45	1.5				1.0	19,500	320	6.6	
						CX-299 Sm. Std.	4½"	1 3/16"				67.5	3.0				1.7	16,500	380	6.6	
												90	4.5				2.5	16,500	425	6.6	7
CX-220	Power Amplifier	Dry Cell 4½ V. Storage 4 V.	20 Ohms	3.3	0.132	Small Standard	4⅜"	1 3/16"	------	-------	-------	90	16.5				3.2	7,700	428	3.3	
												135	22.5				6.5	6,600	500	3.3	110
CX-322	Screen-Grid Amplifier	Dry Cell 4½ V. Storage 4-6 V.	20 Ohms (with 6 V source add 15-Ohm Resistor)	3.3	0.132	Large Standard	5⅜"	1 13/16"	-------	-------	-------	*SCREEN GRID VOLTAGE + 45 Characteristics shown do not apply for space charge connection					1.5*	500,000	340	175	
												90	1.5				1.5*	850,000	350	290	
												135	1.5				1.0*	1,100,000	280	300	
												135	3.0								
CX-300 A	Special Detector	Storage 6 V.	20 Ohms	5.0	0.25	Large Standard	4 11/16"	1 13/16"	2 to 3	45	1.5	45	0					30,000	670	20	
CX-301 A	Detector Amplifier	Storage 6 V.	20 Ohms	5.0	0.25	Large Standard	4 11/16"	1 13/16"	2 to 5	45	1.5	45	1.5				0.9	18,500	430	8.0	
												67.5	3.0				1.7	14,000	570	8.0	
												90	4.5				2.5	11,000	725	8.0	15
												135	9.0				3.0	10,000	800	8.0	55
CX-340	Detector Amplifier	Storage 6 V.	20 Ohms	5.0	0.25	Large Standard	4 11/16"	1 13/16"	2 to 5	135 180	0.3 0.4	135 180	3.0 / 4.5	SEE NOTE 4			0.2 0.2	150,000 150,000	200 200	30 30	
CX-326	Amplifier	Transformer 1.5 V.	-------	1.5	1.05	Large Standard	4 11/16"	1 13/16"	------	------	------	90			6.0	1,700	3.5	9,400	875	8.2	20
												135			9.0	1,500	6.0	7,400	1,100	8.2	70
												180			13.5	1,800	7.5	7,000	1,170	8.2	160
C-327	Detector Amplifier	Transformer 2.5 V.	-------	2.5	1.75	5 Prong Standard	4 11/16"	1 13/16"	2 to 5	45	2.0	45			0			8,500	1,050	9.0	
												90			6.0	2,000	3.0	10,000	900	9.0	
												135			9.0	1,800	5.0	9,000	1,000	9.0	
												180			13.5	2,250	6.0	9,000	1,000	9.0	
CX-112 A	Power Amplifier	Storage 6 V. Transformer 5 V.	6 Ohms	5.0	0.25	Large Standard	4 11/16"	1 13/16"	2 to 5	45	-------	90	4.5	850	7.0	1,300	5.5	5,300	1,500	8.0	30
												135	9.0	1,300	11.5	1,650	7.0	5,000	1,600	8.0	120
												157.5	10.5	1,050	13.0	1,300	10.0	4,700	1,700	8.0	195
												180	13.5	1,350	16.0	1,600	10.0	4,700	1,700	8.0	300
CX-371 A	Power Amplifier	Storage 6 V. Transformer 5 V.	6 Ohms	5.0	0.25	Large Standard	4 11/16"	1 13/16"	------	-----	------	90	16.5	1,650	19.0	1,900	10.0	2,500	1,200	3.0	130
												135	27.0	1,700	29.5	1,850	16.0	2,200	1,360	3.0	330
												157	33.0	1,850	35.5	2,000	18.0	2,150	1,400	3.0	500
												180	40.5	2,000	43.0	2,150	20.0	2,000	1,500	3.0	700
CX-310	Power Amplifier Oscillator	Transformer 7.5 V.	-------	7.5	1.25	Large Standard	5⅜"	2 3/16"	------	------	------	250	18.0	1,500	22	1,800	12.0	5,600	1,330	8.0	340
												350	27.0	1,700	31	1,950	16.0	5,150	1,550	8.0	925
												425	35.0	1,750	39	1,950	20.0	5,000	1,600	8.0	1,540
CX-350	Power Amplifier	Transformer 7.5 V.	-------	7.5	1.25	Large Standard	6¼"	2 11/16"	------	------	------	250			45	1,600	28.0	2,100	1,800	3.8	900
												300			54	1,550	35.0	2,000	1,900	3.8	1,500
												350			63	1,400	45.0	1,900	2,000	3.8	2,350
												400			70	1,300	55.0	1,800	2,100	3.8	3,250
												450			84	1,550	55.0	1,800	2,100	3.8	4,650

SPECIAL TYPES	USE	FILAMENT SUPPLY	CIRCUIT NOTE 5	FILAMENT TERMINAL VOLTAGE	FILAMENT CURRENT AMPERES	BASE	MAXIMUM OVERALL HEIGHT	MAXIMUM OVERALL DIAMETER	OPERATING CONDITIONS
CX-380	Full-Wave Rectifier	Transformer 5.0 V	Full-Wave Circuit	5.0	2.0	Large Standard	5⅜"	2 3/16"	Max. A.C Voltage Per Plate ..... 350 V. (r.m.s.) Max. Rectified Current ..... 125 mA.
CX-381	Half-Wave Rectifier	Transformer 7.5 V.	Half-or Full-Wave Circuit	7.5	1.75	Large Standard	6¼"	2 3/16"	Max. A.C Voltage to Plate ..... 700 V. (r.m.s.) Max. Rectified Current ..... 85 mA.
CX-374	Plate Voltage Regulator	-------	-------	-------	-------	Large Standard	5⅜"	2 3/16"	Rated Voltage ... 90 V. (d.c.) Starting Voltage 125 V. (d.c.) D.C. Current 10-50 mA.
CX-376	Ballast Tube	-------	Trans. Pri. of 65 V. for use on 115 V line	-------	-------	ST'd Mogul Screw Base	8"	2 1/16"	Current Rating ..... 1.7 Amps. Voltage Range ..... 40-60 Volts
C-386	Ballast Tube	-------	Trans. Pri. of 65 V. for use on 115 V line	-------	-------	ST'd Mogul Screw Base	8"	2 1/16"	Current Rating ..... 2.05 Amps. Voltage Range ..... 40-60 Volts

NOTES

NOTE 1. When more than one tube is operated from a single rheostat, the resistance value required is correspondingly reduced. Size specified permits voltage to be reduced below rated, under operating conditions.

NOTE 2. When C voltage is obtained from voltage developed across resistor through which plate current flows, this tabulation shows correct resistor for single tube. When plate current for additional tubes flows through the same resistor, a smaller size will be required. The exact value may be determined as: R(ohms) = E(volts) / I(amperes), where E is required C voltage and I the total plate current.

NOTE 3. The bias required by a tube supplied with a.c. filament current is slightly higher than when the same tube is used on d.c., due to the center-tap grid return. Increase the d.c. value by one-half the filament voltage.

NOTE 4. The correct C voltage for type CX-340 is 1.5 and 3.0 volts respectively when used in a resistance-coupled amplifier. Characteristics of the tube are then identical with values shown if plate resistor is 0.25 megohms.



What greater Endorsement than Public Approval Since 1915

Don't use Old Tubes with New Ones
use New Cunningham tubes throughout

RADIO BROADCAST'S TUBE DATA CHARTS — II SYLVANIA PRODUCTS COMPANY

THE users of vacuum tubes have a right to expect two things from the manufacturer of the tubes; first the proper characteristics at the start of their life, and secondly a long life. Life tests were made in RADIO BROADCAST'S Laboratory on several makes of tubes. The life tests consisted of running the filaments of the tubes from a.c. and putting 100 volts d.c. from a generator on the plate with the grid left free At the end of each hundred hours each tube was taken off test and its plate resistance and amplification factor measured on a tube bridge. The amplification-factor measurement gave an indication of any change in the internal arrangement of the tube elements, the test of the plate resistance indicated whether or not the emission of the filament was falling off.

It is a fact that Sylvania tubes not only had the correct characteristics at the start of such a life test and held them throughout the test, but the majority of the tubes tested actually decreased slightly in plate resistance, and thereby had a somewhat higher mutual conductance at the end of 1000 hours than they did at the start of the test. In other words the tubes improved. The curve in Fig. 3 shows the average tube of the lot. Its starting resistance was 12,700 ohms, and at the end of 1500 hours when the test was discontinued the resistance had decreased to 12,000 ohms or about 6 per cent.

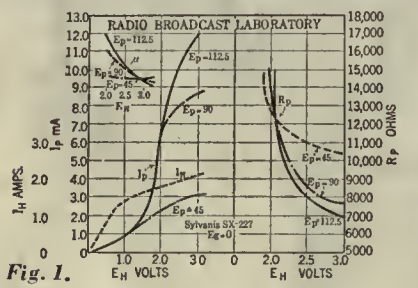


Fig. 1.

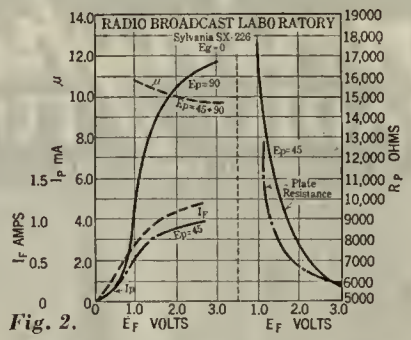


Fig. 2.

The Sylvania Company makes 19 types of tubes, including two special detectors, the SX-200A and the SX-200B. The latter is an eighth-ampere special detector tube. Both are caesium vapor tubes, and get special care in manufacture and test. With each special detector tube is packed a certificate which guarantees "greater distance receiving range and more volume in the reception of weak signals than any other tubes."

Characteristic curves made in the Laboratory on the Sylvania eighth-ampere general-purpose tubes, the SX-201B tubes, prove them to have as good or better characteristics than the average quarter-ampere tube of the 201A-type.

Some characteristic curves of Sylvania a.c. tubes of the heater and filament types are shown in Figs. 1 and 2. These data are plotted against heater volts Eh, for the SY-227 tube and against filament volts, Ef, for the SX-226 tube. They show the futility of running these tubes at voltages beyond their normal rating, and prove that voltages slightly under rated values will produce practically identical characteristics. For example, the plate resistance (Fig. 1) of the SY-227 at a plate potential of 90 volts with a zero grid bias is approximately 10,000 ohms when using a heater potential of 2.25 volts; with the same grid and plate voltages the plate resistance is about 8500 ohms at normal heater temperature.

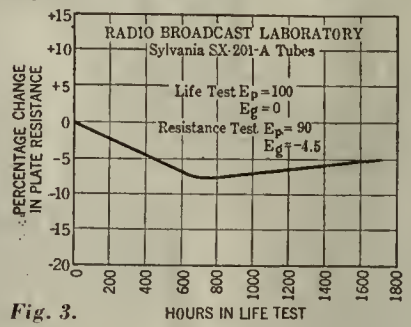


Fig. 3.

AVERAGE CHARACTERISTICS OF SYLVANIA RADIO TUBES

TYPE	USE	BASE	HEIGHT (Max)	DIAM. (Max)	FILAMENT			PLATE VOLTS		PLATE mA.	GRID VOLTS	PLATE RESISTANCE (OHMS)	AMPLIFICATION FACTOR	MUTUAL CONDUCTANCE MICROMHOS
					SUPPLY SOURCE	VOLTS	AMPS.	DETECTOR	AMPLIFIER	AMPLIFIER	AMPLIFIER			
SX-201-A	Detector Amplifier	X	4 11/16"	1 13/16"	Storage 6 V.	5.0	0.25	20-45	45-135	1.0 to 3.0	0 to 9.0	11,000	8.5	725
SX-201-B	Detector Amplifier	X	4 11/16"	1 13/16"	Storage 6 V.	5.0	0.125	20-45	45-135	1.0 to 3.0	0 to 9.0	11,000	8.5	725
SX-200-A	Detector	X	4 11/16"	1 13/16"	Storage 6 V.	5.0	0.25	20-45	-------	Detector 1.0-1.5	--------	30,000	20.0	680
SX-200-B	Detector	X	4 11/16"	1 13/16"	Storage 6 V.	5.0	0.125	20-45	------	Detector 1.0-1.5	-------	30,000	20.0	680
SX-112-A	Semi-Power Amplifier	X	4 11/16"	1 13/16"	Storage 6 V. A.C. 5 V.	5.0	0.25	------	90-180	5.5 to 13.0	6.0 to 12.0	5,500	8.0	1500
SX-171	Power Amplifier	X	4 11/16"	1 13/16"	Storage 6 V. A.C. 5 V.	5.0	0.50	------	90-180	10.0 to 20.0	16.5 to 40.5	2,200	3.0	1400
SX-171-A	Power Amplifier	X	4 11/16"	1 13/16"	Storage 6 V. A.C. 5 V.	5.0	0.25	------	90-180	10.0 to 20.0	16.5 to 40.5	2,200	3.0	1400
SX-240	Det-Amp. Res.Coupling	X	4 11/16"	1 13/16"	Storage 6 V.	5.0	0.25	135-180	135-180	0.1 to 0.3	1.5 to 4.5	150,000	30	200
SX-199	Detector Amplifier	X	4 1/8"	1 3/16"	Dry Cells 4.5 V. Storage 4 V.	3.3	0.06	20-45	45-135	1.0 to 3.2	0 to 10.0	15,500	6.6	425
SV-199	Detector Amplifier	V	3 1/2"	1 1/16"	Dry Cells 4.5 V. Storage 4 V.	3.3	0.06	20-45	45-135	1.0 to 3.2	0 to 10.0	15,500	6.6	425
SX-120	Power Amplifier	X	4 1/8"	1 3/16"	Dry Cells 4.5 V. Storage 4 V.	3.3	0.125	-------	135	6.5	22.5	6,300	3.3	525
SX-226	Amplifier	X	4 11/16"	1 13/16"	A.C. 1.5 V.	1.5	1.05	-------	90-180	3.5 to 7.5	4.5 to 15	7,400	8.2	1100
SY-227	Detector	Y	4 11/16"	1 13/16"	A.C. 2.5 V.	2.5	1.75	20-90	90-180	3.0 to 7.5	6.0 to 13.5	10,000	8.2	900
SX-222	Amplifier	X	5 3/8"	1 13/16"	Dry Cells 4.5 V. Storage 4-6 V.	3.3	0.132	-------	135-180	1.5	1.5	850,400	300	350
SY-222A.C.	Amplifier	Y	5 3/8"	1 13/16"	A.C. 2.5 V.	2.5	1.75	-------	135-180	5.0	1.5	200,000	150	650
SX-210	Power Amp. Oscillator	X	6 1/4"	2 7/16"	A.C. 7.5 V	7.5	1.25	-------	250-425	10 to 18	18-35	5,000	8.0	1600
SX-250	Power Amp. Oscillator	X	6 1/4"	2 11/16"	A.C. 7.5 V	7.5	1.25	-------	250-450	28-55	45-84	1,800	3.8	2100

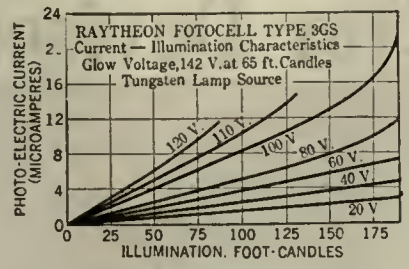
Model	Use	Base	Height (Max)	Diam. (Max)	Filament			Plate	
					Supply Source	Volts	Amps.	Max A.C. Volts	Max D.C. mA.
SX-281	Half-Wave Rectifier	X	6 1/4"	2 7/16"	A.C. 7.5 V.	7.5	1.25	750	110
SX-280	Full-Wave Rectifier	X	5 3/8"	2 3/16"	A.C. 5 V.	5.0	2.0	300 per Plate	125 Both Plates

Notes:
Where only one set of characteristics is given these apply to the mean or most used values of plate and grid voltages.
Bases will be designated by the following letters, according to their styles:
X = Standard Push Type, Four Long Prongs. V = Old Navy Type Four Short Prongs Y = Push Type, Five Long Prongs

RADIO BROADCAST'S TUBE DATA CHARTS — III RAYTHEON MANUFACTURING COMPANY

IN THE opinion of the Laboratory, one of the single most important steps toward bringing radio reception to its present point of near perfection is to be credited to the Raytheon Company's gaseous rectifier tube which was the first really satisfactory tube useful in supplying d.c. voltages from an a.c. source—and which is to be found to-day in thousands of plate voltage supply units as well as in equipment supplying A, B, and C voltages.

The "Raytheon tube," by which everyone means the 125-milliampere rectifier tube, came at an opportune time. The tubes used ranged from



an overworked 201A-type tube with its grid and plate connected together, to some few special two-element filament-type tubes, none of which was able to stand up under the heavy demand for electrons in plate voltage supply devices. The Raytheon tube stood up—and so "B eliminators" became successful adjuncts to modern radio receivers.

When television began to interest development engineers, there was an immediate demand for photo-electric cells. These are glass bulbs, not unlike radio receiver tubes, into which a light can be directed. When this light falls upon the sensitive electrode, it liberates electrons which are attracted toward a positive plate, and so a light beam can release an electric current from a local B battery. The strength of this current should be proportional to the light falling on the sensitive plate, the tube should not be microphonic, should be of low electrical capacity, should have a high order of sensitivity—that is, the current released from the local battery must be as high as possible with a given amount of incident light—and must be stable in operation.

The experience accumulated in the Raytheon laboratories since 1920 in the purification and study of rare gases made possible the development of such photo-electric cells. A graph gives the characteristic of the type 3GS Foto-Cell.

There is also a demand for a tube which has opposite characteristics from the Foto-Cell, that is, a tube which will give off light when excited by an electrical input. This light should vary in direct proportion to the strength of the incoming signal. The tube must be uniform in illumination, low in power consumption, and as brilliant as possible. Such a cell is the Raytheon Kino-Lamp. Under full-voltage conditions it supplies 10 candle power of illumination which can be easily and positively controlled by television signals.

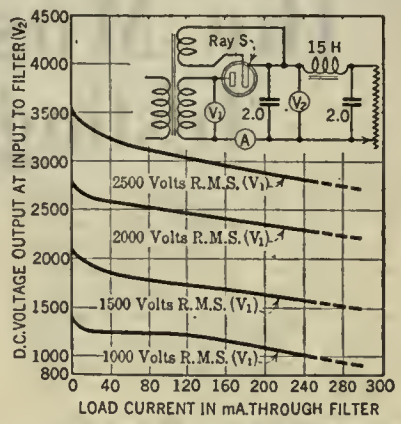
High Power Rectifiers

For years the "S" tube was the stand-by of the amateur. The passing of the "S" tube was a regrettable incident—but now the Raytheon Company has a new rectifier that has characteristics as shown on this page. This looks like an ideal tube for the amateur and anyone who wants a source of high voltage d.c. secured from the a.c. lamp socket. The curves show that the tube has a low internal resistance which indicates that very little power will be lost in the tube.

Low internal power losses, good regulation characteristics, high efficiency, and high output voltages are the advantages of this new Raytheon product known as the Ray-S tube. It can be used wherever high current at high voltage is desired. For example, at an input r.m.s. potential of 2500 volts, a current of 200 milliamperes can be supplied at a d.c. voltage of 2860, which represents a power of 570 watts.

Receiving Tubes

The Raytheon Company has recently begun the manufacture of receiving tubes of the types indicated in the chart. All of these tubes have been tested in the Laboratory and were found to check the characteristics described by the manufacturer. They are distinct in their method of construction, and their design will permit the building of usable and practical tubes of types now considered only theoretical. The rugged construction also assures the consumer of receiving the tubes with the same matched characteristics as are achieved in the factory.



AVERAGE CHARACTERISTICS OF RAYTHEON TUBES

TYPE	USE	FILAMENT VOLTS	FILAMENT AMPERES	BASE	MAXIMUM HEIGHT	MAXIMUM DIAMETER	DETECTION: B VOLTAGE (VOLTS)		DETECTION: GRID LEAK (MEGOHMS)			PLATE CURRENT (mA.)	AMPLIFICATION FACTOR	PLATE RESISTANCE (OHMS)	MUTUAL CONDUCTANCE (MICROHMS)	MAXIMUM UNDISTORTED OUTPUT (MILLIWATTS)
RAY X-112-A	D.C. Detector	5.0	0.25	4-Prong Standard	4 1/16"	1 13/16"	45	—	2-5	—	—	5.5	8.0	5300	1500	—
RAY-227	A.C. Detector	2.5	1.75	5-Prong Standard	4 1/16"	1 13/16"	45	—	2-5	—	—	5.0	9.0	8500	1050	—
							AMPLIFICATION: B VOLTAGE (VOLTS)	C BIAS VOLTAGE: FILAMENT ON D.C.	C BIAS VOLTAGE: FILAMENT ON A.C.	BIAS RESISTOR: FILAMENT ON D.C.	BIAS RESISTOR: FILAMENT ON A.C.					
RAY X-226	A.C. Amplifier	1.5	1.05	4-Prong Standard	4 1/16"	1 13/16"	90 135 180	—	6.0 9.0 13.5	—	1700 1500 1800	3.5 6.0 7.5	8.2 8.2 8.2	9400 7400 7000	875 1100 1170	20 70 60
RAY-227	A.C. Amplifier	2.5	1.75	5-Prong Standard	4 1/16"	1 13/16"	90 135 180	—	6.0 9.0 13.5	— —	2000 1800 2250	3.0 5.0 6.0	9.0 9.0 9.0	10,000 9000 9000	900 1000 1000	20 65 140
RAY X-171-A	A.C. or D.C. Power Amplifier	5.0	0.25	4-Prong Standard	4 1/16"	1 13/16"	90 135 180	16.5 27.0 40.5	19.0 29.5 43.0	1700 1700 2000	1900 1900 2150	10.0 16.0 20.0	3.0 3.0 3.0	2500 2200 2000	1200 1360 1500	130 330 700
RAY X-112-A	A.C. or D.C. Power Amplifier	5.0	0.25	4-Prong Standard	4 1/16"	1 13/16"	90 135 180	4.5 9.0 13.5	7.0 11.5 16.0	800 1300 1350	1300 1650 1600	5.5 7.0 10.0	8.0 8.0 8.0	5300 5000 4700	1500 1600 1700	30 120 300
RAY X-245	A.C. or D.C. Power Amplifier	2.5	1.5	4-Prong Standard	5 5/8"	2 3/16"	150 200 250	—	27.0 38.0 50.0	—	1200 1400 1500	23.0 27.0 32.0	3.5 3.5 3.5	2200 2050 2000	1600 1700 1750	400 900 1600
RAY X-210	A.C. or D.C. Power Amplifier	7.5	1.25	4-Prong Standard	5 5/8"	2 3/16"	250 350 425	18.0 27.0 35.0	22.0 31.0 39.0	1500 1700 1750	1800 1950 1950	12.0 16.0 20.0	8.0 8.0 8.0	5600 5150 5000	1330 1550 1600	340 925 1540
RAY X-250	A.C. Power Amplifier	7.5	1.25	4-Prong Standard	6 1/4"	2 11/16"	250 350 450	—	45.0 63.0 84.0	—	1600 1400 1500	28.0 45.0 55.0	3.8 3.8 3.8	2100 1900 1800	1800 2000 2100	900 2300 4600
RAY A.C.22	A.C. Screen-Grid Amplifier.	2.5	1.75	5-Prong Standard	5 3/8"	1 13/16"	180	—	1.5	—	Screen Grid Volts 75	3	400	500,000	800	—

AVERAGE CHARACTERISTICS OF RAYTHEON RECTIFIERS

TYPE	USE	FILAMENT VOLTS	FILAMENT AMP.	BASE	LENGTH	DIAMETER	MAX. A.C. PER PLATE (VOLTS)	MAX. OUTPUT (AMPERES)
8 H	Full Wave	—	—	4-Prong Standard	4 1/2"	1 13/16"	350	0.125
8 A	Full Wave	—	—	4-Prong Standard	6"	2 7/16"	350	0.350
RAY X-280	Full Wave	5.0	2.0	4-Prong Standard	5 5/8"	2 3/16"	350	0.125
RAY X-281	Half Wave	7.5	1.25	4-Prong Standard	6 1/4"	2 7/16"	700	0.085
RAY X-866	Half Wave	2.5	5.0	4-Prong Standard	5 7/8"	2 3/16"	2000	0.250
RAY-S	Half Wave	5.0	5.0	Mogul Screw	8 1/2"	2 1/16"	3000	0.300

AVERAGE CHARACTERISTICS OF RAYTHEON KINO-LAMP

TYPE	USE	BASE	MAXIMUM HEIGHT	MAXIMUM DIA.	STARTING VOLTAGE	OPERATING VOLTAGE	OPERATING CIRCUIT (mA.)	CANDLE POWER PER mA.	SURFACE BRIGHTNESS LAMBENTS Per mA
Kino-Lamp	Television	4-Prong Std	6 1/2"	2 1/16"	210	150	10 To 80	0.14	0.03

AVERAGE CHARACTERISTICS OF RAYTHEON FOTO-CELLS

TYPE	USE	BASE	MAXIMUM HEIGHT	MAXIMUM DIA.	APERTURE	LUMINS PER FOOT CANDLE	SENSITIVITY MICRO-AMPS PER FT. CANDLE	GLOW VOLTS 65 ft. Candles
3 GSS	Television	—	2 1/2"	1 1/16"	1/2" x 1"	0.003	0.03	130
3 VS	Television	4-Prong Std.	6 3/8"	2 7/8"	2" Dia.	0.022	0.04	—
3 GS	Television	4-Prong Std.	6 3/8"	2 7/8"	2" Dia.	0.022	0.15	150
3 VL	Television	—	12"	2 1/8"	1 1/2" x 8"	0.082	0.10	—
3 GL	Television	—	12"	2 1/8"	1 1/2" x 8"	0.082	0.35	150
3 GLL	Television	—	15"	3 5/8"	2 1/2" x 10"	0.170	0.75	150

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The case containing the instrument was designed after careful study by practical radiotricians of many years' experience in radio service. Its arrangement is most complete and convenient—a proper place for every tool, accessory, part, and material that a service man might need; even a swinging tube shelf that affords absolute protection to tubes. A complete set of tools, from electric soldering iron to screw driver, is furnished, and of course, all necessary adapters and accessories. Everything the service man requires—all in one case. And still, due to ingenious design, this case is only 18 x 10½ x 7 in., and weighs complete only 25 lbs.

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Greenwood, Miss.

Please ship me one Model 400A SUPREME.

Upon delivery of the instrument, I will deposit with the express agent either the cash price of $124.65 or $38.50 cash and 10 trade acceptances (instalment notes) for $10 each, due monthly, at my option, subject to the following conditions:

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Signed.....

Firm name.....

Address.....

City..... *State*.....

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Mounted in Bakelite cases.

1 Voltmeter, three scales of 0/10/100/600, 1000 ohms per volt.

1 Milliammeter, of 125 mils and 2½ amps.

1 A. C. Voltmeter, three large scales of 0/8/15/150.

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Makes every test on any Radio Set-

You have waited long and patiently for an instrument such as the SUPREME. It is now here—at your command for greater accuracy and thoroughness, bigger profits and satisfied customers.

Tubes, power units, loads, breakdowns, voltages, all instantly analyzed, peaking condensers, also modulated radiator. Everything you have ever hoped for is there, all contained in one compact instrument.

The only self-rectifying oscillation tester in existence.

The exact working conditions of any tube from 1½ to 15 volts, including screen grid, heater type, and rectifier tubes, are shown by meter readings; the only service instrument that shows output of rectifier tubes on meter.

The oscillation tests from alternating current are made possible by the exclusive self-rectifying SUPREME Power Plant. Every radio engineer and service man will appreciate this feature.

The SUPREME radiator sends out a modulated wave. Simply plug into A. C. line. No more wasting valuable time on broadcast stations; always at your service and finer adjustment assured.

Condensers can be balanced or synchronized—not by the former tedious methods—but with both meter reading and audible click. Easy and much more accurate.

All continuity tests can be made from socket on either A. C. or D. C. sets, with independent cathode readings.

The SUPREME heavy duty rejuvenator provides scientific method of rejuvenation of any thoriated filament tube. Will reactivate up to 12 tubes at one time without removal from set. Push a plug—the SUPREME does the rest.

The SUPREME will give direct reading of amplifying power of tubes and will show actual working condition of all tubes.

The SUPREME will play radios with open transformers and will give condenser, choke coil output and capacity output on radios not wired for that purpose.

Access is provided to all apparatus through pin-jacks. Will test condensers for breakdown. Contains various fixed condensers from .001 to 2 mfd., a 30 ohm rheostat, a 500,000 ohm variable resistance, and an audio transformer, for instant use and various combinations.

It will give plate and filament voltage readings with or without load; will test voltage and current of all radios, including those using tubes such as 210 and 250. It will give grid circuit readings up to 100 volts; plate voltage readings up to 600 volts; will test output of trickle chargers, or any output up to 2½ amps.

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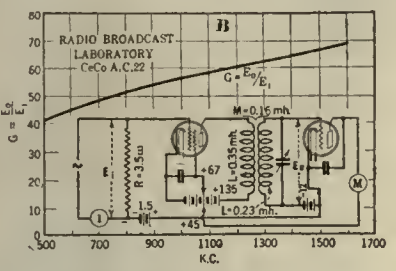
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Radio Diagnometer

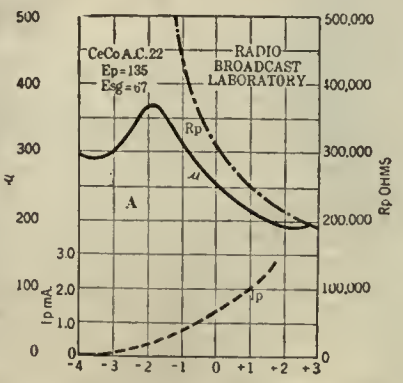
RADIO BROADCAST'S TUBE DATA CHARTS — IV CeCo MANUFACTURING COMPANY

THE chart on this page gives the characteristics of the entire CeCo line of tubes. A glance will show that the line is complete, and that the constants are such as experience and engineering has dictated to be the best for the tubes serving the purposes for which they were made. In addition to tubes whose names and uses everyone knows, there are several others on this list that will need some explanation. For example, type G is a high-mu tube useful for resistance- and impedance-coupled amplifiers. Owing to its rather low plate resistance, 25,000 ohms at a plate potential of 60 volts and at zero grid bias, the tube will make a good detector. In addition to this tube, CeCo manufactures a special detector, type H, which has a somewhat lower mu and a lower plate resistance than type G. Both of these tubes have a fairly high mutual conductance.

Type K is a special radio-frequency amplifier tube, with an amplification factor of 12.5 and a plate resistance of 11,000 ohms. Under normal operating conditions, viz, 90 volts on the plate and a negative bias of about one volt, the mutual conductance is equal or better than the average general-purpose tube, and naturally enough, a somewhat greater amplification at high frequencies results.



Type L 15 is a new power tube, as is Type L45. At the time of compiling these data, only experimental tubes were available, and it is not thought wise to include data on these tubes. Suffice to say, the CeCo organization is awake to the necessity of power tubes fitting into the picture somewhere between the present 171 and the much more powerful tube, the 250 type.



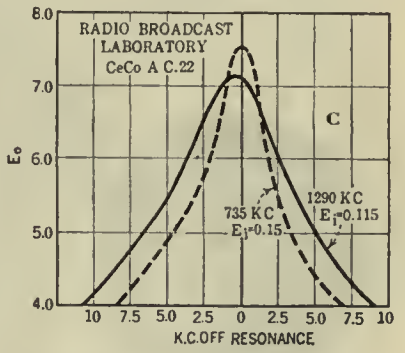
Despite the interest in the screen-grid tube, little has been done with it in commercial receivers, chiefly because it required a source of d.c. current for its filament. The chart below shows the characteristics of the CeCo a.c. screen-grid tube, the A.C. 22. It is a standard heater-type tube, namely, one requiring 2.5 volts and 1.75 amperes, and because of this construction it does not suffer from many of the faults of the d.c. screen-grid tube. It is not microphonic, its filament (cathode) is sturdy and it has copius emission of electrons. Its plate resistance is 450,000 ohms and its mutual conductance over 700 micromhos under normal operating conditions, i.e., 135 volts on the plate, 67.5 on the screen grid, and a negative bias of 1.5 volts on the control grid.

Fig. A gives the essential characteristics of the tube plotted with reference to the control-grid bias.

To see what the tube would do as a radio-frequency amplifier, the data in Fig. B and Fig. C were taken in the Laboratory. The circuit diagram is given on Fig. B and shows a resistance input of 3.5 ohms, a transformer coupling the A.C. 22 to a standard heater-type tube operating as a C-bias or plate-rectification detector, and a microammeter in the plate circuit of the detector which acts as a vacuum-tube voltmeter.

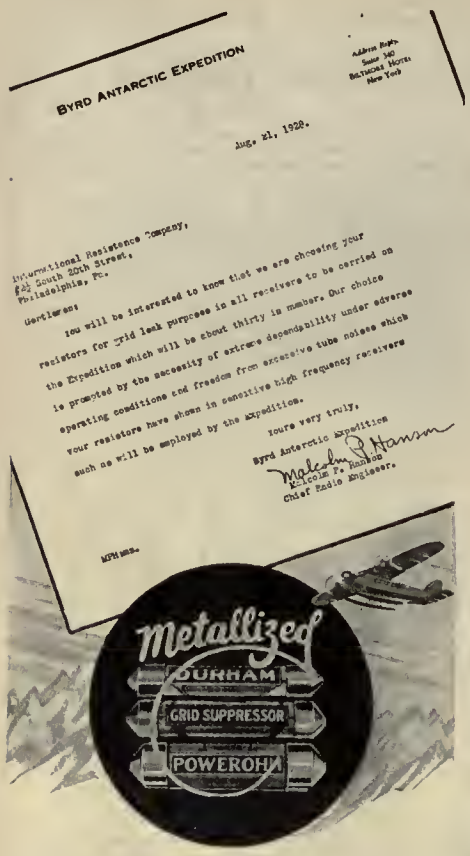
The voltage ratio, E_o/E_i, varies from about 40 at low broadcast frequencies to about 70 at 1500 kc. This means that an input voltage of 0.1 volt, after passing through the screen-grid tube and its coupling transformer, became 4.0 volts on the input to the detector at 500 kc. and 7.0 volts at 1500 kc.

Fig. C gives an idea of the selectivity of a single stage as illustrated in Fig. B. The primary of the transformer had an inductance of 350 microhenrics, the secondary an inductance of 235 microhenries and the mutual inductance between them was about 160 microhenries, giving a coefficient of coupling of about 0.56. The secondary had a diameter of about 2 inches and was space wound so that its resistance was quite low. The input resistance of the detector was high since it was an overbiased tube. As Fig. C shows, the selectivity of such a single stage varies at the two frequencies used. At 1290 kc. the selectivity is such that a 5000-cycle note would suffer a loss of about 3.5 DB while at 735 kc. the loss would be 4.4 DB.



TEST CHARACTERISTICS OF CECO TUBES

MODEL NO	CORRESPONDING TYPE	USE	A BATTERY VOLTS	FILAMENT VOLTS	FILAMENT AMPERES	DETECTOR PLATE VOLTS	AMP. MAX. PLATE VOLTS	GRID BIAS	TEST DATA AVERAGE: PLATE VOLTS	GRID VOLTS	PLATE CURRENT (mA.)	PLATE RESISTANCE (OHMS)	MUTUAL CONDUCTANCE MICROMHOS	MU	NOTES
A	01A	Detector Amplifier	6.0	5.0	0.25	45	135	0.5-9.0	90	4.5	3.1	9500	900	8.5	General Purpose
018	201 8	Detector Amplifier	6.0	5.0	0.125	45	135	0.5-9.0	90	4.5	3.1	9500	900	8.5	" "
8-BX-C	199	Detector Amplifier	4.5	3.0	0.06	45	90	0.5-6.0	90	4.5	2.8	16,000	400	6.4	General Pur.3 Types of Bases
RF 22	222	R.F. Amplifier	4.5	3.3	0.132		180	-1.5/+45	135	-1.5/+45	-----	600,000	666	400	Special Circuits for 4 Element Tubes
AC 22	222	R.F. Amplifier	----	2.5	1.75 A.C.	----	180	-1.5/+75	180	-1.5/+75	4.0	400,000	1,050	420	
E	120	Power Amplifier	4.5	3.0	0.12	----	135	15.0-22.5	90	16.5	4.0	7,500	440	3.3	Last A.F.Stage
F	112	Power Amplifier	6.0	5.0	0.50	45	180	4.5-12.0	90	4.5	4.8	5,000	1,600	8.0	" " "
F 12A	112A	Power Amplifier	6.0	5.0	0.25	45	180	4.5-12.0	90	4.5	4.8	5,000	1,600	8.0	" " "
G	240	Hi Mu	6.0	5.0	0.25	90	180	0.5-5.0	60	0	0.8	25,000	800	20	Res.and Impedance Amplifiers
H	---	Detector	6.0	5.0	0.25	67-90		1.5-4.5	80	0	9.0	14,000	1,030	14.4	Hard Detector
J 71	171	Output	6.0	5.0	0.50	------	180	16.0-45	90	16.5	9.0	2,500	1,200	3.0	Last A.F.Stage
J 71 A	171A	Output	6.0	5.0	0.25	-----	180	16.0-45	90	16.5	9.0	2,500	1,200	3.0	" " "
K	-----	R.F.	6.0	5.0	0.25	45-90	135	0.5-3.0	80	0	4.8	11,000	1,130	12.5	Radio Frequency Amplifier
L 10	210	Power Amplifier	8.0	7.5	1.25	------	425	12.0-35.0	180	12.0	7.0	7,000	1,100	7.8	Power Stage
L 15	------	Power Amplifier	6.0	5.0	1.0	------	180	15.0	180	15.0	15.0	3,750	2,000	7.5	" "
L 45	-----	Power Amplifier	---	2.5	1.5 A.C.	------	250	-33 to-50	250	-50	32	1,900	1,845	3.5	" "
L 50	250	Power Amplifier	8.0	7.5	1.25	------	450	45-84	250	45	28	2,100	1,800	3.8	" "
M-26	226	A.C. Amplifier	----	1.5	1.05 A.C.	------	135	6.0-16.5	90	6.0	3.7	9,400	875	8.2	A.C.on Filament
N-27	227	A.C. Detector	------	2.5	1.75 A.C.	45	135	6.0-13.5	90	6.0	3.0	11,300	725	8.2	Separate Heater A.C.
R-80	280	Rectifier	------	5.0	2.0	------	350	-----	----	-----	125	------	-----	----	
R-81	281	Rectifier	------	7.5	1.25	------	750	------	------	-------	110	-----	-----	-----	



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The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE aim of the Radio Broadcast Laboratory Information Sheets is to present, in a convenient form, concise and accurate information in the field of radio and closely allied sciences. It is not the purpose of the Sheets to include only new information, but to present practical data, whether new or old, that may he of value to the experimenter, engineer or serviceman. In order to make the Sheets easier to refer to, they are arranged so that they may be cut from the magazine and preserved, either in a blank book or on 4″ x 6″ filing cards. The cards should be arranged in numerical order.

Since they began, in June, 1926, the popularity of the Information Sheets has increased so greatly that it has been decided to reprint the first one hundred and ninety of them (June, 1926-May, 1928) in a single substantially bound volume. This volume, "Radio Broadcast's Data Sheets", may now be bought on the newsstands, or from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Inside each volume is a credit coupon which is worth $1.00 toward the subscription price of this magazine. In other words, a year's subscription to RADIO BROADCAST, accompanied by this $1.00 credit coupon, gives you RADIO BROADCAST for one year for $3.00, instead of the usual subscription price of $4.00.

—THE EDITOR.

No. 265 RADIO BROADCAST Laboratory Information Sheet **March, 1929**

Electrifying Battery-Operated Sets

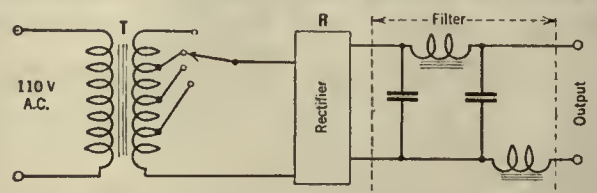
IT IS much easier and generally more satisfactory to change a battery-operated receiver over to complete a.c. operation by the use of an A-power unit than by rewiring the set for a.c. tubes; in both cases a source of B and C voltages is, of course, necessary. The use of an A-power unit to permit light-socket operation may be accomplished without rewiring the set, and, if the unit is a good one, one can be sure that the operation of the set from the A-power unit will be essentially the same as when it was run from the storage battery.

An A-power unit is somewhat similar to a B-power unit, both of them consisting of a transformer, rectifier, and filter system. The A unit differs from the B unit simply in the rectifier and filter system which must be capable of supplying two or three amperes instead of a few milliamperes.

The circuit of a typical A-power unit is given on this sheet. The transformer, T, supplies a.c. voltage to the rectifier, R, which feeds pulsating d.c. to the filter system where the ripple is removed so that the current leaving the output terminals of the filter system is practically pure d.c.

The arrangement of the chokes and condensers in the filter system varies in different units. In some cases both the chokes are placed in the same side of the line and three condensers are frequently used instead of two.

The transformer, T, is generally provided with taps on the secondary, as we have indicated, so that the output of the system may be corrected for different current drains. The greater the output current required from the unit, the higher must be the voltage impressed across the rectifier.



No. 266 RADIO BROADCAST Laboratory Information Sheet **March, 1929**

Effect of Room Acoustics

MR. IRVING WOLFF, of the Technical and Test Department of R. C. A., remarks in an article on loud-speaker measurements (*Proc.* I. R. E., December, 1928) that,

"We are sometimes annoyed after having conducted listening tests on a loud speaker, and having reached the conclusion that it is pretty good, to find it unsatisfactory when moved to a different room or even a different position in the same room. It is, therefore, very important when taking loud-speaker curves to consider the question of room acoustics and loud-speaker position.

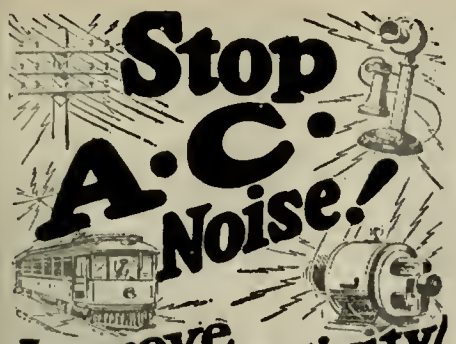
"Some of the factors which may be expected to have a pretty big effect are:

Room absorption characteristics
Room resonances
Position of loud speaker in room
Position of listener with respect to loud speaker.

High frequencies are radiated in a beam. If high response is wanted the speaker should, therefore, be pointed and placed so as to cover as large a portion of the audience as possible. Placing the loud speaker in a corner or in any kind of a cavity will usually have a big effect on the response. The space between the back of the loud speaker and wall or other obstruction will act as a resonant chamber whose vibrations will be excited by the vibrations of the rear side of the loud speaker diaphragm. It is impossible to say whether this effect will be pleasing or otherwise. It will depend on the unadulterated response characteristic and whether the resonance is of such frequency as to supply a region which is lacking.

"Under present broadcasting conditions where the range of frequencies transmitted is cut off pretty sharply at 5000 cycles or below, tube overloading on a loud speaker which reproduces real high frequencies show up as a roughness, rasp, and very often as a sound which resembles a paper rattle. This is caused by the generation of harmonics and combination tones. These added notes show up particularly badly when they are produced at the higher frequencies, as there is no true transmitted sound of the same frequency to act as a mask."

Note: The serial number of Lab. Sheet No. 256, "Power Output" in the January issue was duplicated accidentally in the February issue by a Lab. Sheet, "Three Types of Graphs," bearing the same number. In order to correct their records, readers may assign the number 264 to the sheet entitled "Three Types of Graphs."



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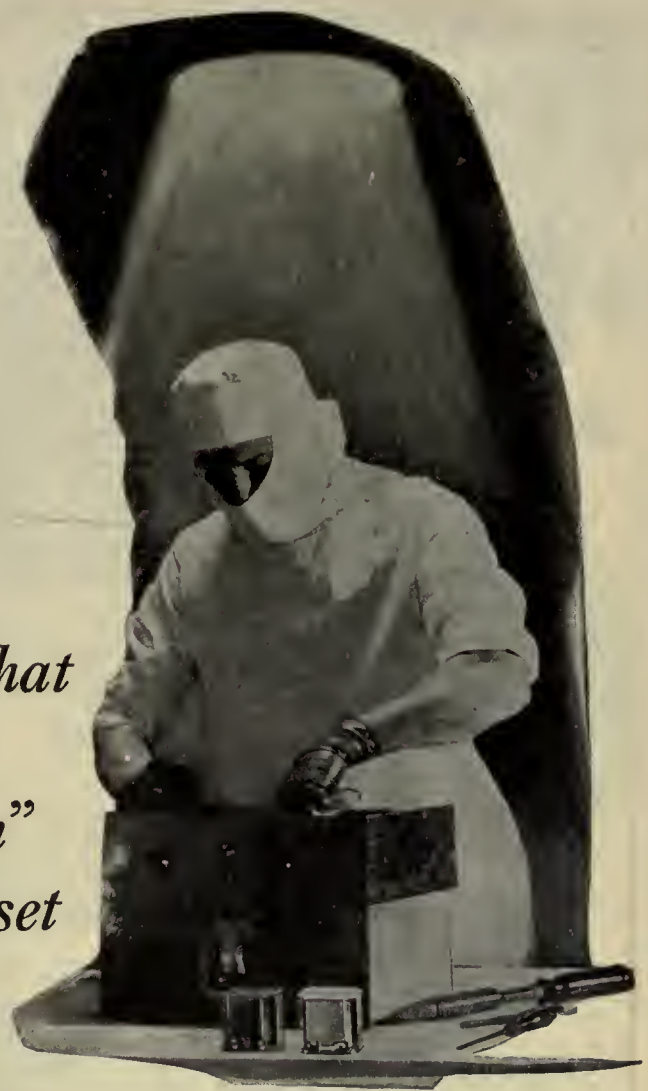
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The panel is 5/16 hlack sanded Bakelite, 19 in. wide and 12½ in. high. Detailed information and circuit is shown in bulletin No. 7, which we will be glad to mail to you. The net price in the U. S. A. and Canada is $275.00, F. O. B. Chicago.

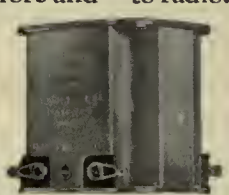
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No. 267 RADIO BROADCAST Laboratory Information Sheet **March, 1929**

Power in Broadcast Harmonics

A BROADCASTING station is assigned to a definite frequency by the Federal Radio Commission. In the operation of the station it is essential that the major part of the radiation take place within 500 cycles of this assigned frequency. Since, however, for reasons of economy, the oscillators at the transmitter are generally overloaded rather than underloaded, it is always found that they generate, beside the fundamental frequency, a considerable amount of energy at harmonic frequencies. A transmitter operating ou a frequency of 500 kilocycles will generate energy at 1000 kilocycles so that the program could be heard on both of the channels—and, of course, it is probable that the 1000-kilocycle wave would produce interference with a station assigned to that frequency. Some method must, therefore, be used to suppress the harmonics since, if they are permitted to get into the antenna, they will cause interference in other broadcasting channels. The greatest interference is caused in the channel corresponding to a frequency twice that on which the station is authorized to operate. In the August, 1928 *Bell Laboratories Record* the following interesting remarks were published relative to the suppression of harmonics from one of the experimental stations operated by the Bell Telephone Laboratories.

"In this respect, as in many others, 3XN, the latest broadcasting development of our Laboratories, marks a new level of attainment. The transmitter has a power input into the antenna system of 50 kilowatts for the carrier wave alone, and the instantaneous peak power during the broadcasting of a program may reach 200 kilowatts. And yet with all that power in the carrier wave, the amount of the second harmonic allowed to escape would not light the tiniest incandescent lamp made. To be exact, it is less than 0.005 watt and represents about one-ten-milliouth of the power of the carrier wave.

"Ordinarily, a purity (lack of harmonics) of 80 to 95 per cent. can be readily and cheaply attained. To carry this to 99 per cent. costs considerably more and to carry it to 99.9 per cent. many times as much. The extent to which the purification is carried out is now left largely to the designers of the radio transmitter, and they look upon it as an economic balance between the joh that they would like to do and the cost of the equipment that can be justified. The more powerful the broadcasting transmitter, the more important becomes the problem of attennating its harmonics, and the greater the care which must be bestowed upon its harmonic filters."

No. 268 RADIO BROADCAST Laboratory Information Sheet **March, 1929**

Mathematics of the Tuned Circuit

THE tuned circuit and its characteristics are important. Therefore, in this sheet are presented a few of the mathematical expressions concerning such circuits.

The current (I) flowing around a circuit consisting of a coil and a condenser connected in series may be determined by the following formula:

$$I = \frac{E_i}{\sqrt{R^2+\left(\omega L - \frac{1}{\omega c}\right)^2}} \qquad (I)$$

where

I = current in amperes
E_i = voltage induced in the eircuit
R = resistance of circuit
L = inductance of coil in henries
c = capacity of condenser in farads
$\omega = 2\pi$ times the frequency in cycles

At resonance ωL equals $\frac{1}{\omega c}$ and equation (1) is therefore reduced to

$$I = \frac{E}{R} \qquad (2)$$

At resonance the energy stored in the condenser is

$$\frac{cE_g^2}{2} \qquad (3)$$

where Eg is the voltage across the condenser. The energy in the coil is

$$\frac{LI^2}{2} \qquad 4)$$

and if the resistance is small in comparison with ωL then the energy is equal in both cases and

$$I = E_g\sqrt{\frac{c}{L}} \qquad (5)$$

whence

$$E_g = I\sqrt{\frac{L}{c}} \qquad (6)$$

The last equation indicates that the voltage, Eg, across either the coil or the condenser is proportional to the ratio of L to c.

The gain of a tuned circuit may be defined as the voltage, Eg, generated across the circuit divided by the voltage, Ei, induced in the circuit.

$$E_g = I\omega L \qquad (7)$$

and combining equation (2) with (7) and solving for the gain, we have

$$\text{Gain} = \frac{E_g}{E_i} = \frac{\omega L}{R} \qquad (8)$$

No. 269 RADIO BROADCAST Laboratory Information Sheet **March, 1929**

Importance of Bass Notes

SUPPOSE that a certain note on the piano is sounded in the studio of a broadcasting station and the characteristic of the radio circuit is such that the fundamental frequency of the tone is not transmitted but all the harmonics are. Even though the frequency of the fundamental never even reaches the loud speaker, if all the harmonics are reproduced we will he able to tell what note was sounded. It is a peculiar characteristic of the human ear that to a considerable extent it can, in some manner, supply to our consciousness many of the fundamental frequencies which are not reproduced by an ordinary radio system.

The fact that the ear is capahle of supplying missing fundamental frequencies under some conditions does not mean that it is not worth while to design the radio system so that it is capable of reproducing them. The results would be much better if the fundamental were transmitted—this may be proved easily by playing the same note on the piano. The difference would be quite noticeable as the true note would sound much richer and be somewhat lower in pitch. The qualities which the note lacked when the fundamental was eliminated would be quite evident and the advantages, of designing a radio system to transmit the fundamentals of all the audio frequencies, of obvious valuc.

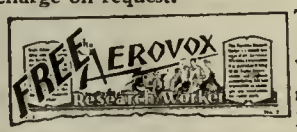
Since there is a large group of instruments in an orchestra—the trombone, 'cello, double bass, bassoon, drums, etc.—which sound many notes that are low in frequency, say below 150 cycles, it would seem that just as these instruments are essential in an orchestra to give correct balance, so the reproduction of the fundamental frequencies of their notes is essential for good quality. Imagine a symphony orchestra with all of these instruments lacking! However, it is usually unnecessary to reproduce notes below 60 cycles.

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Remedy: connect 104-04 Interference Eliminator to the line circuit at the point where interfering device is connected.

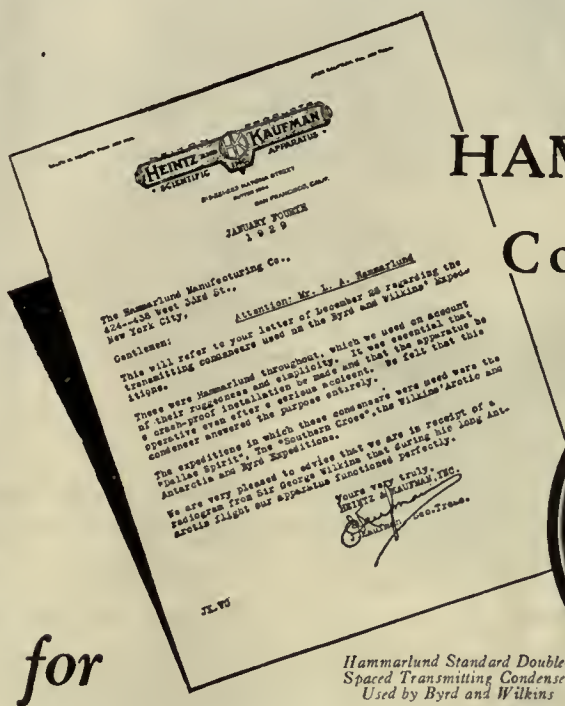
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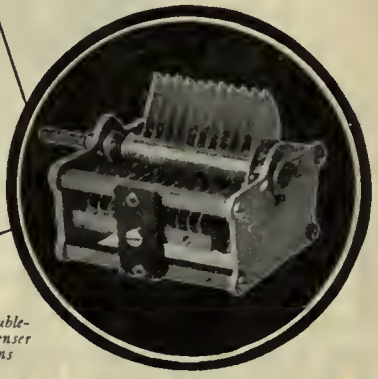
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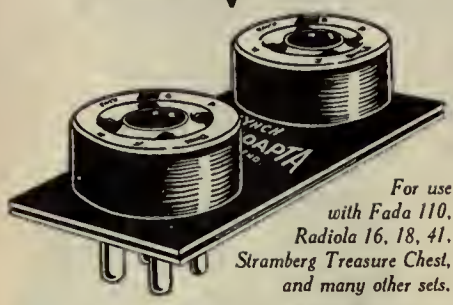
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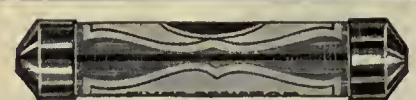
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No. 270 — Radio Broadcast Laboratory Information Sheet — March, 1929

Formulas for Power Output

THE undistorted power output of a tube is defined as the maximum power which can be supplied to a load without introducing more than five per cent. distortion due to the curvation of the tube's characteristic. It has been determined that the maximum amount of undistorted power is obtained from any given tube when the load resistance equals twice the plate resistance of the tube. The power output can be computed from the formulas

$$P = \frac{2\ (u E_{gr})^2}{9\ R_p}\ 10^3 \qquad (1)$$

when

P = power in milliwatts
u = amplification constant
E_{gr} = r.m.s. value of signal voltage on the grid
R_p = plate resistance

If peak values of a.c. voltage on the grid are used instead of r.m.s. then the formula is:

$$P = \frac{(u E_{gp})^2}{9\ R_p}\ 10^3 \qquad (2)$$

when E_{gp} = peak value of signal voltage on the grid.

Both of these formulas are calculated for the condition that the load is twice the plate resistance —the condition for maximum undistorted output.

These general formulas can be simplified if applied specifically to the various power tubes in use, and the table on this sheet gives these simplified formulas. For example, the power output of a 112A is equal to 2.86 times the square of the r.m.s. value of the a.c. voltage on the grid of the tube.

The column R_p indicates the plate resistance used in calculating the simplified formulas.

Type of Tube	R_p	Power in Milliwatts	
		R. M. S.	Peak
171A	2000	E_g^2	$0.5\ E_g^2$
112A	5000	$2.86\ E_g^2$	$1.43\ E_g^2$
210	5000	$2.86\ E_g^2$	$1.43\ E_g^2$
250	1800	$1.78\ E_g^2$	$0.89\ E_g^2$

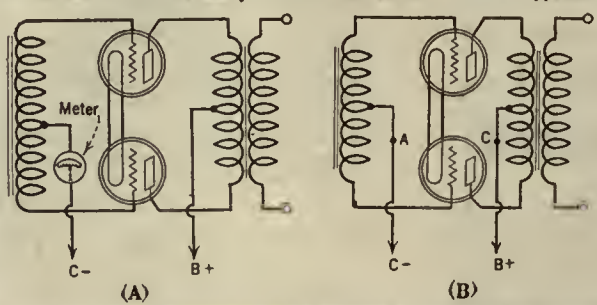
No. 271 — Radio Broadcast Laboratory Information Sheet — March, 1929

Test for a Faulty Push-Pull Amplifier

SEVERAL letters have been received recently by the Laboratory relative to the operation of push-pull amplifiers. Evidently some servicemen, quite capable of servicing any ordinary type of amplifier, are frequently unable to repair the push-pull amplifier that does not give good quality but which is wired correctly, uses good apparatus, and employs tubes that take normal plate current. The trouble is generally due to oscillations in the push-pull amplifier but to detect these oscillations it is necessary to apply to the push-pull amplifier a somewhat unusual test.

The test which is necessary to detect the oscillations consists of placing a meter in the C minus lead to the push-pull stages to determine if there is any grid current. The location of the meter is shown in sketch A. Under normal conditions there will be zero current in the grid circuit but if the circuit is oscillating several milliamperes may flow in the grid circuit. If such a test indicates that an amplifier is oscillating, then one or both of the following remedies must be applied.

The first thing to do is to connect a 50,000-ohm resistor in the common C-minus lead at the point indicated as "A" in sketch B; this resistance should *not* be bypassed with a condenser. The fidelity will not be affected in any manner by the inclusion of this resistor in the circuit but it is practically always effective in suppressing the oscillations.



In some cases a second change may have to be made to suppress completely the oscillations. If the resistance is not entirely effective, a choke coil, such as might be used in a B-power unit, may be connected at point "C" in sketch B. A choke coil must be used here instead of a resistance because of the loss in plate voltage which would be produced by a resistance.

No. 272 — Radio Broadcast Laboratory Information Sheet — March, 1929

Importance of Correct Filament Voltages

THIS Laboratory Sheet supplies additional information on the subject covered in Sheet No. 254 published in the January issue. The latter sheet suggested the use of somewhat lower than rated voltage on the filaments of 226- and 227-type a.c. tubes. The information which follows from R. M. Wise, Chief Engineer of E. T. Cunningham, Inc., points out that the use of lower than rated voltages is not to be recommended generally.

"In using new tubes, and particularly with certain tube types, very satisfactory operation will be obtained at considerably reduced voltages. However, we find that reduction of the voltage below a certain point has little beneficial effect on tube life, and in some cases may shorten it due to the fact that the coated filament at times loses its activity when operated at very low temperatures.

"As an example, we find that average new c-327 tubes will give excellent performance below 2.0 volts, yet the emission life of the cathode at this temperature is not as satisfactory as is the case when it is operated at, or near, rated voltage.

"The c-327 heater voltage rating has been chosen with all of these factors in view, and, while for detector service we find it advisable for a time to recommend 2.25 volts, this recommendation has never been extended to the operation of the tube as an amplifier. As an amplifier we consider the preferred operating range to be from 2.4 to 2.6 volts, while as a matter of fact it will show satisfactory operation over a wider range of voltages. This recommendation has also been extended to include tubes used for detector service.

"It is particularly important to operate power and rectifier tubes within a range of + or — 5 per cent. from the rated value. Several instances of unsatisfactory operation of type cx-350 have been traced to operation at 6 volts. In each case satisfactory operation was obtained as soon as the filament potential was raised to 7.5 volts.

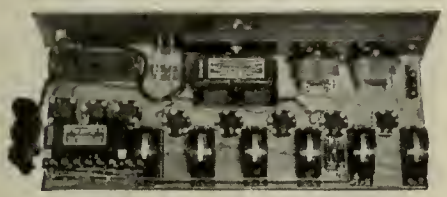
"It is true that there is not much change in characteristics when the tubes are operated somewhat below rated voltage. This holds for new tubes, but the question of maintaining uniform emission throughout the life of the tube is an important factor, and, as previously mentioned, this is best realized by operating the tube close to rated voltages. There is added advantage that when so operated a moderate change in emission will not affect operation, due to operation on or below the knee of the saturation curve, while if operated at reduced voltages a similar change in emission will result in impaired performance."

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Prepared by Official Examining Officer

The author, **G. E. Sterling,** is Radio Inspector and Examining Officer, Radio Division, U. S. Dept. of Commerce. The book has been edited in detail by **Robert S. Kruse** for five years Technical Editor of QST., the Magazine of the Radio Relay League. Many other experts assisted them.

16 Chapters Cover: Elementary Electricity and Magnetism; Motors and Generators; Storage Batteries and Charging Circuits; The Vacuum Tube; Circuits Employed in Vacuum Tube Transmitters; Modulating Systems; Wavemeters; Piezo-Electric Oscillators; Wave Traps; Marine Vacuum Tube Transmitters; Radio Broadcasting Equipment; Arc Transmitters; Spark Transmitters; Commercial Radio Receivers; Radio Beacons and Direction Finders; Radio Laws and Regulations; Handling and Abstracting Traffic.

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(Radio Broadcast 3-29)

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BOOK REVIEWS

PRACTICAL TELEVISION By E. T. Larner, with a Foreword by John L. Baird. D. Van Nostrand Co., New York, 1928. 175 pages, $3.75.

This book, as one of the earliest texts on television, is a volume of some importance, although, judging by the price in comparison with the number of pages, the publishers do not anticipate any considerable circulation for it.

In his Foreword Mr. Baird asks, "Where better can we seek for truth than in scientific research? Sport, Business, Art, Music, and all the other avenues into which man directs his energies, are tainted with commercialism, self-interest, passion, and emotion." It is painful, beside such iridescent idealism, to be forced to quote the irresponsible ballyhoo of Captain Oliver George Hutchinson, Managing Director of Baird International Television, Ltd., who is engaged in promoting Mr. Baird. Said Captain Hutchinson on a recent visit to the United States:

"I am happy to say that no longer is the 'Television' in a state of experimentation. John L. Baird, the inventor, has perfected the instrument, so that it can no longer be said to be in a visionary state. It now reproduces, in the minutest detail, the features and the actions of a human being on a glass disc which can be a part of one's radio set at little cost.

"A month ago Mr. Baird went a step further, a step which brings nearer the possibility of seeing actions at the time they are actually taking place, sent from a distance in their natural colors with their natural lighting—green fields, blue sky, sunset, even the varied colors and movements of the English Derby scene. In other words actual vision in color has been transmitted. This, combined with the transmission of scenes in daylight, will mark the greatest advance toward seeing from afar in their natural state without any artificial lighting, scenes and people as they exist."

Thus, the duly authorized spokesman of Mr. Baird. "No longer in a state of experimentation!" "Perfected!" "Reproduces in the minutest detail!" Any one who knows the theory and practical status of present-day television, including Mr. Baird's brand, will tell you that it is in a highly experimental state, far from perfection, and that it reproduces only objects of limited size, moving slowly if at all, and with details missing. Mr. R. P. Clarkson, in his television articles in RADIO BROADCAST (July and August, 1928) depicts the present field of television much more accurately.

Aside from a tendency to act as one more of Mr. Baird's press agents, Mr. Larner has written an informative book. After an introductory chapter he proceeds with a historical discussion, in which he states truly that the name of the early inventors in the field is legion. He mentions Caselli, Bain, Bakewell, Vavin, Fribourg, the ubiquitous Edison, Mimault, Willoughby Smith, Senlecq, Graham Bell, Aryton, Perry, Kerr, Middleton, Connelly, McTighe, Hick, Carey, Bidwell, Knudsen, De Bernouchi, Ruhmer, Rignoux, Fournier, Szczepanik, Rosing, Campbell Swinton, Korn, Poulsen, M. J. Martin, the Bell Telephone Laboratories, Thorne Baker, Ranger, Marconi's Wireless Telegraph Company, Ltd., The Radio Corporation of America, Belin, Hollweck, Dauvillier, von Mihaly, Jenkins, Alexanderson, and Baird. Larner himself is an engineer of the British Post Office, but, save in the case of Baird, he seems to have little pro-British bias in his historical résumé.

The chapter on "Photo-Electricity and the Photo-Electric Cell" will interest sound-movie technicians as well as experimenters in the field of television. There is a reasonably comprehensive discussion of the vacuum and gas-filled types, with descriptions and curves of the British General Electric Company's potassium and potassium-argon cells, the Cambridge Instrument Company's potassium-helium cell, a somewhat inadequate treatment of methods of coupling photo-electric cells to amplifying systems, and a brief description of the three- and four-electrode type of photo-cell in which the transition from the photo-electric device to the input of the amplifier is affected internally in a single tube.

Reviewing television research in the form of specific attempts, Larner outlines two general solutions: (1) Imitating the construction of the eye by using a large number of selenium cells, forming a mosaic of the scene; and (2) Using one cell only and causing the illuminated elemental areas of the scene to fall in rapid succession on this cell. The first attempts followed method (1) and failure was due to the lag of the cells and the complication of multiplying cells, controls, and wires. By the second general method partial success was attained by a considerable number of the investigators. Among others Jenkins's prismatic disc, the Moore glow lamp, and Alexanderson's 1927 seven-channel apparatus are mentioned. Following this chapter there is one on cathode-ray devices and another on optical aspects ("Images and their Formation"). Chapter VIII is entirely devoted to the Baird televisor. The three-disc transmitter and Baird's other devices are clearly diagrammed. The last two chapters of the book include a discussion of television technique.

This book has the virtues and defects of any premature treatment of a scientific problem. Although the major principles of television are old, it is only recently that methods and apparatus have been refined to a point where a restricted success could be achieved. Mr. Larner has written his account while methods are still everywhere in flux and before any authentic commercial solution is in sight. He deserves credit as a pioneer in the literature, but of necessity his work is incomplete, and to a large extent lacking in perspective and impartiality.

CARL DREHER.

Letters from Readers

Service Men Disagree

DURING the last few months considerable space has been devoted in the pages of RADIO BROADCAST to articles of interest to radio servicemen; notable among these was the series of experiences in radio servicing which were recounted by Mr. Alcorn, a practicing serviceman. Considerable interest in material of this nature has been manifest in recent letters which have been received from readers. Although much of the correspondence has been very liberal in its praise, other letters have contained constructive criticism which is also appreciated.

In the following paragraph are excerpts from a letter written by the president of QRV Radio Service, Inc., one of the oldest and largest service organizations in New York City. Although the views expressed in this letter do not coincide with those of Mr. Alcorn, the arguments are very interesting.

To the Editor:

We are roused from our literary lethargy by a driving desire to comment on the service article by Mr. Alcorn, appearing in November RADIO BROADCAST. We strongly disagree with the author's opinion that the cost of manufactured set analyzers is prohibitive. We believe that, if a service organization is to function to the optimum efficiency, its servicemen in the field must be equipped

(*Continued on page 356*)

For the New Tubes!



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for A. C. Sets

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This improved NATIONAL Tuning Unit embodies matched condensers for better single control, and coils designed for use with this wonderful new A. C. Tube.

For the new R. C. A. Power Tube

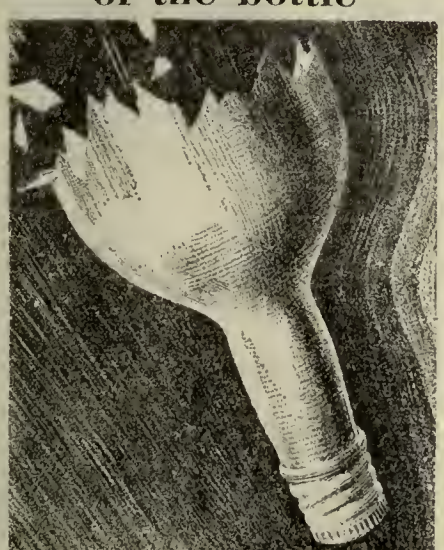
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BROADCASTING FROM THE INSIDE

EVERY month in RADIO BROADCAST appears the department "As the Broadcaster Sees It," written by Carl Dreher, one of the best known broadcast engineers in the country. Alive with humor, news, apt and searching comment, Mr. Dreher's writings have become one of the most popular features of radio writing anywhere. Are you reading it? Subscribe by the year and make sure of not missing a single issue. Mail your check for $4.00 to Subscription Department, Doubleday, Doran & Co., Inc., Garden City, N. Y.



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Letters from Readers

(*Continued from page 354*)

with the most complete time-conserving testing apparatus obtainable, within the limits of practical portability. We believe that a good set analyzer, or diagnoser—as we prefer to call them—when carried by an intelligent experienced radio serviceman who is thoroughly familiar with the uses to which such a device may be put, will pay for itself within six months, by reason of increased efficiency in locating trouble exactly, in saving of time, and also in the very beneficial psychological effect on the customer.

As one concrete example of the value of a good-diagnoser, in rebuttal of Mr. Alcorn's statement to the contrary, a really well-designed one will accurately show an open r.f. grid suppressor, as well as other open circuits in the r.f. portion of a receiver.

JOHN S. DUNHAM, New York City.

A copy of these paragraphs of Mr. Dunham's letter was forwarded to Mr. Alcorn, and the following reply has been received to the opinion expressed above:

To the Editor:

I have read with interest the comment received from Mr. Dunham on my November article. I disagree with your correspondent, because the costly elaborate test equipment is prohibitive to the small radio dealer who has only two or three servicemen. Of course, if an organization is as large as your correspondent's seems to be, judging from his letter, the cost of testing equipment is not as important, especially if servicing constitutes the entire activity of the business. On the other hand, the small dealer finds that an outlay of about seventy-five dollars for the portable test equipment of each serviceman is considerable, unless his financial condition is much better than the average.

B. B. ALCORN, Kew Gardens, N. Y.

No. 32 Tinned Hair Wire

SINCE the publication of the article "From Milliammeter to Multimeter" in June RADIO BROADCAST a number of readers have asked where the wire specified for the shunts may be obtained. The author of the article has come to our aid in answering this question.

To the Editor:

The No. 32 tinned hair wire, specified in the article "From Milliammeter to Multimeter," consists of an annealed steel base on which a coating of tin has been applied. It should be obtainable at any good hardware store. The Pickering Hardware Company, Fifth and Main streets, Cincinnati, Ohio, can furnish the wire on five-cent spools. One spool is more than sufficient to make the shunts described.

G. F. LAMPKIN, Cincinnati, Ohio.

Our Policy Appreciated

A QUESTION always open to debate is whether a radio publication is justified in mentioning in its columns the trade names of manufactured parts. It is our opinion that readers derive the greatest benefit from articles when complete information is given, but all magazines do not agree on this point. A letter from South Africa shows the foreign reader's reaction to our policy.

To the Editor:

I wish to express my appreciation of the fact that you always mention the name of the manufacturer when describing a circuit in your magazine. This is particularly desirable from the viewpoint of readers in foreign lands. As you may easily understand, it often takes months to secure apparatus from the United States, and when trade names are not included in an article the time required to secure

(*Continued on page 358*)

SCREWDRIVER
RESISTANCE

Don't Guess

at resistance values! You can't fool electricity. Instead, use a DUPLEX CLAROSTAT, with its double-barreled resistances, instantly adjustable to any values by means of of an ordinary screwdriver. Neat. Compact. Practical Inexpensive. Foolproof. Just the thing for plate and grid-bias voltages for any set. And don't forget



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Tubes are the heart of radio. Engineers, Service Men, Laboratory Workers must know how good their tubes are. Tube measuring equipment for either the determination of a single tube constant, mutual conductance, or for the most extensive examination of tube characteristics has been designed by the General Radio Company.



To test a number of tubes of the same type, the Mutual Conductance Meter—Type 443 is sufficient to cull the bad tubes from the good. This Bridge has a single dial calibrated directly in Mieromhos with an accuracy of adjustment that is greater than the average uniformity of production tubes. This margin of aceuracy is the user's guarantee that after the Mutual Conductance bridge has discovered the secret of the tube, the story is told. This bridge is now used for production tests in tube p.ants, by dealers who want to protect themselves and insure their customers will get wide awake tubes, and by service men—everywhere, in fact, where a quick tube test is desired.

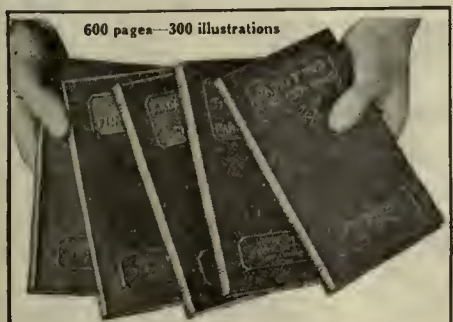
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The Mutual Conductance Meter is but one item in an extensive line of laboratory apparatus, including decade resistance boxes, wave and frequency meters, crystal control apparatus, inductance, resistance and capacity standards, attenuation networks, and high quality audio frequency amplifying and power equipment.

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The new Jensen Auditorium Speaker has already been announced. It is designed to operate with all types of amplifiers from the smallest with one tube to the largest with push-pull stages employing type 250 tubes.

And in sensitivity, in brilliance and separation of tones, in its ability to reproduce tremendous volume, this speaker is unmatched by any other reproducer ever made.

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Type	Jensen Standard Dynamic Unit	Cabinet	Console
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DA4-110 volt D. C. - -	$55.00
DA5-220 volt D. C. - -	55.00
DA5 AC-110 volt A. C.	70.00

Cabinet and Console Models and Prices to be announced shortly.

the 1929 Jensen DYNAMIC SPEAKERS

Letters from Readers

(Continued from page 356)

apparatus is doubled, due to the necessity of first writing the publication for the trade names of the parts required.

B. Strutt Major,
Johannesburg, South Africa.

Short Wave Stations

MANY radio listeners equipped with short-wave receivers are anxious to pick up the signals of experimental telephone stations operating on frequencies within the range of their set. In this connection Radio Broadcast has endeavored to prepare a schedule of short-wave transmissions, but it has been found that the hours of operation of these stations is varied from day to day. The list which is printed below contains as much accurate data as it is possible to publish at the present time. The principal stations of the world, which may be heard regularly in this country with a simple short-wave receiver, are listed in the order of their assigned wavelengths.

Call Letters	Location	Wave-Length
PCLL	Kootwijk, Holland	18.4
W2XAD	Schenectady	19.56
WOWO	Fort Wayne	22.8
W2XAB	New York	24.0
W8XK	Pittsburgh	25.4
5SW	Chelmsford, England	25.5
CJRX	Winnipeg, Canada	25.6
2FC	Sydney, Australia	28.5
2ME	Sydney, Australia	28.5
W2XAL	New York	30.91
PCJJ	Eindhoven, Holland	31.2
W2XAF	Schenectady	31.48
JB	Johannesburg, S. Africa	32.0
3LO	Melbourne, Australia	32.0
W2XAI	Newark	43.0
WBZ	Springfield	50.0
WLW	Cincinnati	52.02
WTFF	Mt. Vernon, Va.	56.0
AJG	Nauen, Germany	56.7
W2XE	Richmond Hill	58.5
GC	Paris, France	60.0
3XL	Bound Brook	60.0
W9XU	Council Bluffs	61.06
KDKA	Pittsburgh	63.5
W6XAR	San Francisco	65.0
W2XBA	Newark	65.18
WBZ	Springfield	70.0

Mexican Short-Wave Stations

The following is a new list of radio-telephone stations in Mexico which has just been received from Mr. L. Lujuan, Consul of Mexico.

RADIO BROADCASTING STATIONS IN MEXICO*

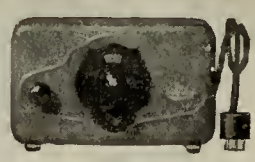
Owner	Call letters	Power Watts
Raul Azcarraga, Mexico, D. F.	CYL	500
"El Buen Tono," Mexico, D. F.	CYB	500
C stulo Llamas, Mazatlan, Sin.	CYR	500
Pablo Langarica, Mexico, D. F.	CYX	500
Roberto Reyes, Monterrey, N. L.	CYM	200
F. Zorilla, Onxaca, Oax.	CYF	100
Partido Socialista del Sureste, Merida, Yuc.	CYY	105
Efrain R. Gomez, Mexico, D. F.	CYS	250
Miguel S. Castro, Mexico, D. F.	CYH	105
Murtinez y Zetina, Mexico, D. F.	CYO	101
Secretaria de Educacion Publica, Mexico, D. F.	CZE	500

*All stations are licensed to operate on wavelengths between 350 and 550 meters.

EXPERIMENTAL MEXICAN RADIO STATIONS*

Owner	Call letters	Power Watts
Constantino Tarnava, Monterrey, N. L.	24-A	20
Rodolfo Krause, Tampico, Tamps.	26-B	20
Liceo Fuente, Saltillo, Coah	23-A	100

*Experimental stations are licensed to operate on wavelengths between 100 and 250 meters.



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"AERO-CALL" SHORTWAVE CONVERTER

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Factory-Built, Ready to Plug Into Your Present Radio Set

The Aero 1929 Converter is a compact factory-built short-wave adapter equipped with special short-wave coils. It is designed for both A. C. and D. C. sets. Operates perfectly on A. C. or D. C. sets without motorboating, by an auxiliary filter system control. It can be plugged into any regular radio set. This amazing radio instrument now makes it possible for you to reach 'round the world—England, Germany, Holland, Australia, Panama, Java and many foreign countries are some that are tuned in regularly on short-wave. Permits you to enjoy international programs and many others from coast-to-coast that your regular receiver cannot get. What a thrill it is to plug this into a tube socket on your regular set and instantly be in another world! No change or wiring required. All complete, ready to operate, tubes and coils hidden, no apparatus in sight, except the neat, golden-brown, compact metal cabinet in crackle finish. Size, 9x5½x2½ In.

The only converter we know of that really works on all sets. Two models—A. C. and D. C. Write for Catalog and literature, or send $25.00 and name of your dealer.

Model A, without tube, for A. C. sets } $25
Model D, without tube, for D. C. sets }

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Gentlemen: Please enter my subscription to RADIO BROADCAST for two full years at the special rate of $6.00—saving me $2.00 on the regular subscription price.

(If you are already a subscriber your subscription will be extended for two full years from date of expiration.)

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☐ Engineering Executive
☐ Service Engineer
☐ Engineer

Radio Retailing
☐ Owner Radio Store
☐ Manager Radio Dept.
☐ Other Outlet

Radio Wholesaling
☐ Sales Executive
☐ Service Executive
☐ Serviceman

Radio Servicing
☐ For Dealer Organizations
☐ Independent

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(Other Radio Connections)

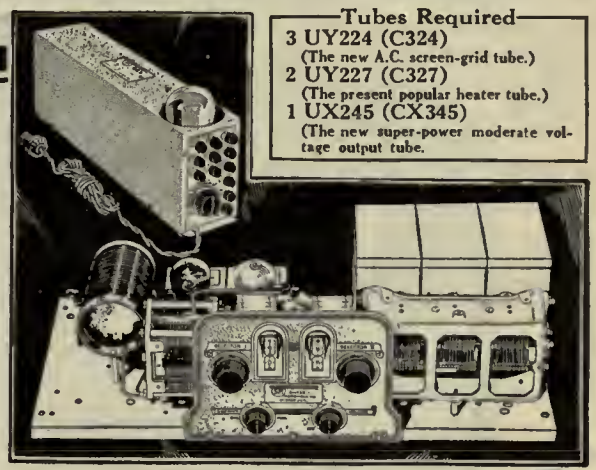
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S-M 720AC All-Electric Screen-Grid Six



Tubes Required
3 UY224 (C324)
(The new A.C. screen-grid tube.)
2 UY227 (C327)
(The present popular heater tube.)
1 UX245 (CX345)
(The new super-power moderate voltage output tube.

Know How Next Year's Best Will Sound

A SCREEN-GRID tube with A. C. heater-type filament, *nearly twice as good* as the wonderful UX222—and the '22 in S-M 1929 sets is enabling S-M setbuilders to get station after station never heard with common factory-built sets. . . A power tube with more than sufficient undistorted output capacity to fill the best dynamic speaker—yet *without* the high plate voltage required for the 250. . . Every refinement of precision manufacture as built into the tremendously successful 720 (D.C.) Screen-Grid Six—plus improvements which make the new 720AC All-Electric a set capable of far better reception, both as to distance range and selectivity, and tone quality as well, than even the original, never-yet-equalled, 720. . . Be the first on the ground with it! Get your order in at once to your S-M jobber or dealer.

Used with the new S-M 669 power supply, the 720AC is a complete all-electric receiver designed especially to bring out the extreme possibilities of these new tubes. Price, completely WIRED in 700 two-tone shielding cabinet, less tubes and power unit, $117.00. Component parts total $78.50; cabinet $9.25 additional. S-M 669 Power Unit, WIRED, $57.50.
S-M 720 receivers can be changed over at slight cost to the 720AC circuit.

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The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries

. . . *among other things*

SO MANY of you have said so many nice things about the March issue that there was some wonder in the editorial offices about the possibilities of compliments—and what is more to the point, real use and appreciation—on this number. But on examining the contents, which can be found not far to the left, we are just as proud to launch this issue as we were the preceding one. Mr. Morgan's story on the condenser loud speaker packs all the available information into three interesting pages, beginning on page 369. Mr. Dunham's article on page 375 gives dealers and servicemen an interesting outline of set testing routine which is practical down to the last period. The figures on set and tube sales for the last two years, compiled by the Editor should prove interesting and useful reading for everyone in the industry. And then, Mr. Kruse makes his bow as conductor of the new experimenter's section, Prof. Terman has a corking article on "power" detection, Mr. Jarvis puts a new angle on the selectivity question which is by no means a theoretical one, Roger Wise writes of characteristics of filament rectifiers, and there are our regular departments, all of them unusually interesting.

WE OWE a general apology for an error which crept into Mr. Kruse's article in the March issue which described the work of the Radio Frequency Laboratories. The caption under Fig. 1 should have read: "A model set using screen-grid tetrodes." The caption under Fig. 2 should have made clear that the device shown was used for checking the design of single stages which are placed in the central compartment.

THE May issue will contain the third of Prof. Terman's articles in his series on "Detection" and will deal with the principles of C-bias detection. In addition there is an interesting article on self-shielded coils, a discussion of audio-transformer measurements by J. Kelley Johnson, and many special articles of interest to radio dealers and servicemen. The latest addition to our new news section, "The Radio Marketplace," the Radio Dealer's Notebook, is continued with more practical data. Incidentally, the welcome given this feature by radio dealers has been most encouraging. Dealers who have not seen this feature are referred to page 407 of this issue and to page 332 of our March number. The service side of radio sales—the relation is written in that way intentionally—will not be neglected in our May number: an address given by the Editor at the Federated Radio Trades Association convention in Buffalo will be printed for the first time. That article, "The Inseparability of Sales and Service" emphasizes a division of the dealer's business that has had all too little attention.

—WILLIS KINGSLEY WING.

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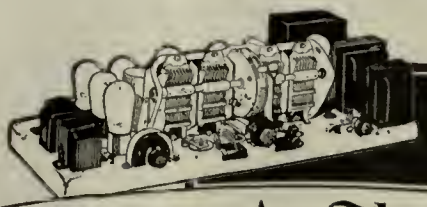
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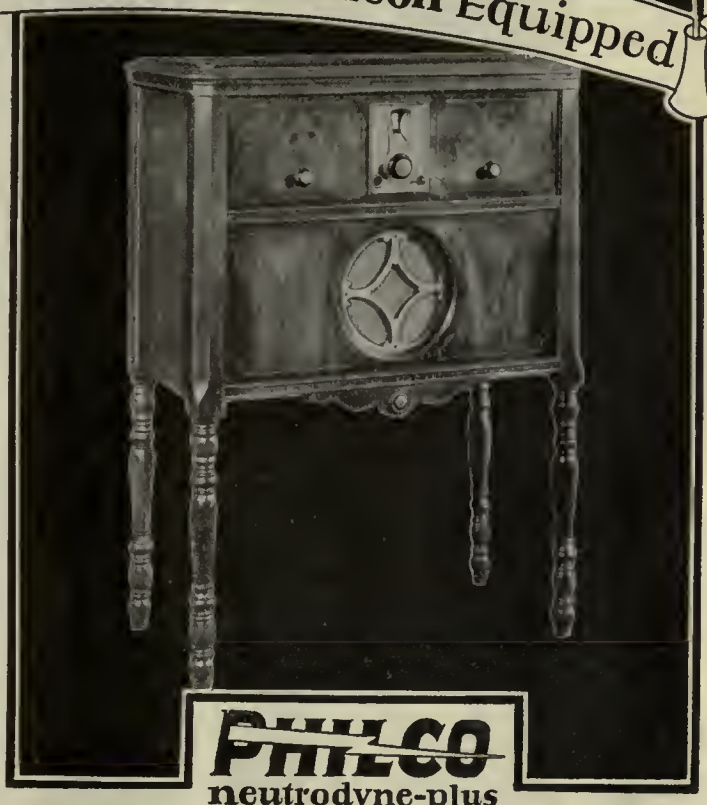
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THE SERVICEMAN'S RESPONSIBILITY TO THE INDUSTRY

It is the serviceman's responsibility to keep the radio receiver sold. The satisfaction which the products of our industry give the user may be jeopardized by unskillful installation and failure to instruct the new owner in the maintenance and manipulation of his new receiver. We recognize the importance of service and no progressive manufacturer is without an active and extensive service organization. Indeed, through the Radio Division of the National Electrical Manufacturers Association, the industry has collaborated in the preparation of a course for dealer technicians, with the objective of improving the standards of consumer contact with the radio dealer after the sale is made.

As radio retreats from the position of a seventh-day wonder and becomes a stabilized fixture in the home, the importance of the dealer technician in the radio structure rises proportionately. We have already observed many instances of dealer success founded upon a reputation for good servicing. RADIO BROADCAST'S *contributions to better servicing by its articles for the instruction of the dealer technician are helping to raise service standards and increasing consumer satisfaction and confidence in the products of our industry.*—L. B. F. RAYCROFT, *Vice-President in charge of the Radio Division, National Electrical Manufacturers Association.*

NEW USES FOR POWER AMPLIFIERS

By FRED H. CANFIELD

One use of radio apparatus that has grown in striking fashion in the last year is the wide application of powerful audio amplifiers to all sorts of non-radio uses. In the installation and operation of these amplifiers, the local radio-trained man, whether he be dealer, independent serviceman, or whatnot, is best equipped to do the work. This article by Mr. Canfield, a member of the RADIO BROADCAST *editorial staff, attempts to show the breadth of the field and how the real demand for public-address equipment can be turned to the profit of the individual.*

—THE EDITOR.

RADIO dealer-servicemen—and everyone else in the business world, for that matter—are approached constantly by promoters and high-powered salesmen who offer—always very confidentially—some "wonderful" get-rich-quick scheme which must be acted upon immediately in order to derive the full benefits. These men have their hooks baited for the novice of the business world and to this class their arguments sound very convincing. On the other hand, the hard-boiled business man, recognizing instantly these men and their schemes, dismisses them from his office as soon as they are detected. Without listening to their story he knows the fallacy, for from experience he has found that earning money legitimately requires hard steady plugging. Also, he suspects (rightfully perhaps) that the salesmen themselves hope to get rich quick by selling him their ideas.

The writer of this article has nothing to sell (except a manuscript now and then), and it does not bring an extra cent to his pocket if radio dealer-servicemen follow the suggestions presented in the following paragraphs. Therefore, inasmuch as there is no ulterior motive, it is advised that serious consideration be given the following plan which points to a way in which radio dealers and service organizations may increase their revenue. No guarantee is given that one's income may be doubled almost immediately, but the ambitious man, who is not afraid to work hard for his money, may find that it is a solution to his problem.

Enough valuable space has now been taken by the introduction so the "meat" of the article will be attacked without delay. The first question which it is necessary for the dealer-serviceman to ask himself is, "From what sources do I derive the greater part of my income?" Secondly, he should debate over the question, "What other sources of revenue are available if I should decide to increase the scope of my business?"

In most cases the answer to the first question is that the business includes the repair of radio receivers, custom set-building, and the sale of tubes, small replacement parts, and accessories. To these three items the dealer may also add the sale of complete receivers. In answering the second question many dealer-servicemen have explained that they have found it difficult to make a business consisting exclusively of radio support a large firm; the result has been that they were forced to enter other closely allied fields such as electrical contracting, sale of electrical appliances, sale of musical instruments, phonographs, etc. The writer advises another alternative for increasing revenue.

The Solution

THE installation of public- and group-address systems is a branch of the radio business which has hardly been scratched commercially, although there is a big demand for specialists in this field. The work provides numerous opportunities for large profit to the serviceman who is willing to go out into the field and dig up prospects. It also has the added advantage of keeping the activities of the firm strictly within the radio field, which is highly desirable for several reasons.

In considering this question a factor which should not be neglected is the good-will publicity which may be derived in public-address work. It must be remembered that every public- or group-address installation is heard by thousands of persons. Therefore, if good reproduction is provided by the apparatus, it cannot help but reflect credit on the firm which engineered its construction. For this reason it is logical to assume that the firm making the most successful large installations will lead also in the servicing field, providing newspaper advertising emphasizes the fact that such work receives the same careful consideration.

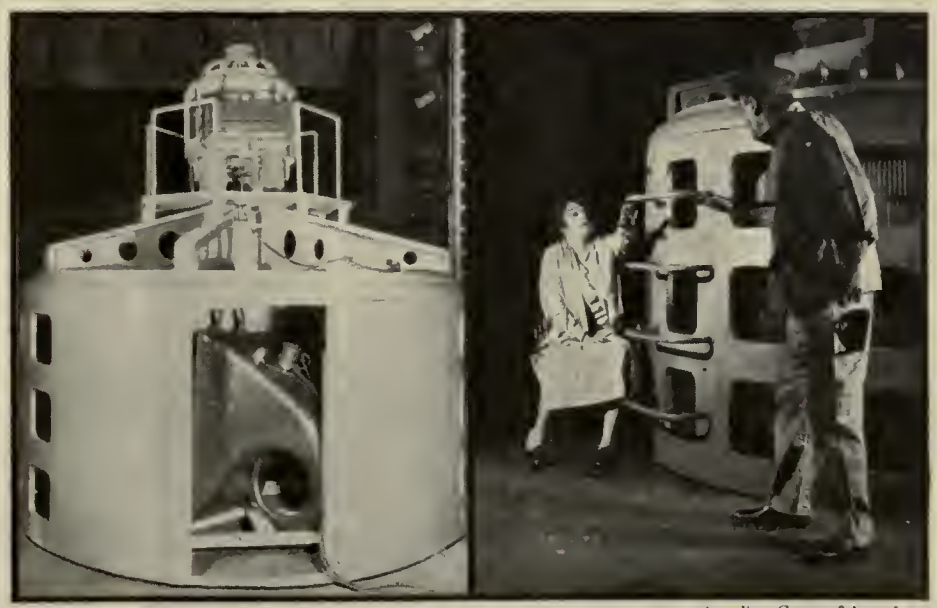
Another factor in favor of public-address work is employment of the same staff of men in all branches of the business. With a little study a good serviceman may learn quickly how to build and install the large amplifiers which are required in this work, and this feature tends to increase the efficiency of the business. On the other hand, if the firm enters the electrical or musical field in order to increase its income, extra trained men are required.

Public- and group-address work should not be considered only as an extension to a regular radio business, as, in most cities, this line of work alone could be made to provide sufficient income for a good size firm. Although it is obviously impossible to build up as large a clientele as in the servicing field, the income derived from each customer per year is much greater, due to much higher cost of the apparatus and the need for more frequent inspections. These factors will be considered in greater detail later.

It should also be pointed out that specialists in public- and group-address work may develop other sources of revenue aside from installing and servicing. For example, many firms renting public-address systems for special occasions have found this a very profitable undertaking. Other radio dealers, after making an amplifier installation, provide an operator for the apparatus during the hours it is in use, and, where an operator is not needed, the amplifier is inspected at regular intervals rather than waiting for a service call. It is also possible, in many cases, for the serviceman to design and build the amplifier rather than install a manufactured outfit, thus providing additional work for the shop.

Selling P. A. Amplifiers

PROBABLY this question has already reached the reader's mind. "How can I sell public- or group-address amplifiers?" It requires hard work in the field until the business is established; hanging a shingle outside your door stating that you are a "specialist in public- and group-address amplification" will not help in most cases. However, even in a small town there are hundreds of potential purchasers who are just waiting for you to "sell" them the idea. In the following paragraphs a few of the various types of installations which have been made by dealer-



—Amplion Corp. of America

A public-address amplifier is used to produce the hum of a dynamo in any desired volume in presenting the play Dynamo *at the Martin Beck theatre, New York City. The rear view (left) shows the electrodynamic horn loud speaker inside the dynamo. The picture on the right shows a scene during the third act of the play*

serviecmen in all parts of the country will be considered.

Dance halls, caharets, restaurants, and road houses are places where puhlic-address systems have heen used with great suecess. In sueh places the amplifier is used mostly in conneetion with an electric turn-tahle for the reproduction of phonograph records, hut it frequently is employed for announcing and for radio music. In the restaurant husiness a puhlic-address amplifier is a real asset as well as an economy. By connecting the amplifier with a phonograph pick-up unit it is possihle for the proprietor to provide his guests with dance music at hours of the day when it would not he profitahle to employ an orchestra for the purpose. In some cases the amplifier is used to supplant the orchestra entirely, and in other cases it is used in conjunction with the orchestra, thus permitting continuous music throughout the husy evening hours. Group-address amplifiers are also used in some large restaurants to provide music for the smaller or private dining rooms; in these cases the music may he picked-up with a mierophone near the orehestra in the main dining room or a phonograph pick-up unit may he employed. Also, in restaurants the amplifiers are used as a eoin-operated affair.

Small motion-picture theatres everywhere are heginning to use puhlic-address amplifiers to provide music during the picture. By using an amplifier to reproduee phonograph records they are ahle to dispense with their pianist, organist, or small orchestra at a great saving of expense, and at the same time to provide *much* hetter music. Nowadays, even in the smallest theatres, one is ahle to listen to the hest orchestras of the country.

Surprising as it may seem many factories have found it very profitahle to providc their employees with music, not only during lunch hour, hut throughout the entire day. In this connection Mr. Cotton of the Samson Electric Company writes, "We have tried in our factory, the proposition of using amplified music on the assemhly help, mostly girls, and have found that when running music the production is increased. The music has a tendency to cut out talking among the girls and keeps their minds off the clock. As a result all hands seem to move faster." This same scheme is used in other factories and the same results are reported in each case.

There is at present a fast growing tendency to use amplifiers for the instruction of pupils in puhlic schools. Many special programs designed especially for schools are now heing hroadcast regularly and for this reason most school amplifiers are provided with a radio tuner. However, amplifiers in schools are also arranged for use with a phonograph pick-up unit as phonograph records have heen found helpful in the instruction of music, languages, etc. In many cases a school installation consists of a comhination public- and group-address system. A group of loud speakers are installed on the platform of the auditorium for the instruction of the school as a group, and in addition a small loud speaker is located in each class room.

A numher of cases are on record where churches and funeral parlors have made use of puhlic-address systems. In funeral parlors they may be used for reproducing phonograph records of a nature suitahle to the occasion when the people holding the service have heen unahle to afford a quartet or musician. Churches as well as funeral parlors have also used amplifiers to permit an overflow crowd in another room of the huilding to hear the services. In particular, several Christian Science churches have found public-address amplifiers very helpful during special lectures.

Selling Group-Address Amplifiers

THERE are just as many persons interested in group-address amplifiers as in public-address installations, hut the different uses for the former are slightly more limited. Apartment house landlords are prohahly the largest group interested in these systems. In the modern radio-equipped apartment house a radio outlet is provided in eaeh apartment and this is supplied continuously with radio music from a group-address amplifier located in the superintendent's apartment. Also, in some apartment houses a duplex system is used to furnish a choice of two programs at the same time. In order to receive the programs it is only necessary for the tenant to plug the cord from his loud speaker in the jack of the outlet plate.

Many hotels and cluhs are heginning to provide the same radio service that the apart-



—Samson Electric Company

A large amplifier is used for instructing pupils at the Frank A. Day Jr. High School, Newtonville, Mass.

ment house landlord is giving. However, in hotels a much larger amplifier is used, as it is usually employed for puhlic-address work in the main dining room as well. Hospitals, veterans' homes, and charitahle institutions of various kinds are also making use of group-address systems hut in these cases headphone outlets are often provided in the various rooms instead of loud-speaker outlets.

Amplifiers For Special Events

IN ADDITION to the places where permanent amplifier installations may he used there are numerous cases where amplifiers are required for special evcnts; in fact, a wide-awake radio dealer should be ahle to rent his puhlic-address system several times each weck. This husiness, which is just as profitahle as installing and servicing puhlic-address amplifiers, also provides excellent puhlicity. It should he unnecessary to mention all of the places where such apparatus may he leased, as the necessity for a puhlic-address system will occur to the dealer when he hears of the evcnt. However, it may be stated that amplifiers are used constantly during hanquets, for intensifying the speaker's voice in remote corners and alcoves of the dining room as well as in other small rooms where guests may he assembled. Private dances, which are held in homes or in rented hall rooms, may also use puhlic-address amplifiers to provide orchestra dance music in the same manner that they are used hy restaurants. At regular annual events such as automohile shows, motor boat shows, music carnivals, etc., puhlic-address amphifiers may often be leased for an entire week. During the foothall and haseball seasons newspapers often find a need for puhlic-address amplifiers to permit them to announce scores and news to the crowds assemhled in front of their huildings. In addition there are numerous advertising stunts where large amplifiers may he used to advantage.

The suggestions given in the ahove paragraph are of greatest valué during thc winter months. However, contrary to most hranches of the radio husiness, there is just as mueh need for amplifiers during the summer as during the colder months. At county and state fairs a radio dealer may find it possihle to rent several amplifiers for one or two weeks at a time. Other times when amplifiers are really needed are during pageants, chureh festivals, water carnivals, horse races, automohile races, heauty contests, haby parades, etc. In faet, the demand for amplifiers could be made great enough, hy proper sales promotion, to makc the summer wceks very profitable for the radio dealer as other husiness is slow and he would he ahle to concentrate his entire attention on this work.

The charge whieh may he made for the rental of a puhlic-addrcss system varies with the use to which it is placed. For strictly commercial purposes where the apparatus is required for several days or a week the dealer may ask as much as fifty per ccnt. of the eost of the equipment. For semi-commercial cvents where the amplifier is needed only for one evening, twenty per cent. of the cost of the amplifier is a fair charge. On special oeeasions, sueh as election eve, on the night of a presidential hroadeast, etc., amplifiers may be rented at a very handsome profit to motion-picture theatres, men's clubs, hanquet halls, and other places of amusement where people assemhle. For church affairs a very low charge, if any, must he made. However, in such cases the dealer or serviceman can afford to provide the equipment free in return for puhlicity received.

Technical Considerations

THE space availahle for this article is not sufficient to permit an adequate discussion of the technical side of the public- and group-address prohlem. However, a few of the important questions will he considered hriefly. Readers who are interested in a more detailed description of the typc of apparatus required are referred to constructional and technical articles which have appeared in previous issues of RADIO BROADCAST ("A Dual Push-Pull Puhlic-Address Amplifier," January, 1929, RADIO BROADCAST, page 195, "An Efficient Push-Pull A. F. System," hy Kendall Clough, February, 1929, RADIO BROADCAST, page 241). In addition, several manufacturers (Silver-Marshall, Inc., American Transformer Company, Samson Electric Company, General Radio Company, The National Company, etc.) have prepared excellent literature describing the type of apparatus required and the method of making installations. In particular, Silver Marshall's house organ, *The Radio Builder*, and their book, *Manual for Authorized Service Stations*, contain much practical and technical data on the subject.

The question regarding which there seems to he the greatest lack of information concerns the size amplifier required for various types of installations. In general it may he said that each magnetic-type loud speaker requires approximately 500 milliwatts (0.5 watts) for normal volume in the average size homc living room. In halls or auditoriums where high volume levels are required one or a group of several dynamic loud speakers provide most satisfactory results. Dynamic-type loud speakers of standard design should not he called upon to handle more than three and one-half watts of power. Where a distribution system with headphone outlets is heing planned about 14 milliwatts (0.014 watts) per pair of phones must hc allowed.

The usual public-address amplifier employs three or four stages with two 250-type tubes in the output circuit. Sueh an amplifier has an output of approximately 15 watts. Larger outputs may he ohtained by connecting two or more push-pull output stages in parallel.

Advantages and Disadvantages of

THE CONDENSER-TYPE LOUD SPEAKER

By JOSEPH MORGAN

International Resistance Company

IN 1881, Professor Dolhear announced the first condenser receiver for telephone systems. This was the fore-runner of the condenser loud speaker which is being introduced into radio to-day. While the principle is interesting and may very well yield important results, there is nothing essentially new in the idea. It is to be noted that the magnetic and condenser types of loud speakers are about equally old in principle and, therefore, we must examine the condenser loud speaker with great care before we pronounce a verdict. It must be evident, therefore, that the condenser loud speaker is no more nearly ideal in its basic principle than the magnetic.

In this article the principle of the condenser-type loud speaker will be set forth together with its advantages and disadvantages. Also, a brief account of some typical loud speakers which are now being manufactured will be given together with a description of the method of application of such loud speakers.

When two conductors of electricity are separated in space by a non-conductor of electricity, we have what is called an electrical condenser. If these two conductors are charged with electricity of like sign, they tend to repel each other and if they are charged with electricity of unlike sign, they tend to attract each other. Suppose that these two conductors are large, flat, metallic plates of equal area, separated by a thin film of air. (See Fig. 1A.) If a difference of potential or voltage is applied to these plates, a force will be exerted tending to draw these plates together, and the force will be proportional to the area, A, of one side of one plate; it will be proportional to the square of the voltage between the two plates; and it will be inversely proportional to the square of the distance, D, between the two plates.

From the above paragraph it is seen that the greater the voltage the greater the force, the larger the size of the plates the greater the force, and the smaller the distance between the plates the greater the force. If we make one of these plates quite heavy and stationary and the second plate very light and movable (see Fig. 1B), the application of a varying voltage to these plates will tend to draw the light movable plate to the heavy stationary plate with a force which will increase as the square of the voltage. If an alternating voltage, for example, the usual 60-cycle, 110-volt house current, is applied between the two plates, the movable plate will tend to move in and out at double the frequency of the applied voltage which, in this case, would amount to 120 times per second. This result would be obtained since the plates tend to pull together both on the positive and on the negative halves of the alternating-voltage cycle (see Fig. 2, diagrams A and B). Thus instead of obtaining a 60-cycle tone by virtue of the motion imparted to the surrounding air by the movable plate, we would obtain a 120-cycle tone. This is a perfect instance of complete distortion, since the original tone is absent and is replaced by one of entirely different frequency.

Suppose that this alternating house current



Colin Kyle (left), inventor of the Kyle condenser loud speaker, is demonstrating his invention to three authorities on radio and acoustics. In his hand he is holding a section of the loud speaker, and standing on the floor is a completed model

As has been predicted in these pages, the condenser-type loud speaker is apt to attract a great deal of attention in the industry during the coming season. What is it? How does it work? How does it compare with other types? These and other questions, Mr. Morgan, of the International Resistance Company, whose previous articles on loud speakers in this magazine have been so well received, attempts to answer. The device is not a panacea; it will not "revolutionize" the industry, Here is a straight-forward analysis of the whole question.

—THE EDITOR.

be replaced by the voice current from the output of a broadcast receiver. It must be obvious that the light movable plate, which we shall henceforth call the diaphragm, would produce a hopelessly distorted sound since it would move in accordance with the square of the voice voltage and at double the voice frequencies.

Minimizing Difficulties

LET us see how these essential difficulties are minimized. Suppose that we place a high direct voltage, for example 500 volts, across the plates of our crude condenser loud speaker. There will be a strong constant attraction between these plates, due to this constant direct voltage. If now we superimpose a much smaller 60-cycle sine-wave voltage upon these same plates, this alternating voltage will tend to increase and decrease slightly the direct potential which we have already established between the plates. In other words, the force will alternately become a little greater and a little less than the initial force due to the direct voltage (see Fig. 2, diagrams C and D).

It can be shown mathematically, that the motion of the diaphragm under these conditions will be approximately in accordance with, and proportional to the alternating voltage applied between the plates. The smaller the ratio of the alternating voltage to the constant applied direct voltage, the more accurately the diaphragm will follow the alternating voltage variations. It is exceedingly important to note that there will always be a component of the motion which is *twice* the frequency of the original voltage and also that the motion will never be *exactly* directly proportional to the applied alternating voltage. In other words, in this type of loud speaker, as well as in the magnetic and electrodynamic types, there is always some inherent distortion. A mathematical analysis of the condenser loud speaker shows that the greatest response is obtained when the plates are as close as possible together and both the constant direct voltage and the alternating applied voltage are as great as possible.

We have just shown that the alternating voltage must be a small fraction of the direct voltage in order to minimize distortion. This, therefore, is our first limitation. Second, the direct voltage, which we shall henceforth call the polarizing voltage, must not be increased beyond 500 or 600 volts because of the danger of break-down between the fixed plate and the diaphragm. Further, it is not safe nor practicable to generate much higher voltages than 600 for such a purpose. Third, the distances between the plates cannot be made indefinitely small for several reasons: (a) because the polarizing voltage would tend to puncture the insulation between the two plates (in this case, air) if the distance were too small; (b) there must be sufficient distance so that the diaphragm may move back and forth in order to impart a mechanical wave motion to the air in front of it; (c) if this distance were too small, the diaphragm might actually strike the stationary plate causing a short circuit if too great a voice voltage were applied or if resonance obtained either in the electrical circuit or in the mechanical construction of the loud speaker. Hence, it is seen that compromises must be effected throughout the design of this type of loud speaker just as in the case of the magnetic and electrodynamic loud speakers considered in previous articles.

As a result of these compromises, the sensitivity and efficiency of the condenser loud speaker is, in general, low. Due to the small permissible distance between the diaphragm and the back plate the large amplitudes of motion necessary for the adequate radiation

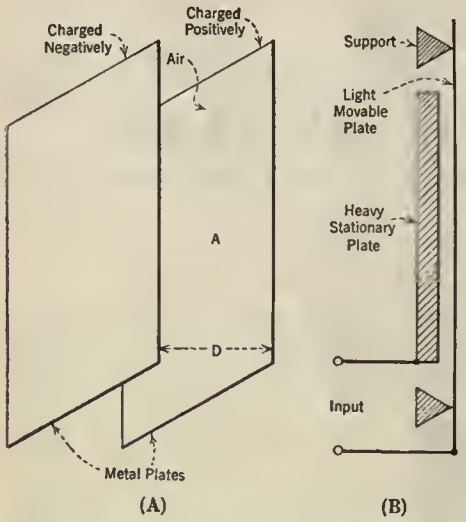


Fig. 1—(A) An electrical condenser; (B) A simple condenser-type loud speaker

of low tones is not practicable. Consequently, it is difficult to obtain adequate response at the lower audio frequencies.

Points of Superiority

AFTER this more or less discouraging introduction, let us now discuss the points of superiority inherent in the condenser-type loud speaker. Chief amongst these is the great simplicity of construction. The loud speaker has but one movable part and contains no coils nor elaborate magnetic field construction. In addition to its simplicity, it can be made to be exceedingly compact. One model of this type is scarcely more than one quarter of an inch thick. A second important advantage is to be found in the fact that the diaphragm is attracted as a whole over the greater part of its surface, instead of being actuated at a point, as in practically all magnetic and electrodynamic constructions. This reduces effects due to complicated modes of vibration of the diaphragm with resultant multiple resonances, and makes possible a smooth frequency-response curve, reasonably devoid of marked peaks and depressions. The third important advantage is the practicability of using exceedingly thin, light, non-magnetic diaphragms of great flexibility and low inertia, thereby making possible the radiation of the high audio frequencies which are so necessary to faithful and intelligible reproduction of speech and music. Another advantage is gained by the use of a large flat diaphragm as contrasted with the small magnetic diaphragms and the conical paper diaphragms used in other loud speakers, since a large, flat surface is better adapted to the radiation of sound.

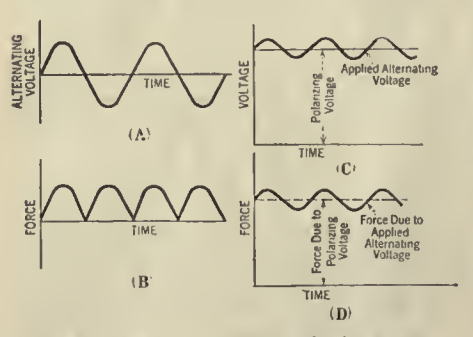


Fig. 2—(A) Variations of alternating voltage applied to a condenser loud speaker; (B) corresponding force variations; (C and D) polarizing voltage eliminates double-frequency effect of (B)

Some features of condenser loud speaker design will now be discussed. The back or stationary plate of the condenser loud speaker must be exceedingly rigid and can be made of any stiff metal. In practice, either iron or aluminum is generally used since they combine the requisite stiffness with low cost. The back plate is usually perforated to permit free passage of the air between it and the diaphragm in order to minimize the loss due to air damping between the plates. A compromise must be secured since too few perforations will allow excessive air damping and too many perforations will cut down the effective area of the plate and hence the force between the plates, thus materially reducing the sensitivity of the device (see Fig. 3).

The diaphragm itself may be made of exceedingly thin, tough metal such as certain of the alloys of aluminum. When so constructed, it is usually very tightly stretched in order that its fundamental natural frequency shall be higher than the highest audio-frequency which it is desired to reproduce. In this way, the natural frequency of the diaphragm will lie entirely outside of the usual audio-frequency range and, therefore, will not cause serious distortion. In one loud speaker designed by Hans Vogt, the metal diaphragm for a 14-inch diameter loud speaker is only 0.015 inch in thickness and weighs less than 0.14 ounce, and is stretched to have a fundamental natural frequency above 15,000 cycles per second.

Push-Pull Design

IN LOUD speakers constructed on this principle, the insulation between the diaphragm and the stationary plate is usually a film of air. In the speaker designed by Vogt,

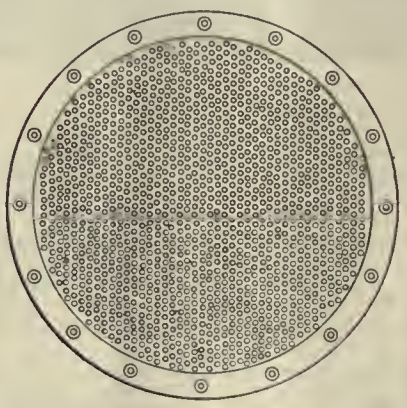


Fig. 3—Perforated stationary plate reduces air damping in condenser loud speakers

the push-pull principle is used as shown in Fig. 4, i.e., the diaphragm is placed between two stationary plates, the diaphragm is under no initial stress with respect to the back plates, and second-harmonic distortion is eliminated. A possible objection to this form of construction which occurs to the writer is to be found in the fact that there is no free passage for the sound from the diaphragm since both surfaces are masked by stationary plates. However, it is claimed by the inventor that this form of condenser loud speaker is quite sensitive and has a long, flat frequency-response curve. The diaphragm sometimes consists of thin, flexible insulating material such as india rubber, gelatine or paper, coated on the outside with gold or aluminum leaf or painted with a conducting material such as graphite. This type of construction has several advantages. In the first place, such a diaphragm is exceedingly light and has no pronounced natural frequency of its own. Second, since it does not have to be tightly stretched, the

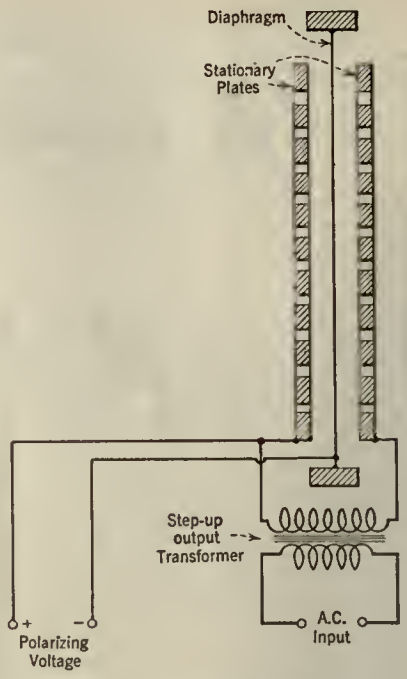


Fig. 4—Schematic drawing of a push-pull condenser-type loud speaker

sensitivity of the apparatus is increased. Third, the insulating material has a property which is known as the dielectric constant and for most insulators, this is greater than for air. Since the force between the plates for a given voltage is proportional to this dielectric constant, a greater force is obtained with such a loud speaker than with one in which air is the sole insulating material.

In one condenser loud speaker recently designed by Colin Kyle, the back plate is perforated and ribbed. Over this back plate is stretched a rubber-like material, called *Kylite*, on the outer side of which is cemented a thin, flexible conducting coating which serves as the diaphragm, as shown in Fig. 5. There are wedge-shaped air spaces between the diaphragm and the back plate. Under the action of voltage applied between the diaphragm and the back plate, these wedge-shaped air spaces tend to become narrower, hence the whole diaphragm behaves as if constructed of a multiplicity of small diaphragms acting in synchronism. It is claimed by the inventor, that this construction yields good sensitivity and a good frequency-response. While it is claimed that the dielectric material used in the Kyle loud speaker has a long life, certain experimenters have found that non-conducting diaphragm materials are apt to change their properties with changes in weather conditions and age. The thickness of the dielectric material in the Kyle loud speaker is 0.005 inch and has a dielectric constant of 3. However, reference to Fig. 5 will show that the force for the given voltage is not equal to three times that of the air-insulation loud speakers since, in this instance, the actual dielectric is a combination of Kylite and air. Therefore, the force is somewhat greater than for air dielectric, but not nearly as great as if the dielectric was Kylite solely. The loud speaker is constructed in units 8 inches by 12 inches. Any number of these units may be connected in parallel in order to give a large surface from which to radiate the sound. As many as 96 of these units have been used together. When a large number are employed at the same time, it is usual to place them on a slightly curved surface in order to prevent the radiated sound from being too directional. The capacity of each section of the Kyle loud speaker is 0.004 microfarads.

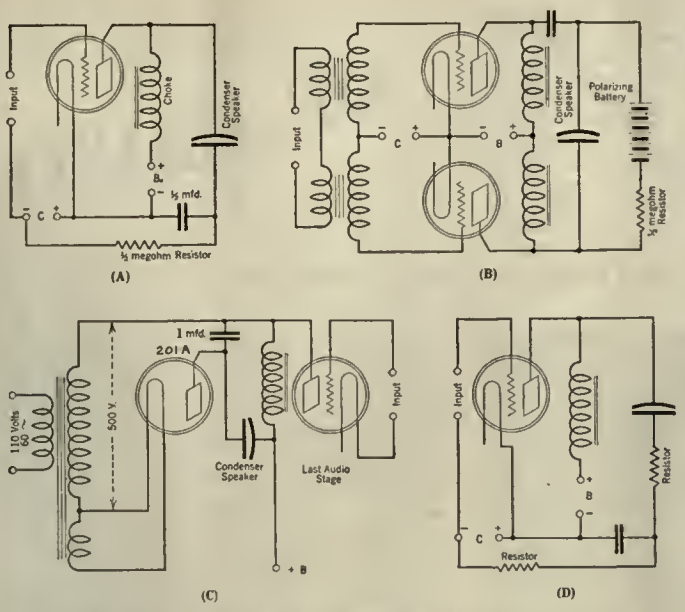


Fig. 6—Circuit arrangements employed for connecting a condenser loud speaker with various types of a.f. amplifiers

Baffleboard Required

JUST as with loud speakers of the electrodynamic type, it is necessary to use a baffleboard or baffle cabinet in order to radiate the lower audio-frequency tones. The same rules apply to the calculation of baffles for this purpose as in the case of electrodynamic loud speakers.

The radio set and associated audio-frequency amplifier must have the same properties as those required for good reproduction with magnetic and electrodynamic loud speakers with the exception of the arrangement of the circuit for the output of the last audio-frequency stage, and the provision of a suitable polarizing voltage. Whereas the impedance of the electrodynamic-type loud speaker is usually very low, averaging approximately 25 ohms at 1000 cycles, and the impedance of the average magnetic-type loud speaker is about 5000 ohms at 1000 cycles, the impedance of the condenser-type loud speaker is very high, that is of the order of magnitude of 50,000 ohms at 1000 cycles. It is, therefore, evident that circuit arrangements must be somewhat different in the case of the condenser loud speaker in order to obtain the proper impedance relationship. If a transformer is used to couple the loud speaker with the output tube of the audio-frequency amplifier, it must have a step-up ratio instead of a step-down ratio such as is usually employed for other types of loud speakers. Such an arrangement is shown in Fig. 4. The last tube may be impedance coupled as shown in Fig. 6A. However, if a low plate impedance power tube is used in the last stage, this is a very inefficient method of connection. A method for connecting this loud speaker with the push-pull amplifier is shown in Fig. 6B. Where the last tube in the set is a power tube, such as the 210 or 250, the B voltage may also be used as the polarizing potential for the condenser loud speaker, as shown in Fig. 6A. Sometimes it is desired to use a separate source of polarizing voltage in which case a step-up transformer, a 201A-type tube, and a 1-mfd. filter condenser are connected as shown in Fig. 6C to provide the polarizing voltage.

Since the impedance of the condenser-type loud speaker is inversely proportional to the frequency, the division of voltage between the resistance of the last stage tube and the condenser-type loud speaker will change with the frequency; the voltage across the loud speaker being greatest at low frequencies and smallest at high frequencies. This quality can be compensated by proper design of the coupling transformer or by the introduction of resistance in series with the condenser-type loud speaker as shown in Fig. 6D. The resistor used must be of the best quality in order that no extraneous noise shall be introduced into the loud-speaker circuit. This latter method improves the frequency-response characteristic at the expense of the sensitivity of the loud speaker, hence, a compromise must be effected between the two. In Fig. 7 are shown curves of the voltage ratio for different values of resistance. R_pC in these curves is the product of the resistance in ohms and the capacity in microfarads. Kyle recommends the value of $R_pC = 65$ for a single section; $R_pC = 100$ for a four section; $R_pC = 180$ for a twenty-four section loud speaker of the Kyle type. It is, of course, possible to design the audio-frequency amplifier in such a manner as to have a rising frequency-response characteristic which will compensate the falling frequency-response characteristic of the condenser-type loud speaker. In this way, a maximum response may be obtained with a very flat frequency-response characteristic. It is not possible to give the details of such design unless the precise characteristics of the loud speaker to be used are known.

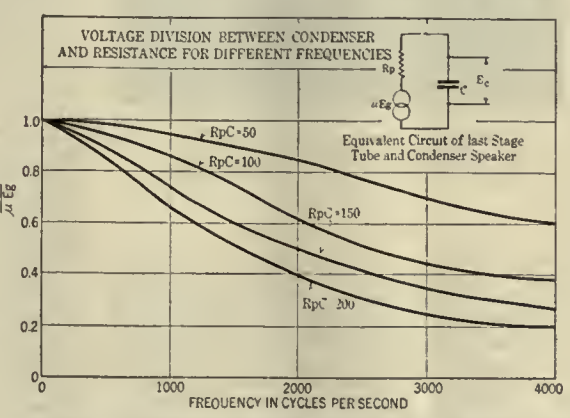


Fig. 7—Curves showing voltage ratio of condenser and tube resistance at various frequencies

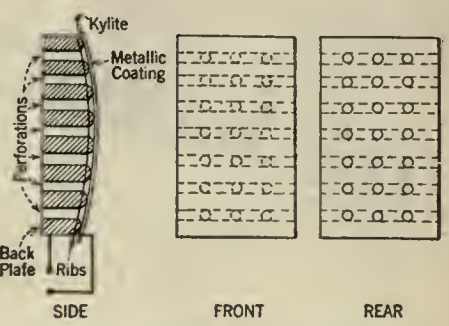
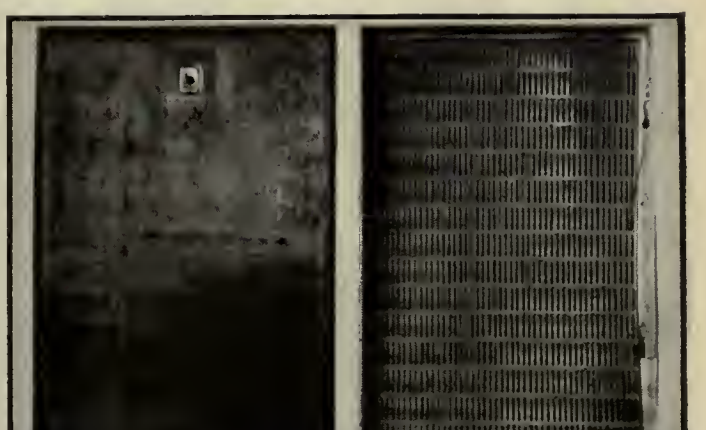


Fig. 5—Schematic drawing of the Kyle condenser loud speaker

Conclusions

IT MAY be seen from the above discussion that the condenser-type loud speaker has many advantages and disadvantages. It is impossible, at this time, to make a valuable prediction as to the ultimate survivor in this field. With present-day power amplifiers, the questions of sensitivity and efficiency are second to that of good frequency-response and if it can be shown that practical condenser-type loud speakers are capable of better frequency-response characteristics than magnetic or electrodynamic types, at least for the time being, this type of loud speaker should find a ready market. However, it is only fair to say that the issue is not a simple one and neither type has as yet been proved to outclass the other. It is hoped that within the near future it will be possible to publish frequency-response characteristics together with the efficiencies of condenser-type loud speakers manufactured for broadcast reception. Until this can be done no reasonable final judgment can be made for or against the condenser-type loud speaker as compared with the standard types now available.

[*Editor's Note:* This is the third article on loud speakers which Mr. Morgan has written for RADIO BROADCAST. The two preceding articles discuss the relative merits and disadvantages of other types of loud speakers and readers desiring further data on the subject of reproducing devices will find them of interest. The first, "All About Loud Speakers," appeared in August, 1928, RADIO BROADCAST, page 188, and the second, "All About the Dynamic Loud Speaker," appeared in January, 1929, RADIO BROADCAST, page 159.—*Editor*]



A close-up view of the front and rear of a section of the Kyle condenser loud speaker. The perforated plate is to the rear

The MARCH OF RADIO

A Well-Balanced Federal Radio Commission

THE nomination of Arthur Batcheller, Radio Supervisor for the Second Zone, to succeed O. H. Caldwell as Federal Radio Commissioner for the First Zone, and of Cyril M. Jansky, Jr., to the Fourth Zone Commissionership, both of whom probably will receive recess appointments from President Hoover before this issue is off the press, is one of the most encouraging indications of better federal regulation of radio which has occurred during the last few months. Both of these men possess high technical qualifications and long and intimate experience with allocation problems. Their addition to the Commission will make it a well-balanced body, both from the technical and legal standpoints. We look forward to greater progress from now on and regret that these men inherit a situation so complex that it prevents them from exerting their fullest effectiveness.

The testimony before the House Committee on Merchant Marine and Fisheries on the radio bill extending the life of the Federal Radio Commission as an administrative body brought forward little that is new to those well informed on radio broadcasting. With respect to the continuance of the Commission, only Commissioner Caldwell, who has already left the body, effective February 23, raised a voice in protest against the commission form of regulation. The remaining members of the Commission are convinced that so many of their problems are unsolved that the present tenure of the Commission should be continued. Broadcasting interests, in general, were indifferent as to whether the machinery of regulation functioned through the Commission or through the Department of Commerce.

As this issue goes to press, Congress passed a bill continuing the Commission until December 31, 1929. There is every hope that President Hoover will seek competent men, who have some understanding of broadcasting problems, to fill any future vacancies.

HIGH-CALIBRE MEN NEEDED

While broadcasting is paramount in public attention, the allocation of high frequencies presents even more difficult technicalities which make it all the more necessary to appoint Commissioners with considerable specialized knowledge, as is the custom with other commissions like the Interstate Commerce Commission. Congress has shown a disposition to meddle with the details of radio regulation and the past record of the Commission, of failure to tackle its problems actively and aggressively, makes it difficult to secure men familiar with the situation and competent to deal with it. The recent nominations, however, indicate that men of high calibre can still be attracted to the onerous duties of Federal Radio Commissioner.

The loss of Commissioner Caldwell, whose firm adherence to principle often led him into difficulties, is one which will be felt most seriously by those who regard broadcast allocation in its broad national aspects rather than from the viewpoint of individual stations or political districts. Caldwell has a better understanding of broadcast allocation as a national and engineering problem than any other member of the Commission, past or present, and he has done more to educate the public and the politicians in the actual difficulties with which the Commission is faced than any other Commissioner. May his shoes be filled by an equally nationally minded commissioner with an equally good engineering background and fully possessed of the diplomatic ability to make that knowledge effective. We hope that Mr. Batcheller will waive his natural reluctance to accepting this appointment.



Adolph F. Linden, president of the American Broadcasting Company which operates the ABC Western Network

Sam Pickard, Commissioner for the Fourth Zone, submitted his resignation to the Commission in order to become Vice-President of the Columbia system. He has risen rapidly from chief of the radio service of the Department of Agriculture to Secretary of the Commission, to Commissioner, and finally to his present position. The congested conditions of the Fourth Zone made his position as Commissioner especially difficult and frequently necessitated reversals of policy, invariably bringing him new difficulties. He faithfully represented the interests of his zone and succeeded in making himself liked by the broadcasters in spite of the problems which his duties entailed.

Congress Considers the Commission's Record

THE allocation of forty high-frequency channels to the Universal Wireless Communication Company was quite severely criticised before one of the committees in these same hearings. Judging from the testimony, little evidence was obtained by the Commission as to the competence of the company in making good use of the vast allocation made to it. If the Universal people ever do get under way with actual commercial communications, they have at least had the benefit of nationwide publicity which should attract business to their channels.

The broad question of whether radio competition with established wire systems of communication is desirable or not is a delicate one to discuss. It has been established quite definitely as a general principle that communication systems are most efficient as monopolies but, as such, should conduct their operations strictly in the public interest without discrimination and at a carefully regulated rate of profit. The Radio Corporation of America is desirous of establishing a nationwide radiotelegraph network for the distribution and collection of its foreign trans-oceanic message business. The Universal Wireless Communication Company is seeking to compete directly with the telegraph companies.

RADIO VS. WIRE AND CABLE

Radio is equipped to handle such a small proportion of the total wire message business that all the fussing about competition with wire communication is still considered a matter of insufficiently significant importance to the wire companies to be worth opposing actively. Radio is, however, a severe competitor to the transoccanic cable systems and has been effective in substantially cutting cable rates. It is for this reason that the overland wire services, with their extensive cable affiliations, have not particularly welcomed the Radio Corporation and have rebuffed its overland message business, making it almost imperative for the R. C. A. to establish a competitive radio distribution service.

Single radio links over long distances can be maintained at lower cost than corresponding wire links. Therefore, a small independent communications company could readily compete with a telegraph system between a few particular points. But the small total volume of traffic and the comparatively few cities which could be taken care of under present conditions would not warrant the scrapping of telegraph systems in part or in whole, while any channels which might be so used would ultimately be required for greatly increased foreign communications. The technicalities and economics of the high-frequency allocation problem and the relation of independent radio and wire systems is altogether too complex for brief annual consideration by Congress. The more competent the men who serve on the Commission, the sooner such problems will be left to it.

IN HIS appearances before the House Committee on Marine and Fisheries, Henry A. Bellows, former Federal Radio Commissioner, now Manager of WCCO and Chairman of the National Association of Broadcasters' Legislative Committee, testified that the Association favored a gradual rather than a drastic re-allocation of frequencies. In such reports of the Association's deliberations as were circulated officially, there was no evidence of any formal declaration to this effect by the membership of the Association, but Bellows, undoubtedly, in his position as Chairman of its Legislative Committee, must have spoken with authority.

A BILL, seeking to appropriate $50,000 for the erection of a standard-frequency station somewhere in the center of the United States, has been placed before the House. Such a station would be extremely valuable

to laboratories calibrating crystal oscillators for use in the broadcast band But who knows how to maintain the standard station on its standard frequency?

More Discussion on Frequency Control

A SERIES of questions were submitted to various associations in the radio field by Dr. J. H. Dellinger, Chief Engineer of the Federal Radio Commission. None of these was more interesting than those concerning the regulation of frequency stability and regulation of synchronizing experiments in the broadcast band. The Institute of Radio Engineers Committee reported that the maintenance of a station on its frequency within fifty cycles is quite possible and commercially feasible. The National Electrical Manufacturers Association Committee, however, stated that the Commission should content itself in maintaining 500-cycle stability, because that would affect as great economy in channels as 50-cycle regulation.

These differing opinions seem to us quite accountable in view of the sources of information. The engineers' viewpoint is that of the laboratory physicist who has demonstrated under laboratory conditions and expert supervision that an oscillator may be maintained within 50 cycles of its average frequency. On the other hand, the manufacturing people know that it is next to impossible to grind a crystal to the precisely correct frequency or to determine accurately just what its frequency is. It must be remembered that the objective of maintaining a station within 50 cycles of its frequency is to enable stations to share the same channels with reduced mileage separation, not to prevent overlapping of carriers on neighboring channels, that objective being satisfied with the obviously feasible 500-cycle regulation.

A 50-cycle deviation produces a maximum heterodyne of 100 cycles which is not heard as a carrier whistle in the loud speaker. But a sub-audible beat, even as little as 15 cycles, has the unfortunate result of producing a ragged effect by modulating the audio-frequency carrier component. While it is possible to maintain two oscillators which happen to be in step for some time, experience has proved that sooner or later a fundamental change takes place in one or the other crystal and the two oscillators cannot be kept in step thereafter. Were any advantage taken of approximate synchronization by closer geographic spacing of stations on the same channel, then such deviations, suddenly occurring without apparent reason, would have the disastrous effect of ruining the service on that particular channel. The fact that 50-cycle stability might be possible under experimental conditions is no immediate indication that any relief can be obtained or more channel space uncovered.

PRECISION OF MODERN STATIONS

The suggestion made by the manufacturers that the Commission first strictly regulate frequency deviations under the present 500-cycle limit is very constructive. This rule has been in effect for over a year, yet the most flagrant violations are tolerated by the Commission. Some difficulty was experienced in obtaining satisfactory crystals when the order first went into effect, but certainly there has been time for the technical staffs of stations to solve the problem of maintaining their carriers within 500 cycles. A good example of license revocation would be a most desirable stimulant to engineering carefulness in this respect.

H. B. Richmond of the General Radio Company states that the cost of a temperature-controlled crystal for monitoring by the heat-frequency method is about $1000, but that control of a station by amplification of the crystal-controlled oscillator is worth about ten times that much. It is doubtful whether the present plan of ten-kilocycle separation can be maintained in full operation without any inter-channel heterodyning unless automatic control of station carriers becomes the rule. Reliance upon the beat-frequency method is the principal cause of the widespread disregard of the 500-cycle regulation.

Regulation of Allocations Attempted

THE New Jersey State Legislature is considering the advancement of radio legislation supplementary to Federal statutes in the effort to "relieve conditions existing since the new allocations," according to J. K. Woods of the New Jersey Broadcasters Association. Since radio communication is distinctly an inter-state function, certainly no state legislation is possible which would interfere with or direct Federal regulation. The State of New Jersey is afflicted with many very small broadcasting stations in the metropolitan area of New York, necessitating considerable time sharing. The leading New Jersey station, won, is not considered by the Association as a New Jersey station, because it obviously serves the entire metropolitan area. The Commission has shown clearly that New Jersey stations are receiving the consideration which is their due under the Davis Amendment and only by moving the State of New Jersey into the Fifth Zone can the present discontent be alleviated. The southern and western part of the State could use the smaller New Jersey stations to much greater effect than the over-served metropolitan area of New York.

In the World of Broadcasting

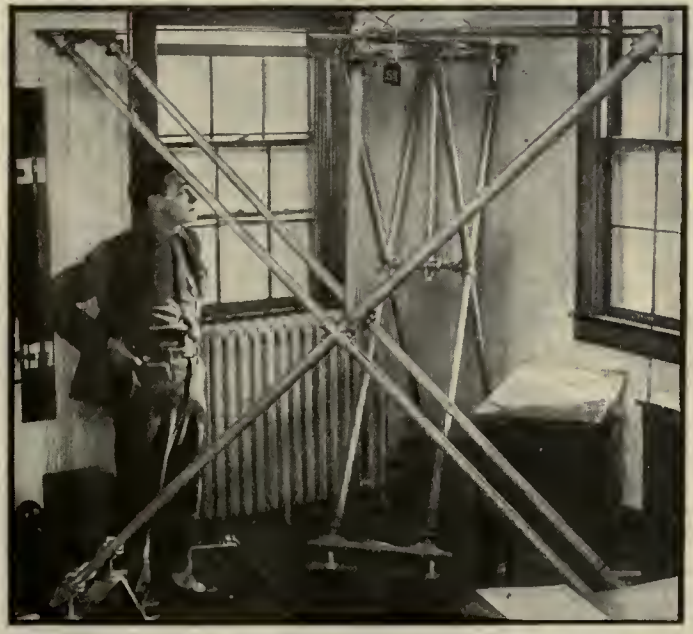
THE American Newspaper Publishers Association has made a survey of the radio situation. Its report states that radio lineage in twenty cities increased but 29.8 per cent. from January to October. This ought to satisfy any reasonable publisher that the editorial space devoted to radio is worth while, but many publishers nevertheless express the opinion that radio programs ought to be classified advertising, paid for by the radio stations themselves. The newspaper publishing business is immensely profitable and we feel inclined to offer the ingenious publishers some other suggestions which may serve to increase their revenues. News of the courts should be paid for as classified advertising by the community; police news should be paid for by municipalities at a classified rate; each stock exchange listing should be charged for at so much per line; death notices should certainly be charged to the estates of the deceased because they cannot protest; news of disasters could well be paid for by the War Department, and huge revenues could be collected from such gentlemen as the handsome Grover Whalen and the stylish Jimmy Walker. The publishers really have not scratched the surface; if they had any imagination, they could so increase the revenue of newspapers that people could be paid to read them.

THE tendency to regard broadcasting as a public utility is further strengthened in the brief of the Federal Radio Commission in the WOK case which states that "broadcasting stations, either partly or wholly, contain all four of the elements usually found in public utilities. By reason of the laws of nature, they serve the entire public within their area without discrimination; if they attempted discrimination by employing a form of transmission which could be received only with a patented device and could not be received with the ordinary receiving set, the Government would soon put an end to the practice. That they are under an obligation to give service during all hours at which the public usually expects to receive broadcasting has already been recognized by the Commission."

This is a clear statement of the obligation of a broadcasting station assigned to a channel to utilize that channel, but there are nevertheless some important differences between radio and recognized public utilities. There are technical limitations which strictly define the amount of traffic which can be handled in broadcasting or high frequencies. A public utility must prepare itself to meet all reasonable public demands for the service which its franchise covers. Public service commissions may order railways to purchase more cars or to extend service while, with radio communication, such extension cannot invariably be made and the time will come when it will become next to impossible. Certainly the obligation of public utility regulation, requiring service to all who apply and can afford the service under reasonable conditions, cannot possibly obtain in radio communication.

THE effectiveness of the chain broadcasting order, limiting the radiation of chain programs to points more than 300 miles apart, has again been postponed by the Commission. So long as the non-chain stations assigned clear channels are of comparatively low power, chain programs are bound to dominate the clear channel region.

A STATEMENT by the National Broadcasting Company, analyzing the programs offered through their key stations, WJZ and WEAF, indicates the still further reduction of the percentage of time devoted to jazz music. The analysis shows 15 per cent., or 36 hours a week, devoted to that type of music,



By means of two 6-foot loop antennas, the U. S Navy are taking cross bearings on static between Anacostia, D. C., and Lakehurst, N. J. In this way they are able to forecast the direction and intensity of storms

28 per cent. to classical, 10 per cent. to novelty and ballad, 4 per cent. band music, 2 per cent. radio drama, 14 per cent. to what is described as balanced features, involving orchestral music, artists, and featured speakers, that is, the typical commercial variety program, 8 per cent. religious, 6 per cent. educational, 6 per cent. women's programs, 4 per cent. health material, and a varying percentage, from 5 to 25 hours a week, to national events. The leading broadcasting systems in foreign countries employ a much larger percentage of their time in spoken and educational features. The tendency in the United States is to appeal to the entertainment demand of the radio public rather than to present the less broad appeal to the educational feature.

THE final breakdown of the opposition of vaudeville business to broadcasting was accomplished when the Radio-Keith-Orpheum hours were inaugurated as regular N. B. C. features. An obvious broadening of radio's appeal is accomplished as a result of recent mergers of the theatrical and concert fields by the consolidation of Radio-Keith-Orpheum and Victor. This is the practical consummation of a trend predicted in past editorials.



Circulating energy at radio frequency, when handled in large amounts, sometimes goes astray. The picture shows the result of an r. f. feedback flashing from the tank circuit of a 50,000-watt broadcast transmitter (WJZ).

A GREAT deal of publicity attended the experiments of KLCN of Blytheville, Ark., which transmitted special programs from one to four a. m. on 1290 kc., using only seven and a half watts power. At the particular hours involved, freak reception over great distances is possible. This, however, is so far short of reliable program service that it is of no great practical value. Short-wave amateur communication to all parts of the world on very small powers is in the same category. Reliable broadcast reception and reliable commercial radio communication must be successful not only under extraordinary conditions but must be of service value at all hours and seasons. It is to be hoped that the successful freak reception of a little Arkansas station in various parts of the country is not regarded as evidence that much lower powers in broadcasting are desirable.

STATION KFAN announces that it will broadcast a news service from 9 to 9:30 a. m. and from 6 to 6:30 p. m., the news to be gathered by its own reporters, stationed throughout the State of Nebraska and at neighboring points. Legislative news will be reported directly from the floor of the legislature. This is the first instance of a broadcasting station relying upon its own news-gathering force.

THE resumption of international broadcasting on a much more advanced technical standard was offered as a surprise to the radio audience through the N. B. C. networks on February 1, when a program picked up from 5sw, the B. B. C. short-wave transmitter at Chelmsford, England, at Riverhead, Long Island, was put on the air through that broadcasting system. The noise level was high, but otherwise the experiment was entirely successful and promises an increase of international program exchange.

Amateur and Commercial Radio

ARISTIDE BRIAND opened the first direct radio telephonic communication between Paris and Buenos Aires early in February. This span of 6870 miles represents the longest commercial radio telephone link, although this record will be exceeded when the New York–Buenos Aires link is put into final operation.

AN INTERESTING instance of the use of transatlantic picture transmission occurred when sketches of a damaged rudder were sent from England to the United States. The cargo liner *Silver Maple* damaged in a storm and awaiting repairs in Bermuda, was saved more than a week's time, estimated at a value of $7000, because the transmission of the sketches by radio enabled a shipbuilding company in Pennsylvania to begin work on the needed parts that much sooner.

ALTHOUGH the conference, held in Canada for the allocation of high frequencies to stations in the North American continent, did not reach a final conclusion, it was agreed that Canadian amateurs shall be permitted to exchange messages with amateurs of the United States and the Philippine Islands of a nature which would not normally be transmitted by any existing means of electrical communication and for which no tolls are charged, for communication with isolated points, having no regular means of message exchange, and for special transmissions of any essential character in emergencies and floods. This is strictly in accordance with the International Radio Telegraph Convention.

THE Mackay Radio and Telegraph Company is soon to place in operation its transoceanic radio service, utilizing the re-conditioned station at Sayville, operated before the war by the Telefunken interests. Several transmitters have been installed, including one with power up to 100 kilowatts. At the time the announcement was made, the Mackay people were still waiting for a license from the Federal Radio Commission.

THE rescue of the crew of the *Florida* by the *America* emphasizes again the value of the radio compass. Due to drift and the difficulty of determining bearings by navigating instruments under difficult conditions, those ships relying on the *Florida's* statement of position searched for it in vain. The *America*, radio-compass equipped, was successfully guided to the spot. Some consideration is being given to making compass equipment compulsory.

GEORGE R. PUTNAM, Commissioner of Lighthouses, suggests that ships hearing SOS calls triangulate their compass readings so that the exact position of the distressed vessel may be determined more accurately than is possible when bearings are taken from a single point.

A 100-watt radio transmitter, suited for installation on all types of aircraft, has been announced by the Radio Corporation of America. The standard equipment includes a wind-driven generator, although the transmitter may be powered from a dynamotor, energized from the usual 12-volt battery sys-



The above illustration shows the quality of pictures which are now being sent over telephone wires by the American Telephone and Telegraph Company. It is actually difficult to detect a difference between the original and the reproduction

tem aboard the craft. It has a 150- to 200-mile telephone range and a 500- to 800-mile range with continuous-wave transmission. The total weight is 89 pounds. Means are provided to use the amplifier for an inter-phone equipment. The Radiomarine Corporation has also developed a special beacon receiver, covering a range from 580 to 1100 meters.

RADIO RETAILING'S annual survey of radio sales predicts a $650,000,000 business for industry during 1928.

—E. H. F.

AT THE January meeting of the Board of Directors of the Radio Manufacturers Association, Joseph L. Ray, General Sales Manager of the Radio Corporation of America, B. J. Grigsby, President of the Grigsby-Grunow Company, and Allan G. Messick, Chairman of the Board of the U. S. Radio and Television Corporation, were elected directors, succeeding three who had previously resigned. It was announced that the Trade Show at Chicago, starting on June 3, this year will embrace the Blackstone and Congress Hotels as well as the Stevens. This may prevent non-RMA members from securing exhibit space adjacent to the Stevens this season as has been customary in past years. An arrangement has been made for the sponsorship under RMA auspices of broadcasting features presented by certain members of the association. A tentative schedule for fourteen weeks of RMA programs has already been arranged for. Progress was reported on numerous other activities.

THE ROUTINE TESTING OF RECEIVERS

By JOHN S. DUNHAM
Q R V Radio Service, Inc.

THE value of an efficient, logical routine in testing radio receivers of all makes, models, and social standing can hardly be over-emphasized. The *Oxford Dictionary* defines the word routine as: "Regular course of procedure, unvarying performance of certain acts, performed by rule." No matter what sort of work one does, any part of which is purely mechanical repetition of the same acts day after day, even though intelligence is required to watch, tabulate, and draw conclusions from the results obtained, much time may be saved and energy conserved by developing an unvarying system of performance of those acts. Fundamentally, there is little difference between radio receivers, and it is entirely practical to devise a routine which may be used universally for the efficient testing of virtually all of them.

Use of Diagnoser

IF THE routine of testing used is to be equally applicable to all sets, then testing equipment must be used which may be applied to all sets with equal facility. The socket contacts of the average modern receiver cannot be reached when the tube is in the socket, and that remains true in some sets even after the chassis has been removed from the cabinet. As it is highly desirable to make some of the essential tests under load conditions, it becomes necessary to use a set-diagnoser ("analyzer" or "tester") to attain that end. If for no other reason, that application alone would be ample justification for the use of such a device.

Fortunately, the set-diagnoser has *many* other advantages which make its use by all servicemen imperative if they are to approach closely the maximum efficiency in doing service work. The set-diagnoser has three distinct and important advantages. It permits a number of essential tests which either are impossible or would consume a totally unjustified amount of time with lesser equipment. It makes all the tests that can be made with ordinary single meters, in much less time. And it has an exceedingly beneficial effect on the customer's impression of the efficiency and ability of the serviceman.

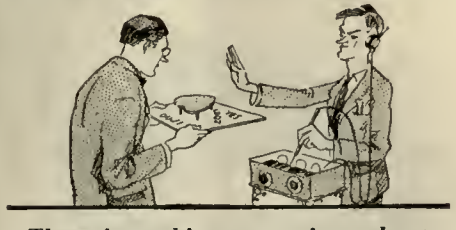
Cost of Equipment

THERE are a good many servicemen and service organizations who are of the opinion that the cost of the manufactured set-diagnoser is prohibitive. We believe a small amount of simple arithmetic can effectively dispel that myth. Five minutes is a conservative estimate of the time saved on the average service call by the use of a good set-diagnoser (we are assuming that the serviceman knows his business, makes all the tests he ought to make, and is thoroughly familiar with his equipment). It is also conservative to assume that the average serviceman can make an average of six service calls per day. Multiplication of six calls by five minutes per call gives a product of thirty minutes saving per day. The serviceman ought to bring in *at least* two dollars per hour for his organization, or for himself if he is working alone. At that rate, the saving of a half hour per day would represent a saving of one dollar per day. The cost to a service concern of a good set-diagnoser is not over $75.00. Paid for at the rate of one dollar per day, three 25-working day-months would accomplish that object. For the remainder of the life of the instrument, the daily saving would be clear profit. The foregoing computation considers only the saving in time, while the money value of the other advantages, added together, is certainly equal to that of the time saved. In the opinion of the author, two months is a fair estimate of the maximum length of time required for a set-diagnoser—properly used by an intelligent, well-trained serviceman—to pay for itself.

A question many dealers and servicemen frequently ask is, "What is the best order of procedure in servicing receivers?" Each service problem is at once the same as every other and different from others. Mr. Dunham, head of one of the largest New York City service organizations, here discusses some of the outstanding phases of this question, and, while he does not attempt hard and fast rules, his thoughts should interest and help those doing this work.

—THE EDITOR.

Even some of the radio set manufacturers have begun to realize the value of their use, and when manufacturers generally come to the conclusion that any particular thing would be advantageous in performing service on their sets in the field, then you may be certain that progressive service organizations came to the same conclusion about two years previously. The American Bosch Magneto Corporation says, in part, in their dealer service manual: "With the introduction and almost universal approval of the a.c.-type radio receiver by the public, the use of some standard and approved radio test set is absolutely essential."



There is nothing mysterious about any radio. Every trouble in radio can be found without the aid of spiritualism, psycho-anal-ism, or guess-ism

Logical Routine Tests

THE ability of a radio serviceman to thoroughly and quickly discover the troubles in any receiver is largely a function of his ability to think logically and to approach the problem, serenely, as one which may *always* be solved by a process of orderly elimination and orderly reasoning out of cause from effect. Every action, whether mechanical, electrical, or chemical, which takes place in a receiver or its associated equipment, is governed by known laws, and any variation from normal action can be determined by known methods. There is nothing *mysterious* about any radio or any radio trouble, except to the man who is not familiar with them. Every trouble in every radio can be found without the aid of spiritualism, psycho-anal-ism, or guess-ism.

Present-day radio receivers are composed primarily of tubes, and secondarily of circuits employed to couple and supply those tubes. As the tubes are the heart of the machine, and the coupling and supply circuits both arteries, veins, and nerves, so are the tube sockets the nerve centers, at which most of the needed information about what is going on in the rest of the system may be obtained. Therefore, any logical system of testing must start at the sockets. More information may be obtained there, far more quickly, than at all other points. One end of each plate, grid, and filament circuit terminates at a socket, *and the other end of each of those circuits terminates at the same socket.* At the sockets one may get plate, grid, and filament voltages, and plate and filament currents.

Tube Tests

TUBES are at once the most important and fragile of the things that comprise a radio receiver. They are the most prolific source of trouble, and, as progress is made by manufacturers in the elimination of other troubles, the ratio of tube to other troubles increases. The serviceman's first object in testing a receiver should be to get as quickly as possible to the business of testing the tubes. They cannot be tested properly, however, unless the voltages applied to them are approximately correct. One must, therefore, test filament, plate, and grid voltages at each socket before the tube may be tested, a statement which requires a degree of modification depending upon the type of set.

Obviously, one does not get grid voltage reading at a detector employing a grid condenser and leak, for no grid voltage is applied when that method of detection is used. Even if it were, the drop caused by the very high resistance of the leak would be sufficiently great to overcome the small applied voltage. Neither is it feasible to test tubes from other sockets to which no grid voltage is applied.

In old battery-operated sets which remain guiltless of a C battery—of which, fortunately, there are few left—the only recourse in testing the tubes is to abandon the set entirely, connect the batteries, and one of the 4.5-volt C



Any logical system of testing must start at the tube sockets

batteries which every serviceman should carry, to the prongs at the end of the diagnoser cable—by means of clip-ended test leads which should also be carried by servicemen—and make the usual I_p-E_g test with the tube in the diagnoser socket. In sets not quite so senile, which have grid bias on the last audio tube or both audio tubes, all of the tubes in the set may be tested from one of those sockets. In more modern apparatus, most of the tubes have grid voltage applied to them, so that those tubes may be tested properly in the diagnoser from their own sockets. Detector tubes employing a grid leak and condenser, oscillator tubes, and sometimes the first detector in a super-heterodyne, must be tested from some other socket. Whatever the type of set, however, *all* of the tubes should be tested, at the earliest possible moment in the routine which is possible without duplication of effort.

It is well to keep always in mind that approximately normal I_p *alone* does not invariably indicate a good tube. For example, there is such wide difference between the I_p ranges of different tubes of the same make and type, that a tube whose I_p range is higher than normal, but whose emission (and therefore mutual conductance) has fallen off just enough, can have a remaining I_p which, at normal voltage values, is approximately the normal *average* for that type of tube. It is also possible for a tube whose emission has fallen to a much lower point, but to the grid of which the normal bias is not applied, by reason of an internal open grid circuit, to continue to show normal average I_p.

Measuring Merit of Tubes

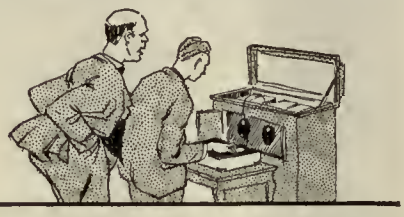
THE measure of merit of one tube against another of the same type is its mutual conductance. Mutual conductance is the *rate* of variation of I_p with variation of E_g over the straight portion of the I_p-E_g curve. A determination of that rate is the only method by which we may know accurately whether a particular tube is doing all it ought to do. All good set-diagnosers possess a means of changing the grid bias, applied to the tube placed in its socket, from the normal value to zero. The amount of I_p change caused by that change of E_g is a rough but sufficient indication of the condition of the tube. Obviously, that change will vary with different applied voltages, and with different types of tubes. It becomes necessary, therefore, for the serviceman to know definitely what the amount of that change should be for different tubes and different plate and grid voltages. While the author does not know of any printed source of such information (which doesn't prove there is none), it is not a difficult fund of knowledge to acquire in the field, and to anyone who is the fortunate possessor of a technically inquisitive mind, the gathering of that data is rather interesting.

It should be remembered that the grid-voltage reading obtained by even a 1000-ohm-per-volt instrument is less than the voltage applied to the tube when no meter load is in the grid circuit, by the amount of voltage drop across the secondary of the preceding transformer. This drop is equal to the current drawn by the meter, multiplied by the d.c. resistance of the transformer winding. The drop across the secondary of an r.f. transformer, with its small d.c. resistance, is so little that it can be neglected, but that is not always true of the secondary of an a.f. transformer. For example, let us assume that the grid-voltage reading obtained when testing a tube from the first a.f. socket is 10 volts on a 50-volt scale. Assuming a one milliampere meter movement, its current drain would be one-fifth of a milliampere, or 0.2 mA. Assuming the d.c. resistance of the secondary to be 10,000 ohms, that value times 0.2 mA equals 2 volts, the drop across the secondary, so that the actual grid voltage applied to the tube with the meter load removed would be 12 instead of 10 volts.



The customer cannot understand the failure of "bad" tubes

Let us take another example, of an output tube. Suppose it is desired to test a 171-type



Using a set tester has an exceedingly beneficial effect on the customer's impression of the ability and efficiency of the serviceman

from its own socket. Assume the grid-voltage reading to be 40 volts on a 50-volt scale. The current drawn by the meter is, therefore, four-fifths of one milliampere, or 0.8 mA. Assume the d.c. resistance of the secondary to be the same as that in the previous case, 10,000 ohms. Then the product of the resistance by the current gives an 8-volt drop across the transformer, so that without the meter the voltage at the grid of the tube would be 48 instead of 40 volts. The drop in each of the two examples given is approximately 16 per cent. of the no-load applied voltage. The percentage drop will increase with increased d.c. resistance of the transformer, and with decreased resistance of the meter. In the case of the 171-type tube test, with a secondary whose resistance is 15,000 ohms, and a meter requiring 2 mA. for full-scale deflection, assuming a no-load grid potential of 48 volts, the drop with the meter load would be 18 volts, or more than 37 per cent. of the applied voltage.

The important point about this grid voltage discussion is that, if the serviceman does not know those factors and does not take them into account when testing the audio tubes of a set from their respective sockets, he may be led to very false conclusions about the tubes and the grid voltages actually applied to them. And the difference between a serviceman who has and applies enough technical knowledge to discover such things, and the serviceman who is devoid both of technical knowledge and desire to acquire it, is usually a large proportion of the difference between a really good serviceman and one who might possibly be a very good plumber.

From a practical business standpoint, tubes whose emission, or mutual conductance (I_p change with E_g change), has fallen appreciably below normal should always be replaced with good tubes. Putting a fairly good tube in some other socket, where it *may* perform practically as well as a new tube, very often results in a no-charge return call within a few days, to replace that tube. When the emission of a tube starts to fall off appreciably, it usually continues to do so at a fairly rapid rate. That is especially true of thoriated filaments. You may expound to the customer the fragility of tubes, the rapidity with which they can become inoperative, and the fact that the manufacturer does not guarantee them, until you are reduced to whispers, but, while he is usually willing to pay for new tubes, he is rarely willing to pay for a return call made within a short time, and no amount of eloquence will thoroughly convince him that such a return call is not due to the negligence or inexperience of the serviceman. And in that belief, *the customer is usually right.*

Microphonic Tubes

NEXT to tubes whose emission has fallen off, microphonic tubes give the most trouble. The detector tube is normally the worst offender, because the audio-frequency variation of plate current set up by mechanical vibration of the tube elements is amplified through all of the audio system. While that same tube may not appear to be microphonic to the degree that it produces a howl, when placed in the first a.f. socket, it is *not* wise to do so, because the condition usually grows worse and within a short time the amplitude of vibration can become sufficiently great to produce sound from the loud speaker when amplified by only the second transformer and last tube. If the microphonic condition in a set is to be remedied by shifting tubes, it should, therefore, never be done by simply exchanging the detector and first a.f. tubes, but always by selecting a quiet tube from one of the r.f. sockets.

Sometimes proximity of the loud speaker causes a degree of additional vibration. In these instances moving the loud speaker farther away also removes the microphonic condition which existed. In cases where a separate loud speaker is used, that remedy is always worth trying. In some cases, when neither moving the loud speaker nor shifting and replacing tubes will effect a cure, the placing of lead weights—manufactured for that purpose—on top of the detector and first a.f. tubes may be effective. If none of those remedies cures the patient, the only remaining one is to re-mount the socket on sponge rubber, or other shock-absorbing material, and make flexible leads. In normal cases, when it is simply a case of tubes themselves, no tube should be left in either of the two critical sockets if the ring caused by tapping the tube sharply with the forefinger is sustained for more than two seconds.

There are few things more exasperating to a serviceman than to put into a set one of the tubes he has with him, and find it to be open, shorted, or paralyzed. The remedy for having poor tubes turn up on the job is to have each man turn in for test, *at least* once a week, every tube he has been carrying, and to enforce rigidly the rule that no tube shall ever be returned to stock, even if it has been out only half an hour, without first having been tested properly. If we may be permitted to digress briefly, in closing Part I of this article, it has always seemed to us that the word *paralyzed* is the most fitting word in the English language to express, for practical purposes, the condition of a radio tube whose emission has become very low. Some years ago a radio engineer of our acquaintance took violent exception to our use of the word, and we were unable to convince him that Webster's definition describes the tube's condition perfectly, insofar as its ability to work goes, which is, after all, the thing in which we are chiefly interested.



The serviceman's first object in testing a receiver should be to get at the business of testing the tubes as quickly as possible



STRAYS *from* THE LABORATORY

Vacuum Tubes as Fuses

IT IS COMMON knowledge that when the A and B batteries on a radio receiver are mixed up, the tubes are ready for the wastebasket. It remains for the General Electric Company to make use of this sad phenomenon which frequently has expensive economic aspects. A tungsten filament which will pass 10 amperes at 15,000 volts is placed in a vacuum. When the current in the circuit rises to 45 amperes the filament burns out, and, therefore, the tube acts as a fuse. If a fuse operating in such high power circuits is opened in air, an arc forms and it is difficult to extinguish it. Even when the arc is broken, strong surges are created in the line which are difficult to control. In the vacuum tube fuse, however, there are enough electrons escaping from the ends of the broken filament to carry the current for a short period and prevent a heavy surge, and yet the circuit is positively opened.

Output Vs. Voltage Amplification

SOME READERS have difficulty in distinguishing between power output and voltage amplification. The power output of a receiver depends entirely upon the final tube in one's amplifier and the load it works into. With a given load it requires a certain a.c. voltage on its grid to produce this power output. (See "Home-Study Sheet No. 14"). Now if one has a strong signal from a local station the voltage amplification between antenna and grid of the power tube needs to be only of low value to produce this a.c. voltage on the grid of the power tube. If one lives twice as far away he must have four times the voltage amplification to produce the same voltage on the tube's grid, and if he lives several hundred miles he must provide much more voltage amplification. The power output has not changed at all—but the voltage amplification of the entire reciever may become many thousand times as great.

Suppose a receiver is so sensitive that with a field strength of one microvolt per meter across the antenna, it provides 50 milliwatts of undistorted output from the power tube. To deliver this much power the tube may require an a.c. potential of 7 volts, r.m.s. on its grid (A 171 working into twice its plate resistance). If the antenna is four meters high, the antenna-ground voltage is 4 micro-volts.

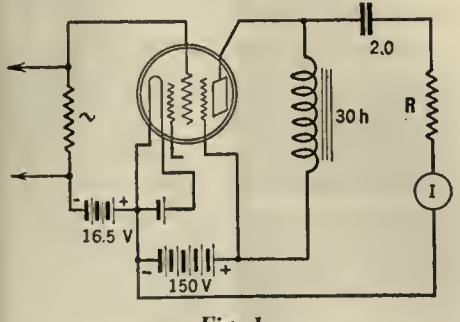


Fig. 1

The overall amplification of the receiver under these conditions is $7 \div 4.0 \times 10^{-6}$, or approximately 2×10^{6}, or two million.

If, however, the listener lives within a mile of a 50-kw. station, he may get a voltage across his antenna-ground coil of 2 volts. He needs only a voltage amplification of $7 \div 2$ or 3.5 to get the same power output.

Possibly power output and voltage amplification are related but they are not synonymous.

The following are among the Subjects discussed in "*Strays*" this Month:

1. *Vacuum Tube Fuses*
2. *Output versus Amplification*
3. *Cause of Winter Static*
4. *Experiments With Pentodes*
5. *"Phantom" Power Tubes*
6. *Novel Dynamic Baffle*
7. *Life of a. c. Radio Tubes*
8. *Amateur Intermediates*

Cause of Winter Static

MR. H. C. JACKSON, of Brooks, Iowa, sends us an interesting account of "snow static." Static in the winter is not uncommon; it must be something of the same phenomenon which causes static in a shipboard receiver when the "old man" blows the whistle in a fog. However, Mr. Jackson's letter gives some data on the subject. "We are in the midst of an electrical snow storm which I think will interest you. It is of the hard dry variety driven by a strong wind, and is of the type which the Middle West designates as a blizzard. The storm began by a heavy snowfall without wind but accompanied by heavy static of the steady crashing variety. That was about 12 to 15 hours ago (Last evening). This morning no static was noticeable on a Hammarlund-Roberts "Hi-Q Six" receiver with the volume well advanced, but about 9:00 a.m. I noticed the regular putt-putting usually associated with a faulty grid connection. As the first step in locating the trouble I removed the antenna wire, and, while holding the bare tip of the wire in my fingers, I chanced to touch the chassis of the set. The result was a considerable shock. Upon holding the antenna wire a half to three quarters of an inch from the chassis (which is grounded) a distinct corona appears which may on occasions be drawn out to one and one quarter inches, accompanied by a faint hissing. Upon coming within three eighths to one quarter of an inch of the chassis, sparking occurs, which becomes a continuous flame at one sixteenth of an inch. As I have not connected the set to the antenna to attempt operation for more than an hour, I do not know whether there is static or not at the present time. The strength of the corona varies with the intensity of the wind and when the sparking at one quarter of an inch is permitted, it produces the putt-putt which first attracted my attention. My antenna is a stranded enameled copper wire 100 feet long plus a 45-foot rubber-covered 14-gauge lead-in wire dropping direct from a height of 40 feet. The ground wire is connected to a lightning rod. I am not using a lightning arrester during winter."

Experiments With the Pentode

WE HAVE already mentioned the Pentode, a new tube that has, as yet, not been manufactured in this country, but which has attracted considerable attention in England and on the Continent. George Uzmann gave us the opportunity to take a Phillips type B-443 valve into the Laboratory to see what would happen when we put a.c. voltages on the grid. The circuit is shown in Fig. 1 and the output power as the load resistance was varied with constant input voltage is shown in Fig. 2. The output power at various input voltages with a constant load of 25,000 ohms is given in Fig. 3.

These figures are very interesting. With a plate potential of only 150 volts, a plate current of only 10.0 milliamperes, and with an a.c. input potential (r.m.s.) of only 12 volts, we were able to get 725 milliwatts into a 25,000-ohm load. Compare this with a 171-type tube which, to produce 700 milliwatts of power into a 4000-ohm load, requires an input r.m.s. potential of about 27 volts, a plate battery of 180 volts and a plate current of about 20 milliamperes.

This tube requires 0.15 ampere at 4.0 volts for its filament. Whether or not this tube would stand up in practice we cannot say. There is one distinct disadvantage—the high plate resistance. When a 540-AW loud speaker was placed in the output of this tube, the quality was poor because of the comparatively low impedance of the loud speaker at low frequencies. With an output transformer of proper characteristics, the transmission of good quality from tube to loud speaker should be possible.

There is this difference between our power tubes and this Pentode—which has three grids, one attached permanently to the filament, one attached to the B plus, and the third corresponding to our signal grid—and it is the fact that its much higher plate resistance implies that much smaller plate current variations are necessary to supply a given amount of power. For example, the 171-type tube with a steady plate current of 20 milliamperes,

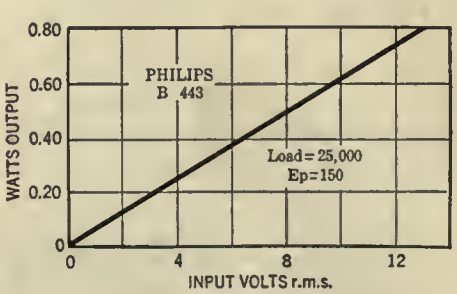


Fig. 2

must have a maximum a.c. plate current at times of this order, i.e., 20 mA. This a.c. current into the load of 4000 ohms gives us the power output. The Pentode with a steady plate current of 10 mA. will deliver the same power into its 25,000-ohm load with an a.c. current that is much smaller. In other words, the filament need not be so heavy nor consume so much power.

The Pentode is distinctly a battery tube. Its filament and plate power to deliver a very respectable power output is less than required with present-day 112-type tubes.

The characteristics of the tube as given by the manufacturer are presented in Table 1, and a characteristic curve in Fig. 4.

Table I

Filament voltage	4.0
Filament current	0.15
Plate voltage	50 to 150
Screen-grid voltage	50–150
Amplification factor	100
Internal plate resistance	87000 ohms
Mutual conductance	1500 micromhos
C bias	16 volts
Normal plate current	10 mA.

Will we have Pentodes in this country? We don't know. We shall take more characteristics in the Laboratory and present them in this department in the near future.

"Phantom" Power Tubes

THE FOLLOWING letter from Albert Allen Ketchum, of Coulterville, Illinois, describes a phenomenon that has been observed by many users of oxide-coated-filament power tubes. It is a kind of fluorescence which takes place when certain substances, usually organic salts, are exposed to visible or ultra-violet radiations or cathode rays. During this exposure these substances give off a light which is of different color than that color they reflect, and is related to the color they absorb most readily. The organic substances are in the oxide coating and do not indicate, as some believe, that the tube is defective or short lived.

"I have a "Phantom" power tube, in the form of a deForest 171A. At least, there occurs in it a phenomenon the like of which I have never seen before in my several years of experience with radio, and I thought perhaps you could explain it to me, or perhaps it may be new to you.

"I discovered this freak ghost to-night for the first time. As I turned on my set and tuned in a station I happened to be looking at the power tube and noticed a shadow moving on the plate. First I thought it was reflection from my clothing but upon more careful observation I noted that the shadow moved in cadence synchronous with the speaking and music, up and down along the outside face of the plate. Then I began to study it. When the music or speech stopped it stopped, when bass notes were played it made a deep jump and when banjoes or lighter instruments were playing it danced a merry little jig up and down in short quick movements. It was not a reflection from a brightening or dimming of the filament of the tube, for I studied it and it seemed as near as the eye can tell to remain constant. Besides the plate is opaque and it would be impossible for the filament rays to pierce it. This shadow had the appearance of a phosphorescent glow, and seemed to be more greatly agitated with the human voice than with music.

"Can you explain it? This is the first time I have ever had the privilege of seeing at least a part of radio at work!"

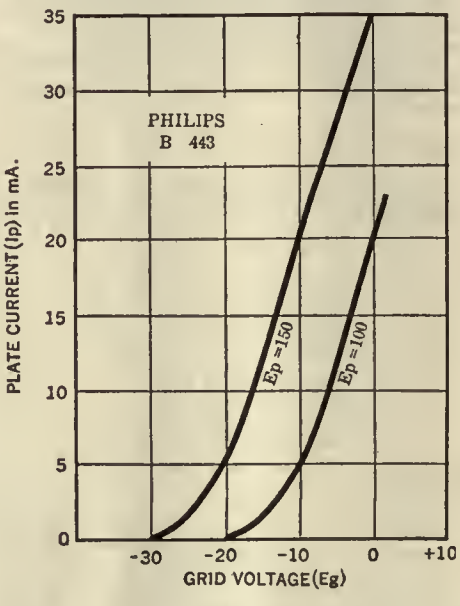


Fig. 4

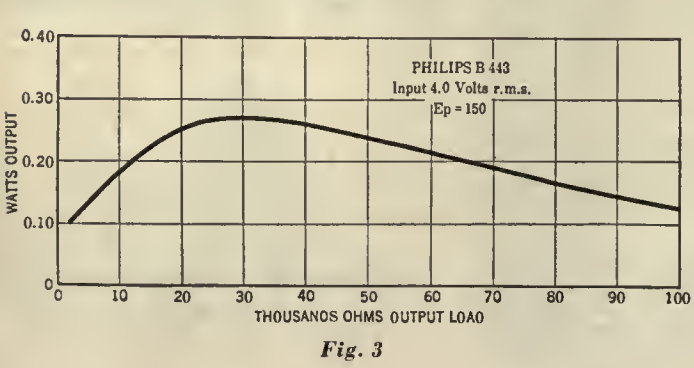


Fig. 3

Novel Dynamic Baffle

WE HAVE often mentioned the unsightly baffleboard which seems necessary for dynamic loud speaker operation. At least three square feet of baffle is necessary if notes as low as 100 cycles are to be reproduced. One way to solve the difficulty is disclosed in the following letter from A. A. Abels, of Dumont, New Jersey.

"Being the proud possessor of an NH-10 Newcomb-Hawley dynamic loud speaker, I was particularly anxious to take advantage of the utmost of its excellent frequency characteristic.

"I occupy a rented house, and could not, therefore, secure the infinite baffle effect obtained by placing the loud speaker in the wall, as described in the excellent article in your January issue. The wife's ideas of interior decoration were an uncompromising barrier, when I suggested a 4-foot square baffleboard.

"I studied the interior architecture of the house for a week before I concurred a plan which proved both effective and in accord with the wife's decorative scheme.

"I placed the loud speaker on the top of the piano, which stands "kitty-corner" in the corner of the room. I consider that the piano forms the lower half of the baffleboard, so that by placing the loud speaker in a baffleboard about 4′ x 2′, the 4-foot dimension being horizontal, I have in effect a 4-foot baffle. I used a piece of Upson Board with a reënforcing framework. With rounded corners and painted to match the walls, or covered with tapestry, or with drapes, or relieved with Dutch wall paper, such as can be bought in the form of panels; the decorative possibilities are great.

"In combination with my Fada special

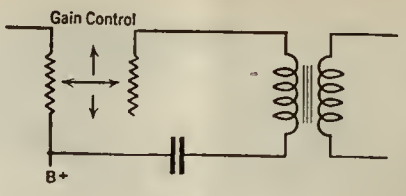


Fig. 5

265-A set, my audio results are as fine as I have ever heard."

Life of a.c. Radio Tubes

READERS STILL complain that their a.c. tubes seem to have shorter life than tubes which operate from batteries. This may be so, but have these readers actually checked up the number of hours they operate their receivers now that battery troubles no longer worry them? An estimate made recently by a prominent tube manufacturer indicates an average of nearly nine hours a day for receivers which operate from a lamp socket. A combination of good programs more hours of the day and freedom from worry about charging the battery is responsible for this estimated increase in receiver service. All the old estimates on tube life were made on the basis of three hours operation a day—and so an apparent short life in tubes is only *apparent* after all.

The following release from the Arcturus Radio Tube Company is pertinent in this connection: "On the twenty-first of April, 1928, twenty-five tubes were placed on life test in a special test rack installed in the office of the sales manager. With the exception of such occasions when the tubes have been removed from the test rack for laboratory measurements, they have been burning constantly for over ten months. This is equivalent to almost seven years of average home reception service. No tubes have burned out to date. The tubes under test are Arcturus 2.5-volt a.c. detector tubes (type 127)."

Approved Amateur Intermediates

BEGINNING January 1, 1929, amateur stations started a somewhat different system when calling each other. The old "intermediates" were abolished, and the following list approved by the respective governments was the substitute on January 10. It was sent to us by A. L. Budlong, of the A. R. R. L.

United States (territorial)	W
United States (possessions)	K
England	G
Germany	D
Mexico	X
Salvador	YS
Portugal	CT
Denmark	OZ
Canada	VE
New Zealand	ZL
Australia	MH-VK (?)
Cuba	CM
France	F
South Africa	ZS
Great Britain	G
Ecuador	HC
Panama	RX
Austria	UO

By the international convention the old system of calling and signing is changed to conform with the universal practice of using the intermediate "de".

A Correction

AN UNFORTUNATE error occured in the diagram of the constant impedance resistor in the article on "An inexpensive audio oscillator," page 187 January RADIO BROADCAST. The correct diagram of the apparatus is shown in Fig. 5.

Manufacturer's facetiousness: The Clarostat Manufacturing Company has announced a variable center-tapped resistor to be used across tube filaments. The name of this new device is the "Hum-Dinger."

—KEITH HENNEY

THE REAL SIZE OF THE RADIO MARKET



COLD figures on the sales of the two chief products in the radio industry—receivers and vacuum tubes—are of great importanee because they furnish a guide to the history of the months past and tbey give an excellent measuring stick for tbe future.

We present below figures on the receiver and tube sales for 1927 and 1928 which should prove of wide interest. Tbey are of especial interest because they include aceurate figures of the tube and set sales of the Radio Corporation and its lieensees for these two years, years in whieh the radio industry was passing through what may be regarded in the future as its most critical period.

Previous estimates, while most useful as a general guide to the progress of the industry, have been incomplete because of the unwillingness of key manufacturers to give out their sales figures. These companies, notably the Radio Corporation and its various lieensees, are probably responsible for far and away the largest sale of receivers, as in this group alone are more than 30 of the biggest company "names" in radio.

The figures which follow were gathered by the Editor in an indcpendent survey in order to provide the most aecurate possihle basis for examining the radio industry tube and set sales. They were presented during a reeent aetion in the Federal Court at Wilmington, Delaware, in which certain tube manufacturers sought to secure a permanent injunction restraining the Radio Corporation from enforcing Clausc 9 of their licensc contract with set manufacturers requiring the purchasc of RCA or Cunningham tubes for each socket of each set sold.

GENERAL SUMMARY

Radio Sets

Sets in use, Jan. 1, 1929	*11,000,000*
Sets in use, Jan. 1, 1928	*8,080,359*
Sets in use, Jan. 1, 1927	*6,352,419*
Sets acquired, 1928	*2,919,641*
Sets acquired, 1927	*1,727,940*

Radio Tubes

Tubes sold, 1928	*61,552,846*
Tubes sold, 1927	*33,662,247*
Tubes sold, 1928 for new sets	*20,472,487*
Tubes sold, 1927 for new sets	*10,332,640*
**1928 Tubes sold for replacements*	*41,080,359*
**1927 Tubes sold for replacements*	*23,339,607*

**new and old sets*

TABLE 1

1928. Set Sales Requiring New Tubes.

Sets sold by RCA	569,641
Sets sold by RCA licensees	2,025,000
Total sets sold by both	2,594,641
All other set sales	340,000
Total sets sold	2,934,641

Note: "Other set sales" estimated and included non-licensed sets and kits, home-assembled sets and transmitting and receiving amateurs. RCA licensee sales were 843,614 sets for first three months. Of estimated total sets sold, RCA sold 19.3 per cent., RCA licensees, 69.05 per cent., and both a total of 88.35 per cent. of all sets.

TABLE II

1928. Original Installation and Replacement Tube Requirements.

Initial Installation		
RCA and licensees (2,594,641 sets, av. 7 tubes ea.)		18,162,487
All others: complete sets, kits, etc., (340,000 sets at average varying: 7, 6, and 3 tubes ea.)		2,310,000
Total tubes required		20,472,487
Replacements (required in sets sold during this year)		
RCA and licensees	2,594,651 sets	
All others	325,000 sets	
Total	2,919,641 sets	
*Replacement tubes required		8,758,923
Old Sets		
**Sets in use as of Jan. 1, 1928	11,000,000	
Sets acquired during 1928	2,919,641	
**Sets as of Jan. 1, 1928	8,080,359	
† Replacement tubes required		32,321,436
Total Tubes Sold For All Purposes		61,552,846

* At 3 tubes per set
**Estimate of Daniel Starch
† At 4 tubes per set

TABLE III

1928. Tube Sales.

Tubes sold by RCA to set licensees	7,122,123
*RCA tubes for RCA sets	3,987,487
	11,109,610
Other RCA sales	19,552,510
**Total RCA tube sales	30,662,120
Sales by other tube manufacturers (est.)	30,890,726
Total tube sales	61,552,846

*569,641 sets, 7 tubes per set
**Including Cunningham

Note: RCA tubes sold to licensees were 11.6 per cent. of year's sales; RCA sets required 6.5 per cent. of the above grand total; other RCA sales, 31.8 per cent. and all other manufacturers sold 50.1 per cent. of total tubes during the year. In above, "sales by other tube manufacturers" is necessarily estimated with Table VI as basis. For derivation of total tube sales, see Table II.
RCA (and Cunningham) sales first 6 months, 7,802,324; second 6 months 22,859,796.

TABLE IV

1927. Set Sales Requiring New Tubes.

Sets sold by RCA	324,878
Sets sold by RCA licensees	966,542
Total sets sold, RCA and licensees	1,291,440
All other set sales	436,500
Total sets sold	1,727,940

Note: "Other set sales," estimated and includes non-licensed sets and kits, home-assembled sets and transmitting and receiving amateurs.
RCA and licensees sold 74.8 per cent. of sets (18.8 per cent. RCA, 56.0 per cent. RCA licensees); 25.2 per cent. of total was sold by all others.
First RCA set license granted Mar. 10, 1927, and some 24 others at different times following, so that total of 966,542 sets does not represent entire sales by makers during 1927 who at end of year were licensed; their sales included in estimate "other set sales."

TABLE V

1927. Original Installation and Replacement Tube Requirements.

Initial Installation		
RCA and licensees (1,291,440 sets av. 6 tubes ea.)		7,748,640
All others: complete sets, kits, etc. (436,500 at average varying: 6 and 3 tubes ea.)		2,574,000
Total tubes required for initial installations		10,322,640
Replacements (required in sets sold during this year)		
RCA and licensees	1,291,440 sets	
All others (est.)	421,500 sets	
Total	1,712,940 sets	
(at 2.5 tubes each, replaced)		4,282,350
Replacements (required in old sets)		
Sets as of Jan. 1, 1928	8,080,359	
Sets acquired during 1927	1,727,940	
Sets as of Jan. 1, 1927 (at 3 tubes per set to be replaced)	6,352,419	19,057,257
Total tubes sold		33,662,247

TABLE VI

1927. Tube Sales.

Tubes sold by RCA to set licensees	5,719,710
*RCA tubes for RCA sets	1,949,268
	7,668,978
**Other RCA tube sales	14,583,097
Total RCA sales	22,252,075
Sales by other manufacturers	11,410,172
Total tube sales	33,662,247

*324,878 sets, 6 tubes each
**includes Cunningham

Note: RCA tubes sold to licensees were 16.9 per cent. of year's sales; RCA sets required 5.8 per cent. of the above grand total; other RCA sales were 43.3 per cent. of the total and all other manufacturers sold 34.0 per cent. of the total. For derivation of total tube sales, see Table V. In above, "sales by other manufacturers" is necessarily estimated with Table V as basis.
RCA (and Cunningham) sales first 6 months 7,116,747; second 6 months 15,135,328.

In the tables above, the RCA set sales and set sales by RCA licensees are grouped and all others are estimated and given separately in order to make it perfectly clear what figures were known and what were estimated. When the entire radio industry releases its sales figures each year, under proper control, it will no longer he necessary to make estimates. All in the industry agree on the necessity of reliable figures, and the manufacturers are not least among these, but as yet it is impossible to secure all figures necessary for the most accurate report of a year's business.

The estimates given in the tables were arrived at by what is thought to be the best means possible: the accurate figures of set sales by RCA and RCA licensees and the tube sales for licensees' sets and for RCA sets were used as the basis. In addition, the total tube sales by RCA (and Cunningham) was known. It was necessary then, to estimate the sets sold by all others which are responsible for installation of new tubes. This estimate (in skeleton form only) appears in Tables II and IV. The derivation of the other figures is apparent from a study of the Tables.

Meaning of the Estimate

IT TAKES no gift of prophesy to read in these figures, concentrated under the heading "General Summary," the record of astounding development in the radio market and, behind that, the remarkable, and growing public acceptance of radio broadcasting. The number of sets in use by the first of January 1929 had increased by 37.5 per cent. over the number in use at the same time the previous year. And the number of sets in use on the first of

(*Continued on page 384*)

THE EXPERIMENTER'S ARMCHAIR

By ROBERT S. KRUSE

THE radio operator has his static room, the adventurer his camp fire, and the chauffeur the gas station. We Experimenters have been without a place in which to tell of our adventures and this one is now opened to us.

Gentlemen, if you are all settled comfortably, we can begin our first meeting. We will not be formal about it, for these meetings are open to any experimenter, whether he be scientist, engineer, laboratorian, operator, serviceman, or plain tinkerer.

In order that no one will be embarrassed by having to make the first talk, I will read an anonymous paper. It is on the subject of filters, concerning which there is so much bilious mathematics and so few easily applied facts. While the writer of the paper speaks from the transmission viewpoint his ideas apply to any filter used on the output of a rectifier fed from a 60-cycle supply. Notice that he does not agree with our general use of the "brute-force" type of filter.

FILTERING WITH SMALL CHOKES

Listening to some of the 60-cycle growls we still hear on the air makes it evident that in some transmitting filters the growl was weighed against the price of 30-henry chokes capable of carrying 200 mA:—and the chokes lost. Another, and very potent, argument, against the use of big chokes, is the fact that their d.c. resistance is high; nobody wants to waste 200 to 300 volts in a filter when those volts might better be keeping the oscillator plates warm. Neither does anyone care for a plate voltage that swoops wildly up and down as the load changes.

How can we make a filter which will do the work well enough to give us a "fairly d-c." note, and at the same time, cost little and waste very few of our precious volts? This problem was taken up from a laboratory standpoint; a rectifier unit was built, as in Fig. 1, and the output of alternating voltages at the various harmonic frequencies was measured by means of a special vacuum-tube voltmeter capable of indicating the value of any one frequency in the presence of others, this being accomplished by means of resonant circuits tuned to the frequency being measured. Calibration was accomplished by means of a single-frequency current of known value flowing through a known resistance, the voltmeter being calibrated at each frequency to be measured. An accuracy of plus or minus one per cent. is obtainable by this arrangement.

The power unit used in the tests comprised an ordinary step-up transformer with a split secondary and two 281-type tubes as rectifiers (see Fig. 1). With this unit working into a 7500-ohm resistance load, no filter being used, output voltages were measured; the result of the analysis is shown in column A of Table 1. The presence of the 60-cycle and other odd harmonic voltages is due either to one transformer secondary having a slightly higher voltage than the other, or to a higher plate-filament resistance in one of the rectifiers.

The magnitude of the 120-cycle voltage explains the growl to be heard in an unfiltered supply; it also shows that our greatest problem in designing a filter will be to get rid of this voltage.

For the next test the simplest type of filter (a condenser across the output of the rectifier as in Fig. 1B) was used. This produced a drop in the harmonic output voltages for the following reason. The greater part of these harmonics is due to the leakage reactance of the transformer. The addition of the condenser, C_3, reduces (in effect) this leakage reactance and thereby reduces the harmonic

As the title of this contribution of Mr. Kruse's indicates, the main content deals with the experimental side of radio. Mr. Kruse has been given the widest latitude in the selection and treatment of the material that appears under this heading. In our judgment, all those who are interested in experimenting with a practical aim will find these pages each month of benefit to them. Contributions are invited and will be paid for if acceptable.

—THE EDITOR.

output. At the same time the d.c. output potential increased from 530 to 750 volts, due to the increase in voltage on the tube which is limited by the leakage reactance voltage, and—as said above—the addition of a condenser reduces the effective leakage reactance. (The same effect as to d.c. voltage rise may be obtained by connecting 0.1-mfd. directly across the transformer secondary but this has almost no filtering action and is not recommended.) The value of the condenser C_3 was varied from 1 to 10 mfd. More than 3 mfd. gave very little increase in filter action. (The subscript 3, as in C_3, indicates a condenser of 3.0-mfd. capacity. Thus, in diagram C of Fig. 1, C_{10} has 10.0 mfd. capacity.) The results for this test (as shown in the table) make it quite evident that we cannot afford to omit condenser C_3 from our circuit, even if that is all the filter we have.

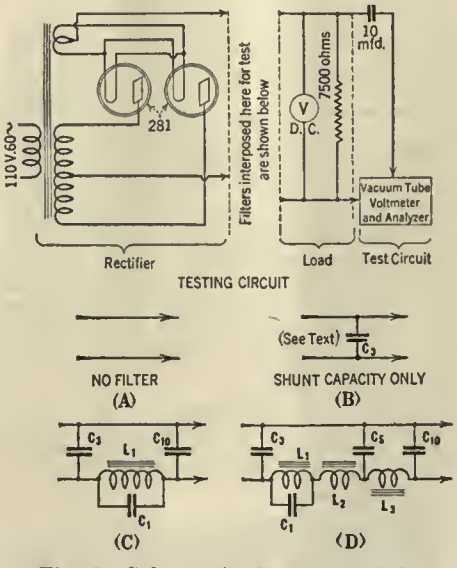


Fig. 1—Schematic diagrams of the rectifier and four types of filters considered in the tests.

RESULTS WITH 120-CYCLE TRAP

For the next test a trap, tuned to 120 cycles, was placed in the negative lead and beyond that another condenser, C_{10}, was connected across the circuit, giving the arrangement shown in diagram C of Fig. 1. The trap was made up of a choke having 12 ohms resistance and an inductance in the neighborhood of 1.2 henries. It was tuned to offer maximum impedance to the flow of 120-cycle current by connecting various condensers across it until the 120-cycle voltage at the load was a minimum. Approximately 1.1 mfd. was required to do this. *Low-voltage* condensers were used and since the trap was in the negative side of the line it could be "worked hot" as the greatest potential encountered is 50 volts or so at 120 cycles. The d.c. drop through the choke is insignificant, and with this connection the output is pretty fair d.c. The total r.m.s. alternating voltage at the load is less than 2, which is less than $\frac{1}{3}$ of 1 per cent. of the direct voltage.

This should be sufficiently smooth for any c.w. transmitter, likewise for a number of other purposes—and we did it with a single choke having a resistance of only 12 ohms! The final condenser, C_{10}, may be reduced to as low as 2 mfd. and maintain a fairly smooth output. Here, then, is a good c.w. transmission filter; one small choke, 4 or 5 mfd. of high-voltage condenser (C_3 and C_{10}) and about 1 mfd. of low-voltage condenser.

A still smoother output for phone work, or other purposes, may be obtained by using the circuit shown in diagram D of Fig. 1. The coils L_1, L_2, and L_3 each have an inductance of approximately one henry and a resistance of 10 to 15 ohms. The condenser, C_5, in the center branch has a capacity of 5 mfds. The analysis of the output of this filter is given in the table under D. It can be seen that the total r.m.s. alternating voltage at the load is now only 1.2. volts (less than $\frac{1}{7}$ of 1 per cent. of the d.c.) and that is mostly at 60 cycles where it will not be particularly troublesome to a phone transmitter. The total series resistance of the filter is less than 50 ohms, so that for ordinary load currents the voltage drop will not be more than 10-15 volts, or 2 per cent. of the d.c. voltage. This should help the "yoop" problem of the C.W. amateur who wants a smooth tone. Part of this difficulty is occasioned by large voltage changes when the key is opened and closed. Of course, no filter can prevent the rectifier from charging the condensers to a value near the peak voltage of the transformer when the load is off but that is avoided easily enough by a resistance permanently connected across the filter output. There is no exact value for this resistance and it must be determined by trial, using the highest value that will still prevent the rise of voltage when the load is off. Where a high-voltage d.c. meter is connected across the circuit no other drain is needed. Incidentally, such a shunt is useful in another way. It prevents one from taking hold of a filter condenser and discovering that the brute is still loaded.

At any rate the 10–15-volts drop is quite an improvement over the common 150–300-volt drop. In one case which was tested a set had

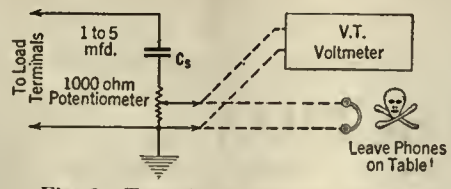


Fig. 2—Test circuit for trap tuning

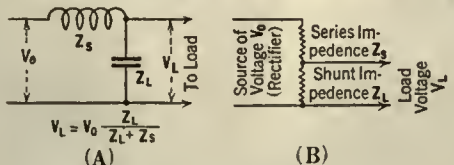


Fig. 3—Method of calculating voltage reduction. (A) Actual circuit, (B) Equivalent circuit.

an annoying "yoop" when keyed with a "brute-force" filter. The drop through the choke was 175 volts. Filter circuits such as shown here cured this almost completely without any change in the r.f. circuits.

TUNING THE TRAP

The question will naturally be asked, "How am I going to be able to tune the trap without some sort of analyzer?" Fortunately this is simple. If you have, can make, or will borrow, a vacuum-tube voltmeter, connect it to the output of the *loaded* filter as shown in Fig. 2 and juggle the trap condenser until the vacuum-tube voltmeter shows a minimum. The 1000-ohm potentiometer is used as a sensitivity control and enables you to keep the meter deflection within reason. The isolating condenser C_s must be capable of withstanding the full voltage of the output. Always do the testing with the rectifier and filter operating at their normal load as the inductance of the chokes vary with the d.c. flowing through them.

If a vacuum-tube voltmeter is not available, a pair of phones may be used and the filter adjusted for minimum sound. *Leave the phones on the table*; the condenser C_s *might* puncture and electrocution is reported to be unpleasant.

The rectifier shown is of the "centertap" variety. If the "Bridge" connection is used for any reason a larger 60-cycle voltage may appear and may call for a 60-cycle trap in addition to the 120-cycle trap. Such a trap will require about 4 times the capacity (in the trap circuit) as is necessary for 120 cycles.

No tests were made on a half-wave rectifier but in this case also a 60-cycle trap is necessary, although the 120-cycle trap may probably be omitted. Incidentally, in the full-wave rectifier discussed some 60-cycle voltage appears because of an unbalance. If for any reason it is objectionable a 60-cycle trap is the cure.

Some measurements of the harmonic currents flowing in various parts of the circuit were made by inserting a resistor in the circuit and measuring the alternating voltage drop across it.

The 120-cycle current flowing in the branch C_3 of diagram c, Fig. 1, was 120 milliamperes. This is practically the total 120-cycle output current of the rectifier, since the 120-cycle current flowing through the trap to the load was only about 4.7 milliamperes. From this latter current and the voltage across the trap it is easy to calculate the impedance of the trap to 120 cycles:

$$Z = \frac{E}{I} = \frac{0.53}{0.0047} = 11{,}300 \text{ ohms.}$$

The impedance of C_{10} to 120 cycles is 132 ohms, hence we should expect a 120-cycle voltage at the load of $\frac{53 \times 132}{11{,}300 + 132} = 0.64$ volts. The voltage measured was 0.60, a fairly close check. The method of calculating the last voltage is explained in Fig. 3.

The combination of series and shunt impedances may be considered as a potentiometer, which permits a fraction of the impressed (or rectifier) voltage to appear across the load. The ratio of these two will be the ratio of the total impedance, $Z_s + Z_l$, to the shunt impedance, Z_L, which latter is made up of the load and the last condenser, in parallel. By varying these impedances we can make the a.c. voltage reduction in our filter anything we please. For instance, suppose that the final condenser, C_{10}, is reduced to 1 mfd. Its impedance will then be 1320 ohms, and the 120-cycle voltage appearing at the load will be (neglecting load impedance)

$$\frac{53 \times 1320}{11{,}300 + 1320} = 5.5 \text{ volts}$$

This simple way of looking at filter action permits you to calculate quickly what reduction of voltage you may expect from a given set of impedances. The impedance of a choke coil is given approximately by

$$Z = 6.3 \times (\text{inductance in henries}) \times (\text{frequency})$$

The impedance of a condenser is given by

$$Z = \frac{160{,}000}{(\text{capacity in mfd.}) \times (\text{frequency})}$$

The impedance of the trap was discussed before.

Of course, the method of calculating drops does not work out if any choke is in resonance with one of the harmonic frequencies by reason of its distributed capacity or if one of the chokes and one of shunt condensers makes a series resonant circuit.

COMMENT AND SUGGESTIONS

The difference between this filter and the "brute-force" type is that it does a very neat piece of work for the particular conditions to which it is adapted, while in the "brute-force" case we squirm out of the necessity of adjustment at the expense of tolerating rather bad voltage drop and rather large expenditure for apparatus.

Probably everyone has found it out before now that choke inductances and paper condenser capacities usually vary considerably from the marked values so that a little cutting and trying is useful. This means changing the condensers around and adjusting the air gap of the choke.

A 1.2-HENRY CHOKE

In Fig. 4 are shown a pair of suggested chokes which can be varied from about $\frac{1}{2}$ to about 1.2 henries by changing the air gap. In both forms (A and B) the core legs are 1 inch square and butt joints are used throughout. The air gap is adjusted by laying different thicknesses of cardboard in it after which the core is again clamped or taped to reduce humming. About $1\frac{1}{2}$ pounds of No. 24 enameled wire will fill the winding space of A while No. 23 enamel may be used for B. The chokes will handle about $\frac{1}{2}$ ampere without

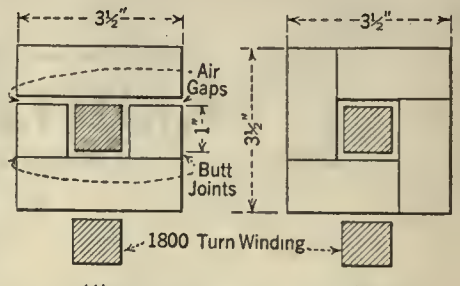


Fig. 4—Details of an efficient filter choke. (A) Usual form, (B) Simplified form with all legs alike.

saturation and may, of course, be wound for any other inductance, keeping in mind that this changes approximately with the square of the number of turns and that the ampere turns must not exceed 800.

Table I

ANALYSIS OF FILTERING ACTION OF CIRCUITS SHOWN IN FIG. 1

Frequency		Voltages at Load			
		A	B	C	D
	d.c.	530.0	750.0	750.0	750.0
	60	25.0	7.4	1.6	1.1
	120	245.0	53.0	0.60	0.3
N	180	1.2	1.06	0.01	0.01
O	240	17.6	14.2	0.90	0.075
T					
	300	0.16	——	——	——
W					
A	360	12.5	1.9	0.13	0.01
N					
T	480	7.5	1.0	0.075	——
E					
D	600	6.7	0.67	0.05	——
	720	3.5	0.156	0.02	——
	840	1.25	0.19	0.15	——
	900	0.51	0.085	——	——

A blank means that the voltage was less than $\frac{1}{100}$ volt.

Unlucky New England

IT HAS been said that if a set will work through the static at New Orleans it will work anywhere except in the Caribbean. To this let us add that if a receiver will give a good account of itself in southern New England it will be an amazing success elsewhere. Here at Hartford we sit in the world's largest nest of high-power radio stations and with rather decent receivers hear materially less than does the Kansan with the most ordinary of home-made apparatus. WEAF is not amazingly strong here, though only 90 miles away over seemingly favorable country, and this is the cause of disparaging comments from our Kansas relatives, who, at 1000 miles, are accustomed to hear the station comfortably in daylight. WGY's high-power commission-defying transmitter fades horribly and is of little use to us, while WJZ fluctuates in a ratio of as little as $\frac{1}{50}$ or as much as $\frac{50}{100}$ if one speaks of audibilities. As to other stations, and other types of signals, matters are not materially better. Television and rayfoto signals have a rather terrible time of it. Altogether one is not surprised that the American Radio Relay League was organized here to relay messages over the 27 miles to Springfield while at the same time amateurs in Illinois, Ohio, Kansas and Missouri conversed freely and easily over distances well up toward 700 miles.

From Here Forward

OUR time for this month is up.

The Editors are leaving the nature of the future material to our judgment. This is not as reckless as it seems—for the copy passes under the blue pencil before reaching these pages!

Since this encouraging "department" was suggested a pleasant number of letters have arrived, bringing material and comment of the most varied sort. We can, so to speak, take from stock a conversation on vacuum-tube voltmeters, variable a.c. supplies, an extremely queer short-wave effect, some ingenious tuning devices, or several other things.

These letters assure our immediate future but they are not a "preferred list." Whatever you have done, are doing, or may be planning is of interest. Do not be too serious about it, this being neither a literary society nor the Franklin Institute. The main thing is to learn of each other's doings, whether they concern a simple mechanical makeshift, an odd effect or large plans for investigation of one of the two score unsettled problems.

Letters—or informal papers—will be welcome. They should be addressed to Robert S. Kruse, care RADIO BROADCAST, Garden City, New York, and should refer to these pages by title.

Part II of a Series

GRID-LEAK POWER DETECTION

By FREDERICK EMMONS TERMAN

Stanford University

IN DETECTING, or what is the same thing, in rectifying large signals, it is generally considered that C-bias detection is neeessary if good quality of output is to be maintained. The common grid leak-condenser rectifier, so sensitive with weak signals, is found to overload with only moderate input voltages and to be entirely impossible.

The unsatisfactory results generally obtained with grid leak-condenser power detection are not an inherent shortcoming of this mode of rectification; they are merely a consequenee of using grid detection improperly. Under suitable conditions the grid leak-condenser method of detection will give *less distortion when the applied signal voltage is large than when it is small*. This perhaps surprising result is obtained by analyzing the causes of distortion in the grid rectifier and then adjusting the circuits and battery voltages to eliminate the trouble. The result is a power detector giving good quality, and having a high degree of sensitivity on both strong and weak signals.

There are two kinds of distortion introduced by detectors. The first type is frequency discrimination, that is, the reproduction of some audio frequencies better than others. The second type is non-linear or amplitude distortion which is caused by the detector output not being proportional to the size of the signal voltage. Non-linear distortion causes the production of audio frequencies in the detector output which were not present in the original sound. Both kinds of distortion are, of course, undesirable.

Power detection! Not so many months ago we called the attention of RADIO BROADCAST'S *readers to the tendency toward the use of a single stage of audio amplification, and thereby got ourselves into controversy with manufacturers of audio equipment. In this article, Professor Terman tells how it is possible for a detector to deliver enough output rectified voltage to "load up" a power amplifier tube. Such a detector is used in the Radiola 60 series, the Sparton receiver, the new Crosley Jewelbox, the R. F. L. airplane receiver, and there may be others whose names we don't recall at the moment. Power detection is coming into its own, evidently.*

The author is Assistant Professor in charge of Communication at Stanford University. He has another article or two on detection in preparation for us.

—THE EDITOR.

Distortion With Weak Signals

THE fundamental basis of grid-leak detection of small signals was considered in the first of this series of articles on detection, and the problem of selecting grid-leak and grid-condenser values to avoid frequency discrimination was taken up at length. In general, it was found that in order to reproduce all audio frequencies equally well the grid-leak resistance should not be too high and that the grid condenser should be as small as possible. At the same time if either the grid condenser or leak resistance is less than certain rather critical values there will be an excessive loss of sensitivity.

Proper attention to these circuit details will eliminate almost completely frequency discrimination when the grid leak is handling small voltages. At the same time, and no matter how well adjusted, the grid leak-condenser detector, like all other known detectors, introduces amplitude distortion with weak signals. This is true because the output of all rectifiers is proportional to the *square* of the signal voltage when this voltage is small (i. e., less than approximately 0.25 volt for grid-leak detection and only a few volts with plate detection).

Over this range of signals for which the detector follows a square law the amplitude distortion is such as to introduce distortion audio frequencies which are twice the frequency of the sound to be reproduced, and also distortion audio frequencies which have frequencies that are all the possible combinations of sums and differences of the frequencies actually present in the original sound. Thus if the modulated signal voltage is simultaneously carrying audio frequencies of 1000 and 1500 cycles, the detector in addition to reproducing the desired 1000- and 1500-cycle currents will produce weaker double-frequency distortion currents of 2000 and 3000 cycles and will also produce a sum distortion-frequency current of 2500 cycles and a difference distortion-frequency current of 500 cycles.

Fortunately, these various distortion frequencies are usually weak in the detector output compared with the output currents of the undistorted frequency. The amount of distortion is proportional to the degree of modulation of the radio-frequency signal voltage, and for this reason it is not always desirable for the transmitting station to modulate its carrier more than 20–25 per cent. With such a degree of modulation the distortion currents will be about 5 per cent. as strong as the main signal currents. When the degree of modulation is 100 per cent. the distortion may run as high as 25 per cent. but will never exceed this value.

The cause of these distortion frequencies in the detector output can be understood readily from the following explanation. Assume that the carrier wave of the transmitting station is 1,000,000 cycles, and that this wave is simultaneously modulated by the 1000- and 1500-cycle frequencies mentioned above. Then the wave actually transmitted from the broadcasting station consists of waves of the following frequencies:

Upper side band	1,001,500 cycles 1,001,000 cycles
Carrier	1,000,000 cycles
Lower side band	999,000 cycles 998,500 cycles

The carrier wave is much stronger than any of the side-band frequencies. Now when several waves of different frequencies are applied simultaneously to a square-law detector each frequency present heterodynes with each other frequency present to produce a component of detector output that has as its frequency the difference between the heterodyning frequencies. The amplitude of this difference frequency is proportional to the product of the amplitudes of the two waves producing it.

Applying these principles to the example at hand, the carrier heterodynes with the first frequency in the upper side band and produces a difference frequency of 1500 cycles. It also heterodynes with the second wave of the upper side band giving a difference frequency of 1000 cycles. The carrier in heterodyning with the two waves in the lower side bands also results in output currents of 1500 and 1000 cycles, which add in with the output of the upper side band to give the undistorted component of the detector output.

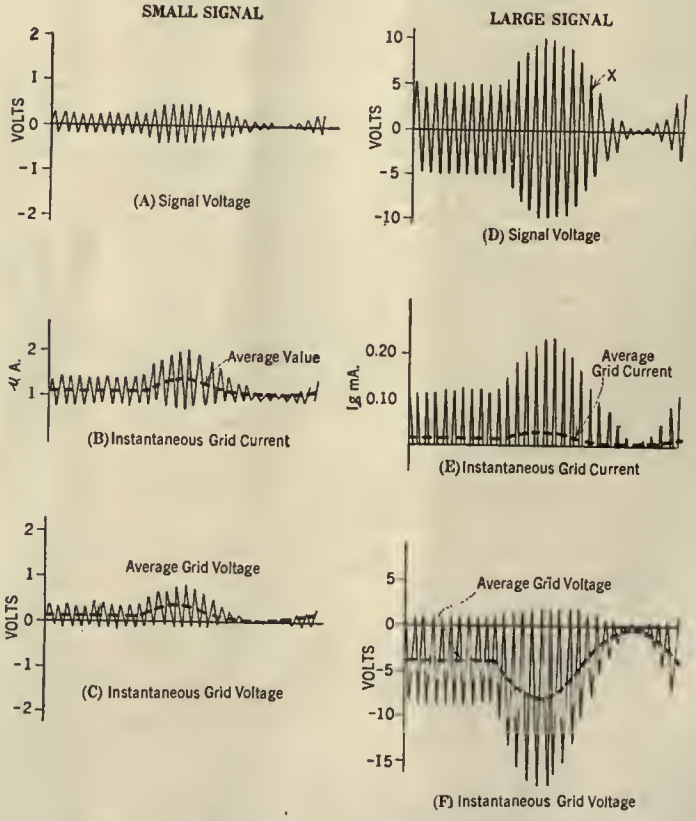


Fig. 1—Comparison of grid action with grid leak-condenser detection of large and small signals.

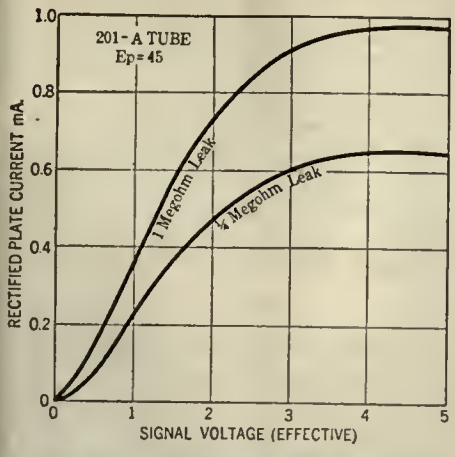


Fig. 2—Rectified plate current of a typical grid leak-condenser detector as a function of signal voltage.

While this is going on the first component of the upper side band heterodynes with each of the other side-band components, resulting in difference frequencies of 500, 2500, and 3000 cycles, while the second component of the upper side band heterodynes with the lower side-band components to produce difference frequencies of 2000 and 2500 cycles. These numerous output frequencies due to side-band components heterodyning with each other are distortion frequencies, but are relatively weak as long as the carrier wave is strong. This is because the undistorted components are obtained by heterodyning of the side bands with the strong carrier, while the distortion frequencies result from the heterodyning with each other of relatively weak side-band components and so are not very strong relative to the useful part of the output.

Small and Large Signals

THE mechanism of grid leak-condenser detection when the signals are strong is entirely different from the action taking place with weak signals. In both cases the radio-frequency signal voltage is rectified in the grid circuit by virtue of the non-linear relation between grid current and grid voltage, but when the signals are weak the grid current flows continuously while when the signals are strong grid current flows only when the signal voltage is at or near a positive crest.

The difference in the two cases is shown in Fig. 1. With small applied radio-frequency voltages the variation in grid current caused by this small signal is not great enough to reduce the grid current to zero. It is to be remembered that in the grid-leak detector there is always a small but very definite grid current flowing, and that this current is necessary for the functioning of the detector. The effect of the radio signal voltage, such as shown at (A) in Fig. 1 is to cause this current to vary with the signal as shown at (B). The dotted line in (B) indicates the average value of grid current, which is seen to vary in amplitude in accordance with the modulation of the signal. This varying average value of grid current must flow through the grid leak-condenser combination, and in doing so produces across the combination an audio-frequency voltage drop that, being applied between the grid and filament of the detector tube, is amplified by the detector acting as an audio-frequency amplifier. The effect of this audio-frequency voltage drop is shown in (C) of Fig. 1, where the dotted line represents the average grid voltage, which is seen to vary in value in accordance with the signal amplitude and with the rectified grid current.

When a large radio-frequency voltage is applied to the grid the situation is changed because with this large voltage the grid potential goes negative sufficiently to stop the grid current for the greater part of the cycle. This is shown in Fig. 1 where (D) represents the radio voltage and (E) shows the grid current, which now flows only for a short time each cycle. The grid voltage during detection of the signal is shown at (F). The average value of this voltage, indicated by the dotted line, is seen to vary in accordance with the signal modulation, and is an audio-frequency voltage that is amplified by the detector tube acting as an audio-frequency amplifier. The average grid voltage becomes more negative as the signal increases in amplitude because the pulses of grid current at each positive crest of the signal then become larger, charging the grid condenser with more electrons and making the average grid voltage more negative. When the detector is adjusted properly some of the charge leaks off the condenser through the grid leak during the part of the cycle when no grid current is flowing. The quantity of charge leaking off the condenser in this way between the impulses of grid current is just equal to the charge supplied by the impulse, and at the same time the amount the average grid potential goes negative is proportional to the size of the impulses of grid current shown at Fig. 1 (E).

In a properly adjusted power grid detector the average grid potential goes sufficiently negative to keep the grid from ever getting very positive, as shown in Fig. 1 (F). This is because the impulses of grid current become very large when the grid becomes a few volts positive. Thus with large signals the average grid potential stays sufficiently negative to allow the grid to become only slightly positive each cycle, and as the signal strength varies the average grid potential varies so that this stays true all the time. Of course, when the signal is extra large the grid becomes slightly more positive during the crest of the cycle in order that the impulses of grid current may be larger, as shown in (F), but in any case the amount of positiveness is small compared with size of the signal voltage because only a small positiveness will cause the grid current impulses to be very large.

Amplitude Distortion

ONE of the first difficulties that has been experienced in the past with power grid-leak detectors was that the audio-frequency output of the detector was far from being proportional to the radio-frequency signal voltage. For example, the solid lines of Fig. 2 show the rectified plate current of a certain grid-leak detector as a function of signal voltage, for the case of an unmodulated signal voltage. It is apparent that the output of the detector is far from proportional to the signal voltage for both high and low grid-leak resistances. When the signal voltage exceeds about 1½ volts effective value, non-linear or amplitude distortion becomes pronounced. As has already been explained, the result is then the introduction in the detector output of audio frequencies which were not present in the original sound.

The cause of the non-linear relation between

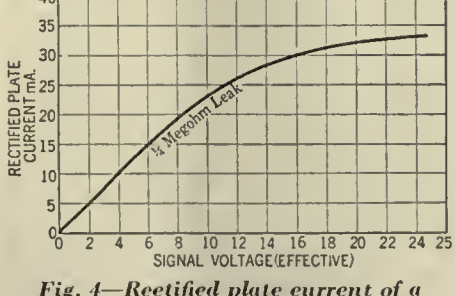


Fig. 4—Rectified plate current of a 210-type tube as a function of signal voltage, showing the possibilities of power detection under suitable conditions.

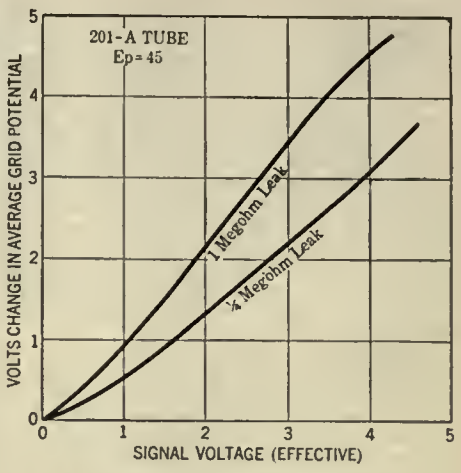


Fig. 3—Change of average grid potential as a function of signal strength for the same condition as Fig. 1.

signal voltage and output for the case of Fig. 2 is not far to seek. If we measure the change of average grid potential from the grid potential with no signal, as a function of signal voltage, we get the result shown in Fig. 3. The average grid potential is seen to vary in almost exact proportion to the signal amplitude even for very large signals. *The reason the average plate current does not also vary in proportion to the average grid potential is due to rectification of the radio-frequency signal voltage in the plate circuit by plate detection.* Plate circuit detection takes place with increase of plate current while grid rectification is characterized by a decrease of plate current. Unless the operating conditions are correct, the plate rectification at large signal amplitudes will be sufficient to neutralize the effects of grid rectification to a serious extent, as in the case in Fig. 2.

In order to prevent amplitude distortion in the grid leak-condenser power detector it is necessary to eliminate all plate detection. Reference to Fig. 1 (F) shows that distortionless power grid rectification can be obtained only when the detector tube gives distortionless amplification of grid potentials ranging from approximately zero to a negative value of twice the crest amplitude of the radio-frequency signal voltage. This is true because Fig. 1 (F) shows that during detection the grid potential varies from about zero to a negative value approximately equal to twice the crest amplitude of the signal—twice the amplitude of the signal measured from its average value shown by the dotted line in Fig. 1 (F)—and distortion will be present unless this variation of grid potential is over a straight-line part of the plate-current characteristic. That is to say, plate rectification can be avoided only by operating on a straight line part of the plate characteristic.

The requirement for avoiding amplitude distortion in the grid-leak power detector is, therefore, that *the power capacity of the detector tube at the plate voltage being used must be sufficient to amplify the radio-frequency signal voltage without distortion.* Since the grid of the detector tube is at approximately zero potential when there is no signal voltage present, the mu of the detector tube must be sufficiently high to keep the plate current of the tube within safe limits for continuous operation with full voltage on the plate, and with the grid at zero bias. Power detection obviously requires a power tube operated at a high plate voltage, and it is absurd to expect more undistorted power output from a particular tube at a given plate voltage when acting as a power detector than one could expect to get out of the same tube operating as an audio-frequency amplifier with the identical plate voltage.

The undistorted audio-frequency power

which can be put out by a grid leak-condenser power detector is theoretically just *one fourth* of the undistorted power which the same tube can put out as an audio-frequency amplifier, the plate voltages being the same in the two cases. This can be seen from Fig. 1 (F), where it is evident that the average grid voltage (which is amplified in the plate circuit and becomes the audio-frequency output of the detector) swings through only half the range of voltage that the radio-frequency signal goes through. As power is proportional to the square of the voltage, the audio-frequency power output is one fourth the power capacity of the detector tube acting as a distortionless amplifier.

The maximum allowable carrier voltage of the radio-frequency signal that can be applied to the grid of the grid-leak power detector is approximately *one half* the audio-frequency voltage that may be applied to the same tube when acting as an audio-frequency amplifier. This is because during moments when the carrier is fully modulated the radio signal voltage reaches an amplitude twice that of the carrier, and the detector must be capable of handling input voltages of this size.

Of the standard tubes available for grid-leak power detectors the moderate mu 112A, 226, and 227 types can be operated at plate voltages from 90 to 135 volts without drawing excessive plate current, and under these conditions will put out enough power to run a 171A- or a 210-type power tube, or even two 171A-type tubes in push-pull. The 171A-type tube is not suitable as a power detector because its low mu allows the plate current to become too high.

By going to higher power tubes it is possible to operate a dynamic-type loud speaker directly from the detector output, and *to dispense entirely with the audio-frequency amplifier*. In order to do this it is of course necessary to go to very large tubes and high plate voltages. By using a 210-type tube at a plate potential of 250 to 300 volts it is possible to supply from 110 to 250 milliwatts of undistorted audio-frequency power directly to the loud speaker from the detector tube.

That real undistorted power can be obtained from a grid leak-condenser power detector under favorable conditions is shown by Fig. 4 which gives the measured rectified plate current in a 210-type tube as a function of radio-frequency signal voltage. It is evident that rectified output is almost exactly proportional to the signal up to an applied potential of about 10 or 12 volts effective. The curves given in Figs. 1 (D), 1 (E), and 1 (F) are actual curves drawn to scale showing the measured performance of this 210-type tube under the same conditions as in Fig. 4.

Eliminating Distortion

IT HAS been shown that adjusting a power grid leak-condenser in such a way as to eliminate plate-circuit rectification will eliminate amplitude distortion, but the problem of reproducing all audio frequencies with equal sensitivity still remains. The general tendency of a grid-leak detector is to be less sensitive on the high notes than on the low, and this is even more so when the signals are large than when they are small.

When the modulation frequency is high the average grid potential may not be able to follow the rapidly varying amplitude of the signal, as is the case in Fig. 5. Here the grid-leak resistance and grid-condenser capacity are too high, and as the signal amplitude decreases the charge on the grid condenser is not able to leak off fast enough through the grid leak to reduce the average grid potential as fast as the signal is changing amplitude, with the result shown in Fig. 5. A correct value of grid-leak resistance and grid-condenser capacity will give the conditions of Fig. 1 (F), in which the distortion is at a minimum.

The rate at which the average grid condenser charge can change is inversely proportional to the product of leak resistance, R, times grid condenser capacity, C. Analysis shows that when the signal voltage is modulated completely, as shown in Fig. 1 (D), and is at the point "X" indicated in Fig. 1 (D), the average grid potential can just barely decrease as fast as the signal is decreasing when the relation $2\pi f = 1/RC$ is satisfied, in which f is the frequency of modulation, R denotes the grid-leak resistance in megohms, and C is the grid condenser capacity in microfarads. Modulation frequencies for which $2\pi f$ is greater than $1/RC$ will not be reproduced as well as the lower notes.

It is evident that to reduce frequency distortion to a minimum it is desirable to have

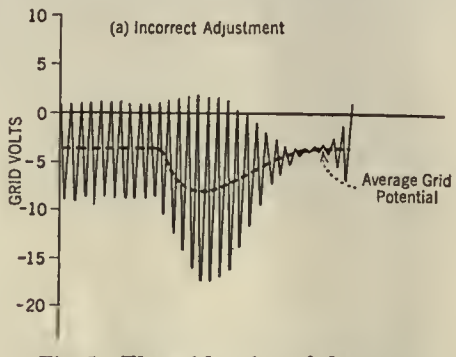


Fig. 5—The grid action of the power detector with a grid leak too large.

small grid-leak resistances and small grid-condenser capacities. At the same time, however, it is undesirable to go to extremes. A grid condenser capacity of 0.0001 to 0.000125 mfd. is about right for a power detector. A condenser much smaller than this will cause serious loss of signal voltage, since the voltage drop in the condenser of the radio-frequency signal voltage will be large enough to make the actual voltage reaching the grid of the tube considerably less than the voltage supplied by the tuned circuit. Grid condensers much larger than the values suggested are undesirable because they make necessary an excessively low grid-leak resistance, which lowers the sensitivity of the detector, and makes the radio-frequency energy lost in the grid circuit unduly large.

If the highest audio frequency to be preserved in the output of the power detector is 5000 cycles, and if the grid-condenser capacity is 0.000125 mfd., a simple computation shows that the grid-leak resistance can not be higher than 0.255 megohms. If the grid condenser was the usual 0.000250-mfd. size, the grid leak would have to be about $\frac{1}{8}$ megohms, an undesirably low value.

Summary

A GRID leak-condenser power detector will deliver approximately one quarter of the undistorted power output that the same tube with the same plate voltage (and suitable grid bias) will deliver when acting as an audio-frequency amplifier. This means that high plate voltages must be used with the power detector, and that the mu of the tube must be sufficiently great to prevent excessive plate current at this plate voltage when the grid potential is zero. If the power detector is overloaded, rectification will take place in the plate circuit and will cause amplitude distortion.

The power detector will reproduce all frequencies equally well only if the grid condenser and grid leak sizes are smaller than the usual values best suited to small signals.

The potential of the grid-return lead of the power detector is unimportant. It can be brought back to either the positive or negative leg of the filament with about equal results. The decision as to whether the grid return should go to the plus or minus filament, or to a plus or minus grid-bias battery should be made so as to give the greatest sensitivity with very weak signals, and can be determined by experiment, or by the principles given in the first article of this series.

In conclusion, it is easy to see why the ordinary grid leak-condenser detector used for weak signals is so unsatisfactory for large signals. The plate voltages usually employed are absurdly small for power work, the usual grid condenser is too large, and the customary grid-leak resistance is about ten times the value best suited for handling large amounts of energy.

THE REAL SIZE OF THE RADIO MARKET

(*Continued from page 379*)

January 1928 increased 27.3 per cent. over the number in use on January 1, 1927.

In the tube market an equivalent increase is noticeable. Total tube sales jumped 82.5 per cent. in 1928 over 1927. The increasing size of the replacement business fairly shouts at one in the summary. Tubes sold for replacements in 1928 increased 74.8 per cent. over the year previous while the number of new sets sold, sets which are in part responsible for the replacement sales, increased in 1928 69.7 per cent. over the year before.

No one can say what the sales in 1929 will be, but there is no prohibition on forecasts. Certainly not less than 3,000,000 receivers will be sold in 1929. Almost that number was sold in the year just closed. It is fair to assume that with the increasing number of sets becoming obsolescent, the year, 1929, will see a tremendous sale of new sets to what one might call old radio customers. Users who have tired of the inconvenience of their antiquated battery set, its poor fidelity, which cannot compare with the reproduction of the best of today can be sold new sets. They need not be sold on radio, but what a sales story radio dealers have for them in the product they now have in their shops!

The number of battery-operated sets which can be replaced with the modern socket-powered set is very large. In 1927, not more than 500,000 "electric sets" were sold. Even if every set sold during 1928 were an "electric" set, there would be hardly more than 3,500,000 sets of this type in use. That means on January 1, 1929 there were 7,500,000 sets not of the modern self-contained type. If 2,000,000 sets be subtracted from that total to allow for those in use in districts where a central station power is not available, there are five and a half million sets which are obviously not modern and which can be replaced with the excellent products the market affords to-day.

Yet the battery set market is by no means inconsiderable—and it is evidence of the astounding vitality of the radio market—as covered at length in an article on page 331 of RADIO BROADCAST for March, 1929.

What this examination of the market means for all in the industry is not difficult to see: in the manufacturing field, tube and set companies have announced plans for great expansion; mergers and combinations have all been calculated toward greater production to meet the 1929 demand which these wise companies anticipate. In the retail field it means that the set market will be greater than ever in 1929, that the sale of tubes for original installation and for replacement will be much larger than last year. Some tube manufacturers who ought to know do not hesitate to say that 100,000,000 tubes will be sold in 1929. The radio dealer can make quickest capital out of this analysis of the probabilities for his sales and service staffs are in direct contact with this public we are talking about. Here is a rich and profitable field for all who purvey to the public who see now in radio, if not a necessity, an almost essential adjunct to the home.

TECHNICAL DATA

SOUND MOTION PICTURES

BY CARL DREHER

Sound Attachments for Standard Picture Projectors

IN THE March issue of this department the general construction and operating principles of standard motion-picture projectors were described. Nothing was said in that article about the motive power for the machine. This is normally an electric motor drive through a system of gears on the left side of the head, a flywheel being provided to steady the speed. The projector may also be operated by means of a hand-crank from the right side, as shown in the accompanying cut (Fig. 1) of a Simplex (International Projector Corporation) machine, where the crank is seen with the handle over the lower magazine. This is feasible only with silent pictures, and then the crank is used only in the rare event of failure of the driving motor.

When sound pictures are projected the speed must be kept constant at 90 feet per minute (24 pictures per second) with a regulation of about 0.2 per cent. in order to hold the pitch. Unless an a.c. source with reliable frequency control is available this requires special speed stabilizing circuits of the type described by H. M. Stoller, "Synchronization and Speed Control of Synchronized Sound Pictures," in the *Transactions of the Society of Motion Picture Engineers*, Vol. XII, No. 35. A synchronous motor operating on a constant frequency a.c. supply is the simplest means of securing the proper speed, and can generally be used in large cities. In projecting silent films a variable speed control is desirable, which means the addition of another motor if a synchronous motor is used for the sound-picture drive.

The lower sprocket of the projector, in the absence of a sound attachment such as is described below, delivers the film to the lower magazine, where it is wound up at a constant rate, as the diameter of the roll increases, by a device known as the "take-up." This is usually an arrangement utilizing a split pulley and tension spring to allow loss of speed as the reel is filled up with the film, with a constant speed drive.

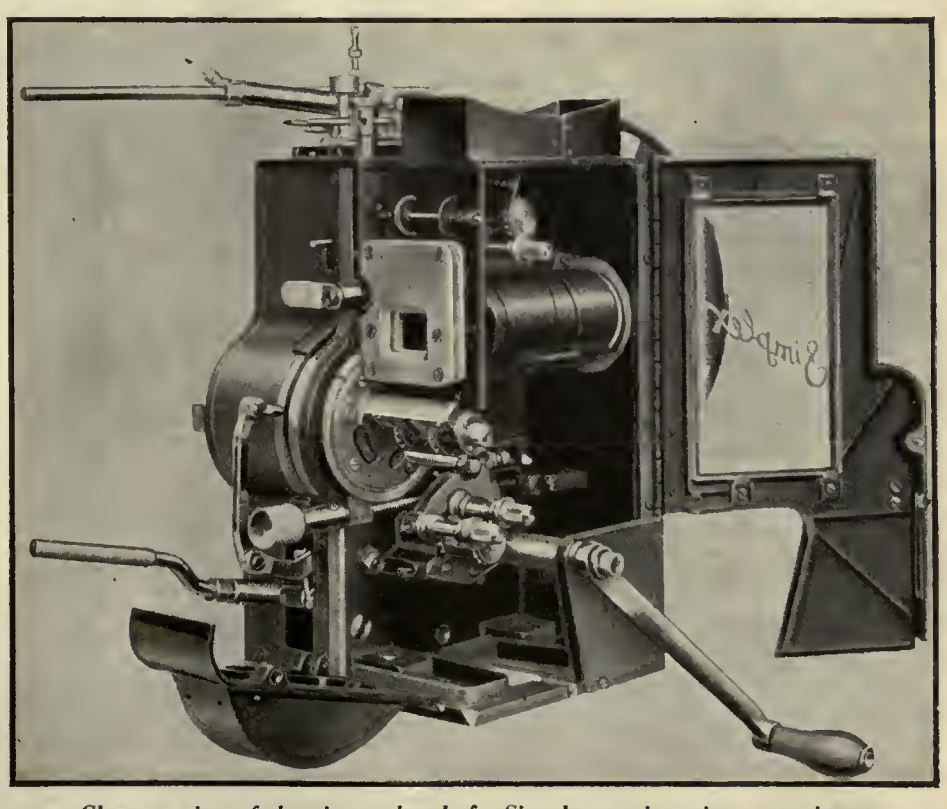
The sound-head attachment shown in Fig. 2 below the picture head is that of the Movietone type, which has been widely illustrated. The optical principles have been described in October and November, 1928, RADIO BROADCAST. The principal problem in the sound head is that of preventing the intermittent movement above from influencing the continuous motion of the film past the point where the sound is taken off. This is accomplished in the mechanism shown, by means of a sound-head sprocket which revolves at constant speed (special mechanical filters to smooth out pulsations usually being applied) and drags the film through a gate similar to the picture gate, containing a spring tension pad which holds the film firmly as it slides through. This sound gate presents intricate problems to the designer. The tension pad must not scratch the film or take off the emulsion; on the other hand, it must not allow the film to vibrate or buckle in the sound gate, even when it has been subjected to the heat of a high intensity arc in the picture gate a few inches above. As soon as the film is allowed to move out of the plane of focus in the sound gate, the output quality deteriorates—high frequencies drop out, "fuzz" and extraneous tremolos come in, etc. This is because the sound track, instead of passing through a sharply defined rectangle of intense light, the dimension of which in the direction of film motion is less than the wavelength, on the film, of the highest frequency to be picked off, runs instead through a relatively wide spot with irregular edges. It must be remembered that at the standard sound film speed of 18 inches per second, a 6000-cycle note, for example, is recorded in a space of 0.003 inch for each oscillation, and it does not take much to spread the light beam, which is designed to cover 0.001 inch, so that it will overlap more than one peak or line of the record. Much, therefore, depends on the construction of the sound gate. As shown in the figure, idler rollers are provided above and below to further control the motion of the film.

Synchronism is maintained by setting up the film with the proper loops, so that when a given picture is at the picture aperture the appropriate portion of the sound track will be at the light aperture in the sound reproducing section of the projector. An error of one or two frames is allowable; beyond this the defect in synchronism becomes noticeable to observers. The proper separation of the picture and sound elements is taken care of in the printing of the film, the sound preceding the picture (since the sound head is below and a given point on the film reaches it *after* it has passed the picture aperture) by such an interval (19 picture frames, or about 14.5 inches) that scene and sound are projected simultaneously.

The Technique of Wax Recording

HALSEY A. FREDERICK'S paper on "Recent Advances in Wax Recording," printed in the *Transactions of the Society of Motion Picture Engineers*, Vol. XII, No. 35, 1928, contains material of much interest, not only to the sound-motion picture specialist, but to students of applied acoustics in general. Mr. Frederick is an engineer of the Bell Telephone Laboratories. His paper is concerned with lateral cut records, in which the groove is of constant depth and undulates about a regular spiral on a flat disc.

After some preliminary discussion, the author refers to a curve, here reproduced in Fig. 3, which shows a typical frequency characteristic for a commercial electromagnetic recorder. The response is allowed to fall off below 250 cycles as a commercial compromise between quality of reproduction, the necessity for getting a certain amount of music onto a disc of reasonable size, and the amount of energy in the form of sound oscillations which it is desirable to get off the record when it is played. The intensity of the sound, in playing a lateral cut record, is a function of the velocity imparted to the needle, and that is the product of the amplitude of the oscillation and the frequency. With the characteristic shown in Fig. 3 constant velocity is secured from about 250 to 5500 cycles, with constant amplitude below 250 cycles. Were the amplitude to be increased below 250 cycles to keep the output constant, the cutter would break



Close-up view of the picture head of a Simplex motion-picture projector

through from one groove to the next in the wax, or, if the pitch of the spiral were increased to allow for a wider swing, the amount of entertainment which could be put on a given disc would be much less. The loss in low frequencies introduced by adhering to constant velocity cutting only as low as 250 cycles may be compensated in reproduction, if desired, by means of corrective net-works, or in the characteristic of the electric pick-up employed.

Of course the amplitude of the cut as a whole can be reduced, and the loss in output made up by increased amplification in reproduction. In this way the constant velocity relationship could be maintained down to a considerably lower frequency, but when this is attempted another limiting factor is encountered—needle scratch or surface noise, caused by the nature of the record material. It is desirable to keep the oscillations corresponding to the speech or music large in order to keep the disturbance caused by the needle scraping the record relatively low. Before the general amplitude of cutting can be reduced, therefore, improvements in record material must be effected.

Frederick states that wax records can be made with special recorders flat to within 1 DB from 250 to 7500 cycles, and not deviating more than plus or minus 4 DB between 30 and 8000 cycles. Such a characteristic, or even the characteristic shown in Fig. 3, can be secured only by flat amplifier design and by constructing the cutting mechanism mechanically on principles analogous to the electrical ones now generally employed. One of these principles, in telephone transmission practice, is to terminate the system with an impedance of such a value as to avoid reflection of energy. In modern electrical recording this is accomplished, in the mechanical portion of the system, by not using the rather variable load imposed by the wax on the cutting stylus as a termination, but instead supplying a relatively large mechanical load in the form of a rubber rod, which dissipates the energy. The work done at the stylus is then incidental mechanically, although functionally it constitutes the whole purpose of the machine.

The actual cutting takes place on what is essentially an accurate lathe with a vertical shaft. The groove cut is generally between five and six mils wide, and 2.5 mils deep. The space between grooves is of the order of four

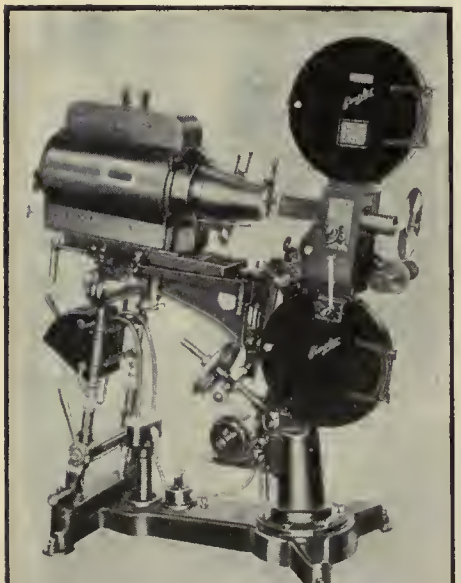


Fig. 1—General view of the Simplex projector

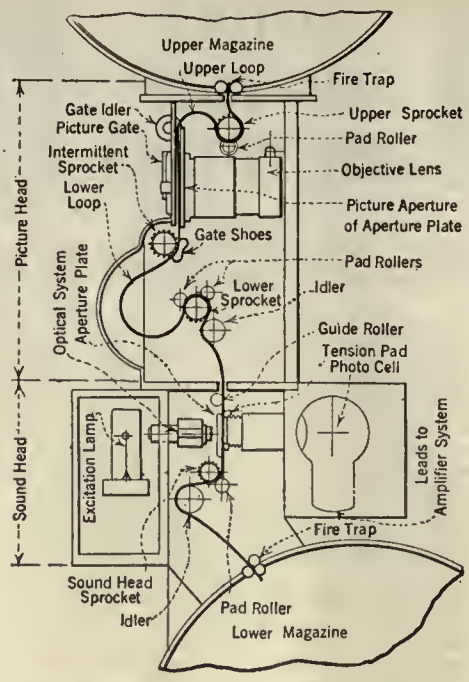


Fig. 2—Schematic diagram of mechanism in a standard motion-picture projector with sound adjunct

mils. The number of grooves per inch varies between 80 and 100 in normal practice, with 90 as the average. This gives a pitch, or distance between turns of the smooth spiral, of 0.011 inch, (11 mils). Since the space between grooves is 4 mils, the permissible amplitude of oscillation is not over 2 mils. If this limitation, for the reasons stated above, is set at 250 cycles, then for a constant velocity cut (amplitude varying inversely with frequency) the amplitude will be 0.0001 inch (0.1 mil) at 5000 cycles. These are microscopic dimensions, and the work is, indeed, best done under a calibrated microscope, which moves across the disc with the recorder stylus.

It is interesting to note that in wax recording and reproduction the linear speed of the record past the cutter or reproducing needle varies between 70 and 140 feet per minute, a figure of the same order as sound film speed (90 feet per minute). For a minimum linear speed and fixed groove spacing, there is an optimum relation between the size of record, rate of rotation, and playing time. This may be mathematically expressed and drawn as a family of curves, here reproduced as Fig. 4.

By means of a special "playback pick-up," which is lighter and more elastic than the usual electrical reproducing pick-up, the newly cut wax may be played immediately through an amplifier and loud speaker system, with quality sufficiently close to that of a hard record to allow an accurate judgment of the performance. This is a valuable feature both in phonograph recording and sound-motion picture applications.

The material of the finished record, or "pressing," has to be hard, in order to afford a sufficient number of playings, and it must contain enough abrasive material to grind a new needle quickly (in 10 to 30 seconds) to fit the groove. Most of this wear is in the starting spiral, in which no sound is recorded. Since pressure is force divided by area, the pick-up, with a weight of about 4.5 ounces, exerts an enormous pressure through the microscopic area of a new needle, and even after the needle is worn to a fit the pressure is of the order of 50,000 pounds to the square inch.

Contrary to a general impression, the finished pressing is a faithful copy of the wax record and loses practically nothing in essential frequencies. Its defect is in the addition of surface noise. By improvements in the material, as well as in the electro-plating process by which the wax is copied, Mr. Frederick states that a reduction of 3 to 6 DB in surface noise has been secured during the last two years. Further improvements may be expected in this line, without change in the present size of records and amplitudes of recording.

By an interesting calculation, Mr. Frederick shows that the diameter of the bearing portion of existing commercial needles used in electrical reproduction is not too great to follow the groove undulations at 7000 or even 10,000 cycles, with standard methods of recording, so that this factor is not a limitation in reproduction of high frequencies by this method.

Advances in electrical pick-up design have been in the direction of reduced mechanical impedance at the needle point, elimination of resonances in the tranmission chain, and reduced weight. These factors combine to secure better reproduction of the higher notes and less wear on the record.

The comment of an engineer who is not a specialist in the wax recording field, based on observation in theatres, would probably be that Mr. Frederick's paper shows interesting and important improvements, but that much still remains to be done before an entirely satisfactory technique is evolved.

Mils, and What They Are

THE theatrical papers are certainly the snappiest on earth, but in technical matters, however simple, they are about as ignorant as one can be without trying. Last summer there was considerable speculation among the Broadway savants regarding standardization of sound track width on talking films, and the trade papers found numerous occasions to write about 80-mil sound tracks, 100-mil sound tracks, and so on. But they hardly ever printed it "mil." Frequently it became "mile." Again it was "mill." And "millimeter." But a mil is neither a mile nor a millimeter. A mil is a thousandth of an inch, and nought else.

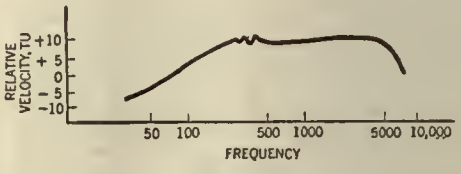
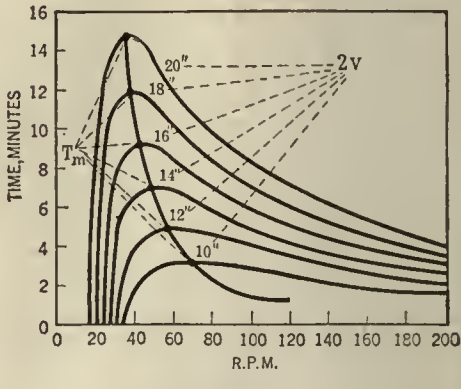


Fig. 3



$$T_m = \frac{\pi N R^2}{24 V_0}$$

T_m = Max. Playing Time, Mins.
N = Grooves per Inch.
R = Outside Groove, Radius, Inches.
V_0 = Min. Linear Speed-Ft. per Min.
V = Inside Groove, Radius Inches
$R = 2v$

Fig. 4

PRODUCTION TESTING WITH OSCILLATORS

By RICHARD F. SHEA

VARIOUS different types of apparatus have been devised and tried by the author in order to obtain accurate matching of coils and condensers with a minimum maintainence cost. These types have included aural and visual tests of all sorts, and the final system has been an adaptation of the beat-frequency audio oscillator. In a preceding article ("A Simple Unit for Measuring Impedances," September, 1928, RADIO BROADCAST) the importance of closely matching the individual coils and condensers in a radio receiver was stressed.

In the heat-frequency audio oscillator we utilize two radio-frequency oscillators, one having a fixed frequency and the other a frequency varying from the fixed frequency up to any desired difference. For instance, one oscillator might be fixed at 500 kc. and the other vary from 500 to 510 kc. This produces a frequency difference between the two varying from zero to 10,000 cycles, and if these two oscillators are loosely coupled to a detector this beat will appear in the output as a variable audio frequency. This system has been used extensively to produce a compact audio oscillator with a continuous range and fairly constant output. The maximum frequency is obviously dependent only upon the frequencies of the two oscillators and the size of the variable tuning condenser. If both oscillators are tuned to very short waves and a large variable condenser is used, the beat can be made to go from low audio notes to radio frequencies far above the broadcast band. The lowest obtainable note depends entirely upon the degree of coupling between the two oscillators. If they are coupled closely they will "pull in" at comparatively high frequencies, and that will set the lowest obtainable note. To lessen this tendency it is customary to set one oscillator at a harmonic of the other. For instance, one might be fixed at 500 kc. and the other vary from 250 kc. to 255 kc. (the second harmonics being 500 to 510 kc.), thus producing a 10,000-cycle maximum beat.

To adapt this device to production testing in a manufacturing plant we see that the audio beat note will pass through zero when the two oscillators are identical in frequency. To match two condensers we merely need to make up two oscillators whose frequencies depend upon the capacities of the condensers under test, and if they match we will get a zero beat. This is the principle of this system applied to condenser matching.

The apparatus (Fig. 1) consists of two oscillators, a detecting system, and an audio amplifier. One unit of the condenser gang is connected to one oscillator and the other oscillator is connected alternately to each of the other units of the gang by means of switches. A small compensating condenser, C_4, is connected across the tuned circuit of one oscillator and a variable midget condenser, C_3, across the other. These are adjusted so that when the vernier, C_3, is set at mid-scale and the two condensers under test are equal, a zero beat will result. If the condenser C_2 is greater than C_1, the dial on the vernier C_3 will have to be moved to one side of mid-scale to reëstablish zero beat. The amount of motion necessary is a measure of the unbalance between C_1 and C_2. The vernier, C_3, should be about 35 mmfd. maximum capacity, and for such a condenser one division on a hundred-division scale corresponds to approximately three-tenths of one mmfd.

Let us now take these parts and dispose them to make a satisfactory production tester. To fill this purpose the apparatus must be sturdy, reliable, and quick of operation. The whole should be mounted on a base of strong steel and should have a jig so that the condenser gang will mount quickly and securely on the base and always in the same position. This latter consideration is important as the position of the gang makes a great deal of difference in the stray capacities which are shunted across the gang. All the wiring should be of heavy bus to insure remaining in place and great care must be taken to make it uniform for all the units of the gang. The drawing of Fig. 2 suggests a successful layout.

Mr. Shea describes in this article an instrument suitable for use in the production testing of coils and condensers for use in manufactured receivers. The author has been connected with the radio division of American Bosch Magneto Company.

Obviously the sensitivity and selectivity of a modern single-control receiver depends to a large degree on the accuracy with which the coils and tuning condensers are matched.

—THE EDITOR.

The coils L_1 and L_2 must be identical, and to insure this fact they should be measured for inductance in the shields. The capacities of the tubes can be compensated by the adjustment of C_4, so that the matching of L_1 and L_2 and the uniformity of leads are the only strict requirements.

To adjust this device place the condenser gang on the jig and set it at zero, i.e., minimum capacity. Set the vernier, C_3, at 50° (on a 100° scale) and adjust C_4 until you get a zero beat. To check this and also the uniformity of the wiring, test about ten gangs and note the readings on all three switch positions. If it is found that the average in all cases is 50° then the adjustment is correct. If, however, all averages are off the same amount from 50° then C_4 should be changed to bring them to 50°. If the average on any one switch position is off it means the wiring is non-uniform, and it can be fixed by pushing the bus wire nearer to or farther from the base. When the tester is correctly adjusted the average of a larger number of gangs should be very close to 50° on C_3.

We are now ready to set limits. If our gang has a capacity of 20 mmfd. at minimum, 200 mmfd. at mid scale, and 500 mmfd. at maximum, and we wish to hold units to within 1 per cent., then our allowance is 0.2 mmfd. at 0°, 2 mmfd. at 50° and 5 mmfd. at 100°. In setting these limits it must be borne in mind that the strays also add to the capacity, and the total minimum will be 40 to 50 mmfd., so that 0.2 mmfd. is holding them much closer than 1 per cent. In such a case 0.5 mmfd. would be the proper tolerance at zero, 2.25 mmfd. at 50°, and 5.25 mmfd. at 100°. If our vernier has 0.3 mmfd. per division this becomes approximately two divisions at zero, 7 divisions at 50°, and 17 divisions at 100°.

Then in testing our gang we set it upon the jig and turn on switch S_1. This matches condenser one with condenser two. We set the gang at zero and rotate C_3 to get zero beat. Let us say it comes at 51°. Snap on switch S_2 and readjust C_3. This time we get 50°. Lastly turn on switch S_3 and here we get 49°. This gives us 50°, 51°, 50°, and 49° for the four units, and as no two readings differ by more than 2 divisions the gang comes within the limits specified above. A similar process at 50° and 100° gives us the deviations at those positions.

So much for condenser matching. Now let us turn to the application of such a system to coil matching. Here we have a much simpler problem and are able to obtain even greater accuracy for reasons which will soon become evident.

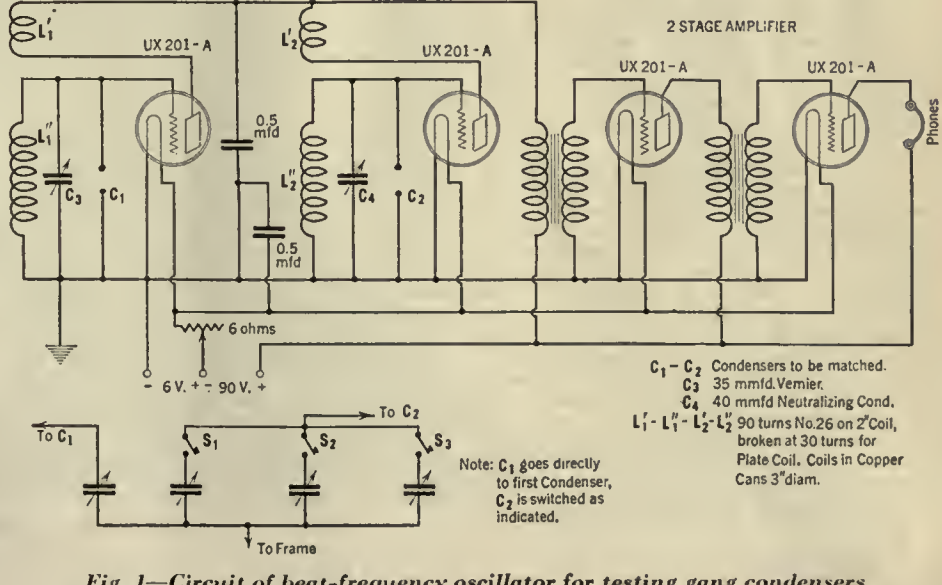


Fig. 1—Circuit of beat-frequency oscillator for testing gang condensers

Fig. 3 shows the set up of the coil tester. It comprises two oscillators and a radio receiving set. One of these oscillators is fixed, say at 300 meters, the wavelength to which the receiving set is tuned. The other's wavelength depends upon the inductance of the coil L_x under test and is brought to 600 meters by the vernier C_3. C_4 is a compensating condenser which can be adjusted to bring the reading of C_3 to exactly 50° when using a standard coil. It will be noticed that the second harmonic is used here for greater sensitivity and also that the coupling between the oscillators is extremely loose, as we have the r.f. gain through the receiving set to make up for it. Thus we are able to get a very sharp reading on this tester.

It will also he noticed that the two oscillators differ in wiring in this tester. The fixed oscillator uses a modified Hartley circuit, i.e., utilizing a coupling coil for feedback, whereas the other oscillator gets its feed-back through a resistance which is common to both plate and grid circuits. This eliminates the need of a tickler coil, and the coil under test has only two connections made to its extremities. Also a filter is provided in L_F, C_F which reduces the coupling between the two oscillators. The two oscillators are shielded from each other hy partitions and the only coupling is through the common batteries, as in the case of the condenser test, except that it is reduced still further in the case of the coil tester by the use of the filter.

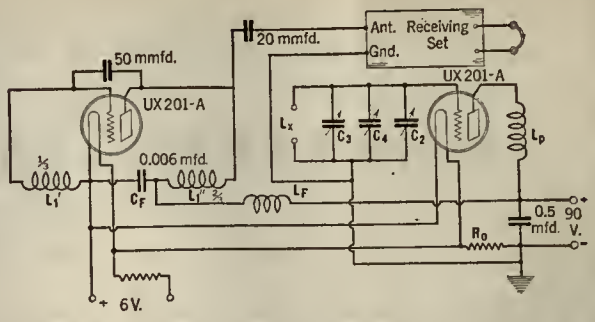


Fig. 3—Circuit of beat-frequency oscillator for testing coils

In using this tester set C_4 so that an average of a large number of coils will come at 50° on C_3. Limits may he obtained for C_3 by measuring the extremes of a large number of coils. For instance, if the average coil is 200 microhenries and a coil giving a reading of 60° is 195 microhenries, and a coil reading 40° is 205 microhenries, then ten degrees on the tester corresponds to five microhenries in 200 or 2½ per cent. If 1 per cent. tolerance is allowed this means 4 degrees. It has been found possible to hold coils to tenths of one per cent. with this tester, as it will easily show a difference of a few hundredths of one per cent. between two coils. In actual use the operation of this tester is very rapid if the coils are at all close, as an audible heat will usually be heard the minute the coil is placed in the jig, denoting that the coil is easily within required limits, so that in most cases it is unnecessary to adjust C_3.

A word of caution is proper here regarding the use of B-power units to operate these testers. While the testers themselves will operate satisfactorily on such devices they will usually cause considerable external annoyance to near-by receivers due to radiation through the power lines. If sets are being tested in the same building they are apt to pick up the beats when they are tuned to the same wavelength as the tester.

The foregoing discussion will no doubt show that the use of beat frequencies in inspection apparatus is much to be preferred to previous methods of aural and visual measurement, not only for accuracy but for speed as well, and consequently is well worth adoption in all plants when precision is desired at low cost.

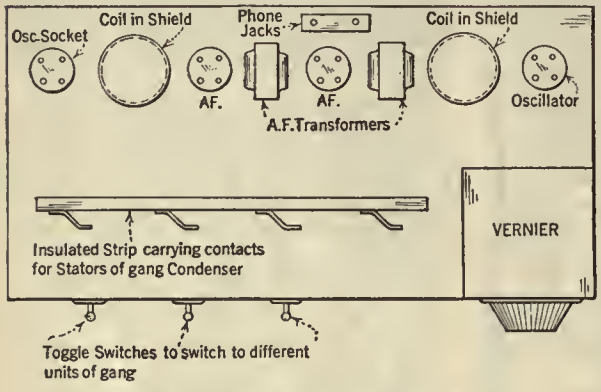


Fig. 2—Suggested layout for oscillator of type shown in Fig. 1

BOOK REVIEWS

Advertising By Radio, By Orrin E. Dunlap, Jr. The Ronald Press Company, 1929. Price $4.00.

In this new volume on radio advertising appear figures for the returns of many recent commercial broadcast features. The author has had access to the sales-promotion material and tabulations of mail return of the National Broadcasting Company and its affiliated stations and also those of WOR. These are quoted liberally throughout his book and should make the volume of immediate interest to all solicitors selling time for broadcasting stations, because any shred of material giving tangible proof or suggestion of proof of the medium's effectiveness is welcome to them.

To one familiar with all the problems of commercial radio broadcasting the rather broad scope covered by the title of the book and the headings of the chapters is hardly fulfilled. But Dunlap provides the complete answer to the question, "Does commercial broadcasting bring mail response?" His observations on broadcast programs are those of any expert listener and critic. He levels a few richly deserved shots here and there at announcers for *faux pas* familiar to radio listeners. In common with the entire broadcast industry he sidesteps the most important point in appraising the value of the good-will program, namely, "Does broadcasting actually influence sales and at what cost?" Conclusive proof that thousands of people send for a cross-word book or a bridge score pad is only indirect and inconclusive evidence as to actual sales return.

Considering that commercial broadcasting is now entering its eighth year, the advertiser certainly has the right to expect some tangible proof that that warm feeling around the heart which the radio listener is supposed to have for those who sponsor programs has in one instance or another actually increased sales volume by a definite number of dollars and a definite cost per dollar increase in sales.

With reference to the practical utilization of broadcasting by an advertiser and such specific and relevant problems as the method of procedure for the selection of stations, programs, management of artists, methods of preparing script, personnel and organization required, and methods of tabulation of returns, little if any information is given. It is characteristic of the writer's style in this particular volume to use the primer method of asking a question and then attempting to answer it. "Of course if you were an advertiser seeking good-will on the radio, what would you send through the microphone to entertain a million listeners and hold them spellbound on a series of wavelengths until the program concludes? Would you contract for the Goldman Band, Will Rogers, Irvin Cobb, or would you link the name of your product with George Gershwin, Galli Curci, Al Jolson, a prize fight or Paul Whiteman's orchestra, or would you select an opera, etc., etc.?"

One chapter is devoted to selecting the broadcasting station for the commercial program. Dunlap calls attention to the fact that the station used must have a good wavelength and that it should reach an area which constitutes a market for the type of product involved.

The selection of broadcasting stations has become much more than a matter of merely selecting one with the best wavelength, covering the area desired. Many complex questions now enter such as chain affiliations, habitual program character and its effect in establishing a particular type of audience at different hours, transmission quality, conditions on the frequency to which the station is assigned, suitability to the particular type of program which the sponsor desires to present and numerous other factors, now habitual considerations when advertising agencies are called upon to select broadcasting stations for a particular client. It is obvious that Mr. Dunlap's rôle has been one of skillful and competent observer at the loud speaker rather than actual contact with the problems of managing directing and placing broadcast advertising features. He deals very fairly with his true subject, the returns obtained by radio advertisers, and the book is certainly enlightening to one interested in this subject. It falls short, however, of a complete study of radio advertising and a guide to the advertising manager who would use the medium of radio broadcasting.—E. H. F.



THE SERVICEMAN'S CORNER

THE quite numerous problems that beset the serviceman can be cleared up best by a general discussion of them by several workers who have encountered and solved similar difficulties. A half dozen or so suggestions on the elimination of categorical troubles are always better than the isolated experience of any one serviceman.

Six servicemen can give their brothers a better idea on how to go about curing a power pack that overheats than any one of them who may have run across only one of the several possible causes of hot transformers.

From month to month, as we scan our correspondence, we are going to pick out the more general attributes of poor reception, and put them before the serviceman for open discussion.

The topic this month is noise. The serviceman every day runs into complaints of this sort. Needless to say an objectionable noise should not be present in any receiver, and it is often the job of the local expert to eliminate it. Many things may cause noise in a receiver, from proximity to the lighting mains to an ageing rectifying tube. The cures for noise are as many and as varied as its causes.

What cases of hum have you run into? What is your general procedure in tracing and rectifying trouble of this nature?

Short articles on this subject of hum reduction will be welcome in "The Serviceman's Corner"—and paid for at our usual rates.

Service Equipment and Procedure

IDEAS on test equipment and the procedure of locating radio troubles are about as diversified as the possible ways of making stuffing for chicken. The tools and methods vary with the individual. It turns out that this business of fixing a radio set is rather a personal affair, and is cut and dried only in its fundamentals. This department has received many contributions from servicemen, describing their favorite equipment and their systems of using it. While, offhand, it might appear that the selection of the proper tools, and the knowledge of how to use them would be kindergarten stuff to the readers of these pages, so much interest has been displayed in the matter, as is evidenced by the many contributions on the subject, that we feel justified in publishing the more representative letters, and drawing from them such conclusions as we can.

SUGGESTIONS FROM KANSAS

RAYMOND E. SNODDY, of Leavenworth, Kansas, boils it all down in a few paragraphs:

"When I am making a service call this is the equipment which I use: a meter with a range of 0–50 volts and 0–35 amperes, a long and a short screw driver, two pairs of pliers, file, soldering iron, headphones, hydrometer, test leads, tape, pipe cleaners, spare wire, a large cloth, and a tube- and set-tester. The tube- and set-tester consists of a 0–8 d.c. filament voltmeter, 0–300 high-resistance plate voltmeter, a 0–15–100 milliammeter, and an a.c. voltmeter with a range of 0–15–150 volts. The tester is also supplied with a cable and tube bases to make the various tests. This equipment is all contained in a small carrying case, very compactly and neatly arranged. I designed and built this service kit myself.

"When servicing a radio receiver this is the routine I always go through: First, upon entering the house and while checking the battery connections, I ask the owner a series of questions as to how the set has been acting, how long it has been out of order, etc. This will often save a lot of trouble as the owner will generally give you some information that will point directly to the trouble. I then check the A- and B-battery connections, test the batteries, and then place the plug from the tube tester in the first radio-frequency socket and test all the tubes in this socket. I then remove the plug and place it in each socket and note the plate and filament voltages, and also the plate current which tells at a glance if the plate, filament, and grid circuits are all complete. Next I replace the loudspeaker with headphones and inspect the antenna and ground connections. Any further continuity tests are very seldom necessary."

ANOTHER SERVICEMAN'S IDEA

BOB BROOKE, of Minneapolis, Minn., goes into more details, and a bit of reminiscence.

"Here I am sort of down with the flu or something and I figured it would be an opportune time to scribble a couple of lines to you about the "Serviceman's Corner." Among other things I am a radio serviceman, and as some satisfied customers think I'm not so bad as a serviceman, I thought possibly I had a chance of getting a line into the "Serviceman's Corner." The other things I am are: amateur radio operator—W9DSH-W6AWR, commercial radio operator, WGDJ-NOG, salesman (house-to-house once when broke and in a small town on the Pacific coast while waiting for my ship to come in), broadcast operator, KNRC, radio engineer in a B-power unit manufacturing company. So now that I've explained myself I'll start on some ideas I have on radio service.

"First, I will give a list of what I consider about the minimum of tools for a serviceman out on the job:

1. A good test kit for a.c. and d.c. sets.
2. A flashlight (I find Burgess snaplights to be the handiest).
3. A kit of tools containing:
   a. several sets of good pliers and cutters of various sizes
   b. several assorted screw drivers
   c. a complete set of spintites
   d. a rat-tail and several small files
   e. a pair of phones
   f. a few fine drills and a hand speed drill
   g. a box of assorted screw nuts and junk
4. A bakelite balancing stick with a hex hole $\frac{3}{16}$" across.

"The test kit has two uses, it gives the customer a higher impression of the serviceman from the start and it makes a positive and quick check of the set and nearly all the circuits in the set as well as testing tubes, voltages, etc. It is the best investment a serviceman can make for himself and often gives or loses you a job. I found mine handy once when I was stranded on the Pacific coast and didn't know when I would get a ship. I took my test kit and made house-to-house canvass in a district that was bound to be good. I offered free tests on the customer's tubes and batteries and told them truly just the condition of their set. In case they needed anything invariably they bought it from me. I also had a Sterling tube rejuvenator along and brought their tubes up for two bits apiece. I also sold several sets during the month I worked the district, and although it was hard work and very discouraging at times it was better than going hungry. I played the game fair and square, made a good many friends, and worked up a good little business that I passed on to a friend whom I had met—that was another example of the helpfulness of a test kit.

"The Burgess snaplight is the handiest little light for a serviceman that I have ever seen as it gets into small places and you hold it in your hand and work with the hand too. I buy them by the half dozen as I lose them or leave them all over town. They cost 26 cents apiece wholesale and last two weeks if you don't lose it in a day or two.

"As for the tools, that is another thing that a customer looks at when the serviceman arrives. A neat kit and a good clean set of tools makes a great impression on the average set-owner."



The Weston tube-checker is an excellent piece of shop equipment for the dealer-serviceman. Any 4 or 5 prong tube may be tested with this set

ANOTHER SUGGESTED ROUTINE

A few additional points are adduced by NEWELL N. WHITE, of Wichita Falls, Texas, who skims the milk of eleven years of servicing as follows:

"I have been in the game since 1917, doing service work on broadcast sets since 1921 with the exception of the two years I was with S. W. Bell Tel. Co. Therefore, I feel at liberty to tell the way I go about checking a set in the home of a customer.

"First I will give the routine I follow on battery-operated sets.

"First the A battery is checked. If it is an acid battery the test is made with a commercial current-drain tester (I find the Hoyt Cell-Check good enough). A hydrometer is never used in the home. A cell checker is sufficiently accurate and there is no danger of spilling acid. Next the B batteries are tested (with no set load) with a low-resistance pocket voltmeter, which puts a heavy enough load on batteries to cause a voltage drop if they are weak. The C battery is checked next. All batteries found defective are replaced before test continues, as all other tests require voltage to give meter readings.

"The next step is to remove tubes from set. When this is done all circuits should be open leading from batteries to set. A *high-resistance* voltmeter is connected in series with each lead from batteries. This will show up any shorted batteries, leads or filter condensers.

"The next and final step in testing the set is with a Jewell a.c.-d.c. box (would not trade it for all the rest of the equipment a serviceman could carry in a truck). This is done with all batteries connected and all tubes in their sockets, except socket under test. The Jewell box tests the filament, grid, and plate circuits of all sockets. In this test, open grid suppressor, open grid coils, poor ground connections, open plate coils, open audio transformers, etc., can be detected. If still no trouble is found the loud speaker is tested by placing it in series with an a.c. plug from a convenient outlet and the a.c. voltmeter of the Jewell test box.

"Next the antenna and ground are inspected. If none of these tests have located the trouble apparently the repairs will have to be made in the shop where I have an oscillator, stationary test board, output meter, etc.

"I might add that while the various sockets are being tested the tubes are also tested.

"In a.c. sets the troubles are less numerous as I find most calls are made on account of bad 227-type tubes or a noisy volume control. In testing these receivers the line voltage is first checked to give me an idea of whether the set voltages are high or low. After this is determined each socket is tested with the Jewell test box which shows the trouble very easily. Since the power pack should be under "set load" while it is being tested, I never like to test from the pack terminal strip. The antenna and ground are also inspected on electric sets.

"In this letter I also wish to comment on the article by Thomas Glose, in January, 1929, RADIO BROADCAST. Probably Mr. Glose was using a high-resistance voltmeter to make his continuity test. If so, the sensitive meter would still show full voltage, because no current to speak of was being passed through corroded contact.

"Now don't get me wrong. I would not start on a call or try to fix a set without my high-resistance voltmeter, but, fellows, you better watch the things. I will bet that a meter of low resistance that had a fairly heavy current consumption, as meters go, would have shown up that poor connection."

SUMMARY

The amount of test equipment the serviceman should carry with him is determined to quite an extent by just how much work he thinks he ought to do in the home of the set-owner. This too, is a matter of personal opinion, but a consensus would limit this to rather elementary tests and repairs. Actually it is a compromise involving convenience and economy. Major repairs can be effected more efficiently in the serviceman's shop than on the library table of the set-owner.

In summation, it would seem that the following equipment is adequate for making all the adjustments and minor repairs that should be made outside of the workshop:

One a.c. and d.c. tube test set;
Two screw drivers, one large and one small;
One diagonal cutter;
One six-inch pliers;
One long-nose pliers;
One small file;
One sheet emery cloth;
One piece of cloth;
One coil of wire;
One knife;
One roll of tape;
One Burgess snaplight;
One pencil with an eraser.

The procedure should be altogether logical. Spend two minutes in finding out the past history of the receiver—then proceed to diagnose the trouble. This will fall into one of four main classes: no reception at all, weak reception, noise, and distortion.

If there is no signal response, endeavor to localize the difficulty without immediate recourse to the test set. If the tubes light, hit the detector tube lightly with a pencil. A ring in the loud speaker shows the a.f. circuit to be o.k., locating the difficulty in the r.f. circuit. (No ring is, of course, indeterminate, and the usual systematic checking of power and tubes should follow.) If the trouble is in the r.f. end of the set, connect the antenna to the plates of different tubes in an endeavor to locate the faulty stage, and then go to work on it. Cases of weak reception should be similarly investigated. The possible causes of noise are many and are treated to some extent elsewhere in this department. If the trouble is distortion, the a.f. circuit should immediately be suspected, and tests made for emission, and incorrect A, B, and C potentials.

The point to be emphasized is that service time can often be cut by using a bit of common sense before resorting to a test set—invaluable as this may be. As John Dunham points out, in his article in March RADIO BROADCAST, a knowledge of radio engineering fundamentals is a servicing tool second to none.

Bad Tubes and Service Troubles

W. S. HARTFORD, of the Kellogg Switchboard and Supply Company, makes a concise and interesting observation: "You may be interested in knowing that 65 per cent. of the reported cases of no reception were traced to incorrect insertion of one or more tubes. About 15 per cent. of the cases were due to low B voltage. In consumer complaints, many owners felt that advancing the rheostat to the tubes will cause shortened tube life. The actual effect is to impair the selectivity and sensitivity of the receiver with a gradual weakening of the tubes."

The Arborphone Company broadcasts a somewhat similar warning on sheet 8 of their service manual: "We wish to call your attention to the fact that the greater percentage of power pack trouble may be attributed to defective tubes. After through tests and reports from various sections we find the following troubles are caused by defective tubes:

Lack of sensitivity, lack of volume, a.c. hum, noisy reception, and fading. However, the most serious of all the defects is that many of these tubes, after being in use a short time, will develop a short in the plate circuit, thereby frequently burning out the power transformer."

Miscellaneous

How Much Current Does My Receiver Consume?: The serviceman is often asked just how much current the particular a.c. set he is servicing consumes—a reasonable bit of curiosity on the part of the owner. MALCOLM CHASE of Taunton, Mass., suggests a simple way of determining just what it costs to operate any a.c. set, as far as current consumption is concerned.

"In order to determine the approximate cost of electricity consumed by an electric set without any accessories the following method may be used. A fifty-watt lamp which consumes five-hundredths of a kilowatt hour per hour should be turned on and, if a kilowatt costs say eight cents, multiply eight by five-hundredths. This will give you the cost per hour to operate a fifty-watt lamp. Now consult your electric watt-hour meter and count the number of revolutions the aluminum disc turns in one minute.

"Now turn on your radio set or battery charger. Suppose the disc makes one and one-half times as many revolutions as it did for the fifty-watt lamp in one minute. Obviously the radio set will cost one and one-half times as much to operate as the fifty-watt lamp. Make sure of course that the only load on the line is the device you are interested in computing the operating cost of."

Selling A.C. Tube Insurance: The Fordham Electric Company, dealers and service in the Bronx, New York, are selling the Ward Leonard Vitrohm Line-voltage Reducer, shown on page 391, to many clients in outlying a.c. districts where the line voltage often rises above safe limits. This is good business. The good will of the customer is more than worth the sale of replacement tubes.

The latest merchandizing scheme at this store will interest the small-town serviceman who is also generally the main source of radio supplies. Hundreds of burned out tubes are heaped in the window surmounted by a sign reading: "For Sale Cheap." A second sign tells the story of the line-voltage reducer as a means of preventing blown-out tubes. Dozens of customers have been brought in the store by this window display and sold on the spot. Many of them spent only two dollars for one of the line units the first time, but came back later to spend much more money for a set and accessory equipment.

Elimination of Noise

THE following trouble is quite common, although the first time it is encountered it might cause a lot of extra work. It starts out like a microphonic howl and grows to a roar of rather low pitch. The usual routine tests indicates everything o. k. except that when a certain 226-type tube is inserted in the set-tester the howl stops. However, when it is returned to the set the noise starts again. Upon examining the tube it will be noticed that the filament and grid are nearly touching each other.

When the tube is in the set the vibrations from the loud speaker cause the filament and grid to short, thus causing the howl. When the tube is inserted in the tester, which was away from the set the vibrations do not affect the tube and everything seemed o.k. The remedy is obvious. A good way to find the offending tube is to hold each tube with one hand and tap it lightly with the other. A defective tube will cause a prolonged scratchy noise in the loud speaker.

H. WEIMAR, Appleton, Wis.

DATA FROM KING MFG. CO.

The service bulletins of the King Manufacturing Company, of Buffalo, N. Y., contain some interesting "dope" on the elimination of noise.

"Some radio tubes are microphonic in action and when used will cause a ringing sound in the loud speaker. This will be especially noticeable when the set is jarred or when the lid is closed. Usually microphonic tubes cause the greatest trouble in detector and first-audio stage.

"To overcome this difficulty first try changing tubes into different sockets to isolate the microphonic ones. If this does not eliminate your troubles ballast the tubes mechanically. To do this either use the commercial devices marketed under the name of "Howl Arrestors," etc., or ballast with rubber tape.

"Wire-wound rheostats will at times, in spite of all precautions, become noisy and produce a grating sound when turned. This is due to the natural wearing of the resistance wire and can be overcome easily. Simply take a soft lead pencil and rub the lead over the wire winding of the rheostat. This slight application of graphite lubricates the rheostat and in no way changes its electrical characteristics."

INSULATION CAUSES NOISE

C. W. MANGOLD, of Richmond, Ind., sends along the following that is typical of the many exasperating cases of noise one encounters when the receiver is jarred.

"Just recently I serviced a Bremer Tully six-tube receiver. The only station that could be brought in was WLW and the signals were very weak. After checking the tubes, antenna, loud speaker and power supply, and finding them in good condition, I started to test the set.

"By moving the first a.f. tube, and getting it in a certain position the signals would come in very loud, but just as soon as the tube would go back to its normal position the signals would become weak again. I then removed the set from the cabinet and looked for a bad tube socket or connection to the socket but they were all right. In placing the tube back in the socket and moving it around, I found that the tube prongs were moving some wires that run to the r.f. coils which were covered with a metal shield. The insulation had worn off of one of the wires and was shorted on the shield.

"By moving the tube it would move the wire far enough to eliminate the short and of course the signals would increase. After the wire was wrapped with tape the set worked satisfactorily."

DETERMINING LOCATION

The Freshman service bulletin contains the following suggestions in reference to checking up on noise:

"Disconnect antenna and ground leads. If set becomes quiet, and signals, though now very weak, are heard, the trouble is in the antenna system or it is caused by electrical disturbances. If due to antenna system, repair same. The location of interfering electrical disturbances may be found with the assistance of the local power company.

"If removing antenna and ground does not eliminate the noise the trouble is in the receiver or power supply. A defective tube may cause noise, and poor or dirty contact at tube prongs or between volume-control arm and winding may be the cause of noisy reception. A poorly soldered or broken connection in the receiver may be the cause of noise. Check the by-pass condenser for leak or intermittent short circuit.

Very often noise is picked up by the antenna system. Such noises are generally caused by line leaks, battery chargers, and static. But the fact that a noise disappears when the antenna is disconnected, or when a station is detuned, *does not necessarily mean that the noise is not in the set itself.* Noises of all kinds, set and external pick-up, are always accentuated when a signal is being received. The detection of a carrier wave sensitizes the receiver to all sound disturbances.

If it is impossible to determine whether or not the noise is arriving by way of the antenna by ordinary means, an oscillator should be coupled to the receiver, and its wave picked up. The oscillator should be so closely coupled that the pick-up is not affected through the usual antenna system. Then the change in sound intensity with the removal of the antenna is a reliable indication of conditions.

The Service Forum

A COPY of John Rider's book, *A Treatise on Testing Units for Service Men*, has found its way to "The Serviceman's Corner." This is a small book containing some fifty pages of material much of which will be of

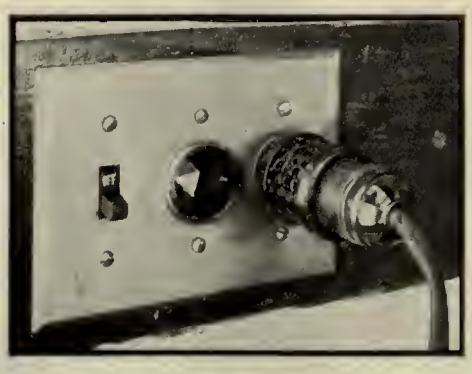


The Weston set-checker which has been designed especially for portable use

value to the radio workers to whom it is addressed. Mr. Rider has succeeded in collecting from diversified sources considerable data of interest to the serviceman. Items of probable utility to our readers are short chapters on tube reactivation, a general utility tube tester, and the section on voltmeters and ammeters with their multipliers and shunts. This book can be obtained from the Radio Treatise Company of New York City for $1.00.

¶ ONE of the best hooks on the general servicing of commercial receivers that the service editor has ever seen (and certainly one of the best all around service manual published by a manufacturer for distribution to his dealers) is that circulated by the King Manufacturing Company of Buffalo, New York. This is furnished in loose-leaf form, with an attractive and durable binder. It covers many general items of interest in an altogether authentic and useful way. Such points as tube rejuvenation, a simple modulated oscillator, adding power tubes, static, test equipment are considered with no special emphasis on King receivers. Any servicemen having occasion to service King receivers should make it a point to secure a copy of these bulletins if they are not already on his radio book shelf.

¶ THE dentist keeps a careful record of his patient's mouths by means of a chart of the teeth noting, their peculiarities and the work done upon them. The service bench might take a tip from the dentist's chair. A simple layout chart of each set serviced, with a notation of voltages, tubes used and in which sockets, along with an abbreviated history of this particular installation and the results expected from it under normal operation, would speed up the next service job on that receiver.



The Ward Leonard Vitrohm line-voltage reducer is valuable when servicing receivers in districts where the line voltage is high

¶ SEVERAL servicemen have suggested that it would be a boon to the independent serviceman if he could buy a test set on the installment plan. Such purchase plans must generally be arranged with through the dealer rather than the manufacturer, and in such cases the serviceman loses the discount that is legitimately his.

¶ A CALIFORNIAN serviceman, in the employ of a dealer, writes us: "In one of B. B. Alcorn's articles he stressed the necessity of good testing equipment. I had a hard time getting mine together and when I came to the Jewell Analyzer thought I never would be able to get the $97.50 together. After a little thought I went to my employer and explained to him the necessity of an analyzer, telling him that I felt our service could be improved greatly by its use. A few days later I received my outfit, getting it at cost and am paying for it $10.00 per month. Maybe some of the servicemen who are reading your magazine have been unable to obtain this equipment but have a big-hearted boss."

¶ THE Supreme "Radio Diagnometer" can be secured from the Supreme Instruments Corporation of Greenwood, Miss., by a down payment of $38.50 followed by ten monthly payments of $10.00 each. This is a complete tool kit and test set combination, mounted in a neat carrying case. The entire equipment weighs 25 pounds.

¶ SPEAKING of test sets call to mind a half dozen letters from servicemen requesting construction data on simple test equipment requiring only two meters, with the necessary switches and shunts. We should be glad to publish pictures and diagrams of such a job. Have you one?

¶ MANY a serviceman can make a profitable connection with a local dealer. Not a few radio dealers have gone into the radio business via a slow evolution from furniture or kitchen stoves. They know nothing whatever of the servicing side of their business and are losing good will because of their ignorance. They would be more than happy to coöperate with a good serviceman.

¶ The F. O. Kinnecom Electric Company (Electrical Engineering and Construction) of Providence, Rhode Island, established many profitable dealer associations by sending out the following form letter on their letterhead to radio dealers:

"Gentlemen:

"For the past 33 years the writer has been engaged in electrical engineering and construction.

"Our experience shows that fully sixty per cent. of the trouble with radio to-day is caused by crude and faulty installations. Two or three years ago the public thought that noise was associated with reception, but to-day, with the number of high-grade sets on the market and the keen competition in making sales, it is our honest belief and experience that the houses that are making proper installations so as to insure a good quality of reception are the ones that will ultimately dominate the trade.

"We are qualified to make inspections of radio installations, or to lay out or supervise the actual work. We have a fine assortment of high-grade testing instruments and we welcome an investigation as to our ability and standing in the above line of work.

"Would it not be a good sales talking point to state that all radio installations made by your house are passed on by an established engineering company, who issue an itemized report to you? May we not be of service to you?

"Yours truly,".

PRACTICAL RADIO SERVICE RECORDS

By JOHN S. DUNHAM

Q R V Radio Service, Inc.

LET'S eavesdrop on the office end of a telephone conversation which runs something like this: "Jones Radio Service. Yes, Mrs. Green, we shall he glad to have a man call. What is the address, plcase? Wbich model is your radio? Are you using batteries or a power unit? About how long ago did you last have new B batteries? Thank you. When would you like to have a man call? Only in the morning? Yes, I know we've heen there a number of times, Mrs. Green, but we have sucb a large number of calls that it is quite impossible to remembcr all the speeial details of each of them. Yes, we'll have a man call to-morrow morning. Thank you."

Now let's eavesdrop in another office. "Smith Radio Service. Yes, Mrs. Green." While Mrs. Green is speaking, tbe effieient young lady at the desk reaches about ten inches to her right, to the alphabetical file containing perbaps a thousand active records, and extracts tberefrom—*within five seconds*—a card bearing the complete record of the last several calls made at Mrs. Green's home. Tbe record makes questions unnecessary,and she immediately replies to Mrs. Green's statement of trouble by saying: "We shall be glad to bave a man call to-morrow morning to take care of it, Mrs. Green. Thank you. Good-bye."

While the example given in the first paragraph is exaggerated—the average service concern would not ask all those questions—every bit of that advance information is of real value in servicing a radio. If complete data is not on record, tben it must eitber be obtained from the customer each time a call is requested, or else the serviceman must approacb tbe job "blind" and bope be'll bave everything he might need. Of coursc, it would be possible to have a serviceman so fully equipped that he would be prepared at all times to meet extraordinary demands for any amount of supplies, but it would be neither practical nor eeonomical. If proper records are kept, each man takes with him, eaeb day, only the supplies he aetually needs, plus a small amount for emergency calls, tbus keeping the average inventory down to a figure of perhaps one-fifth of that wbicb would otherwise be necessary.

A Card System

THE system of records we shall describe briefly has been used hy one organization for the past five years and has proven itself to be very satisfactory. Tbe 3 by 5 inch job card illustrated on this page is written up as soon as a call comes in, and is tben immediately put in a numerical file under the date tbe work is to be done. If it is to be done tbe same day, it is put either into the individual job-card box of the man to whom it is assigned, or, if it is to he telephoned to him, in a special place on the desk until tbat is accomplisbed, after wbich it goes into his box to be written up when he comes in. At the end of eacb day the job-cards filed under the date of tbe next day are assigned to the various men, a record is made of the assignments in a day-book used only for that purpose, and they are then placed in tbe men's boxes. There is no waiting in the mornings for work to be assigned.

The reports written by the men on tbe job-cards, *before leaving each job*, are transferred practically verbatim, the next morning, to the 5 by 8 inch master-cards illustrated. These large cards, which have been filed in tbe "to be done" section pending completion of the work, are now put into tbe "to be billed" section, or if cash was paid, into the "completed" section. The "to be billed" section is removed hodily eaeb afternoon, and after hilling, the cards are filed in tbe "billed" section, where they remain until paid or written off. Statements are sent out monthly, and that fact is recorded on the cards. When payment has been made, the eard is then placed in the "completed" section.

When the first master-card has been filled up, and card number two has heen started witb tbe record of a call made, then card numher one is placed in an inactive "old" file. Every six months, tbe cards in the active "completed" section upon which no call have been recorded during the past twelve months, are removed, carefully tahulated in a elassified record of customers gaincd and lost, and are then placed in a "dead" file.

Arrangement of File

THE plane of tbe cards is parallel to the length of the drawer, so tbat the person at the desk is directly in front of the cards wbich are in eitber the rigbt- or left-band drawers, when tbey are open. Each of the active alphahetical sections employs guides of a color differing from the colors of the other active sections. Each section has a special guide preceding it, with a large tab on which is printed the name of that section, and they arc placed, from front to back, starting at the front end of the drawer, in the following order: "To be done", "To be billed," "Billed," "Completed." The small job-card file, and the supply of hlank cards of both sizes, are kept in the upper left-hand drawer. The lower drawers on both sides are used for less active, and inactive files, arranged for accessibility in the order of their degree of activity.

QRV RADIO SERVICE Job No. 25101

Dealer QRV Phone

Customer Jones, Carl F. Phone

Address 11 E. 12 St. 4-B

Work to be done Svc. Probably needs Set Radiola 25

A's, may need B's Tubes UX-199-120

Supply Dry A, B, C

LS Radiola 100

Service / Inspection by — by Hunt Date 10/30 — A. M. / P. M.

Installation

Flat-top ft.

L. l. Outside ft. / Inside ft.

Gnd. ft.

Stas. hrd. & vol.

Qual.

Remarks

Inspection or Service

Inst. O.K.?

Stas. hrd. & vol. WEAF. WJZ. WOR

good Qual. good

A. 4.6 B 81-40-118 C 4.5-22.5

Report Put in A's. Cleaned and adj. rheo. Put in 3 new tubes. Rest OK

Recommended P.J. meter

Furnished 6 - 6A's 3UX-199 tubes

Collected

Fig. I—These illustrations show a job-card and master-card of the type described by Mr. Dunham completely filled out on both sides

Bill to Dealer/Customer QRV ... (from R.C.A.) Jones, Mrs. Carl F. — ZONE I — CARD No. 6

Address Res. Addr. 11 East 12th Apt. 4-B Bus. Addr. 30 West 23rd St.

Set Radiola 25 — Tubes UX-199-120 — Supply Dry A, B, C — L. S. Radiola 100

Res. Tel. — Bus. Tel. GRA-3200

Date	Done by	Job No.	Work done. Results obtained	Date Billed	Date Pd.
10/30/26	Hunt	25101	SVC: Put in A's, Cleaned and adj. rheos. Replaced		
			3 tubes. Recommended p.j. meter. Rest OK. WEAF, WOR		
			WJZ - good vol & qual. A 4.6 - B 81-40-118 -		
			C 4.5-22.5	10/31	11/15
1/3/27	K'hof	26937	SVC. Open lat a.f. pl cct. Rrot in catacomb for		
			replacement. A's and B's needed		
1/4/27	Price	26964	SVC. Put in new cats. A's, B's, C and one tube		
			Shifted tubes. Adj. L.S. and loop contacts. Rest OK	1/6/27	3/1
			Locals - good vol & qual. A 4.6 B 92-46-138		
			C 4.5-23 Sold p.j. meter		
3/20/27	H.M.L.	28452	SVC. Put in A's. Rest OK. WEAF. WJAM. WHN - good		
			vol & qual. A 4.6 B80-40-120 C 4.5-22½	3/21	6/4
6/5/27	Peds	31004	SVC. Put in A's and replaced open L.S. coils, Fixed		
			loop wires. Replaced open vol contr cartridge. WJZ		
			good vol & qual. A 4.6 B79-38-119 C 4.5-22½	6/6	6/10

5-516-11-28

	Date 10/30/26	Date 1/3&4/27	Date 3/20/27	Date 6/5/27	Data
O. Inst.					
Ant. eqp.					
In. Inst.					
Loop set hukup					
Service Zone I	6 2 50	5 00	2 50	2 50	
As:	6 3 00	6 3 00	6 3 00	6 3 00	
Bs: 10308		2 9 50			
" 2158		2 4 00			
Cs: 5156		1 1 75			
"					
Tubes: UX 199	3 6 75	1 2 25			
"					
"					
Catacomb replaced		a.c.			
Weston pin jack meter		1 7 00			
Radiola 100 coils				1 pr 1 65	
Vol control rheostat				1 45	
Trav. Exp.					
Taxi					
	Total 12 25	Total 32 50	Total 5 50	Total 7 60	Total

CHARACTERISTICS OF POWER RECTIFIERS

By ROGER WISE

Formerly, Chief Engineer, E. T. Cunningham, Inc.

THE first socket-power device sold in any quantity was the "B eliminator" which at the time these devices were first offered, some three years ago, commonly utilized the general-purpose tube, type CX-301A, as the rectifier. Some of these were single-wave rectifiers, capable of supplying 10 to 15 mA., at 90 volts, while others were full-wave rectifiers using two tubes and with an output of 20 to 30 mA. The outputs mentioned were obtainable only with tubes in which the filament was in the best of condition, and the slightest drop in filament emission became noticeable immediately in a reduction in output current and voltage.

These "B eliminators" gave good service at the time they were introduced, the conditions differing considerably from present-day requirements in several important respects, the most important one being the plate current drain of the sets then in use. Five-tube sets were just becoming popular, with six-, seven-, and eight-tube sets quite rare. The average receiver was of the three- or four-tube type, requiring from 10 to 20 milliamperes, at a maximum potential of 90 volts. The rapid increase in the number of tubes per receiver soon raised the maximum demand to 30 mA. in the case of the five-tube receiver in which the C battery was omitted altogether. Two years ago, power-amplifier tubes were introduced, the 371-type tube adding nearly 15 mA., to the total receiver current drain when operated 135 volts, and 20 mA. when operated at 180 volts. As a result of this increase the maximum current requirements became 50 to 60 mA. Other developments were the type of receiver in which the filaments of CX-299 tubes were operated in series from socket power, requiring 65 to 75 mA. and those using CX-301A in series and requiring 250 to 300 mA.

The rectifier using the CX-301A, soon became inadequate in the face of the rapidly increasing current demand, and the CX-313, a full-wave rectifier, and CX-316B, a half-wave rectifier, were introduced, the CX-313 providing an output of 65 mA., the maximum allowable transformer voltage being 220 volts a.c. per anode. The CX-316B also has a rating of 65 mA., but the design is such as to permit the use of higher transformer potentials, 550 volts. With an efficient filter the CX-313 provided a maximum voltage of 180 volts, and the CX-316B, 450 to 500 volts. These types are now being superseded by the CX-380 (full-wave) rated at 125 mA. and 350 volts a.c. transformer voltage per anode and the CX-381

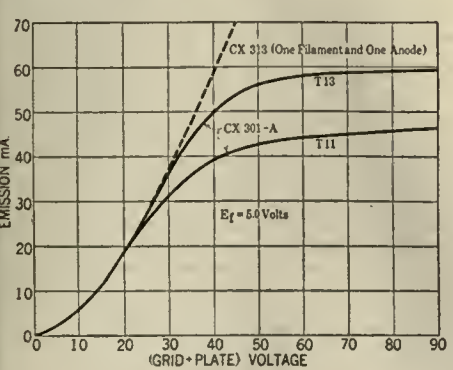


Fig. 2

The author of this article on the whys and wherefores of filament-type rectifier tubes and circuits was, until recently, Chief Engineer of E. T. Cunningham Inc. He is now associated with Grigsby-Grunow and actively engaged in putting into shape a tube manufacturing plant that in size will rival the largest now in existence. Mr. Wise points out the development of the present rectifier tubes of the 280 and 281 types. He shows that with certain types of filter circuits the instantaneous currents that must be supplied by the filament of the tube are much too great for the tube to have long life, and suggests another filter arrangement which increases tube life.

It has been the experience of the Laboratory Staff that the suggested filter arrangement, whereby the first filter condenser is eliminated, produces too much hum for use with good amplifiers and good loud speakers. The Staff's lack of success may be accidental, and should be glad to hear from readers who experiment with these two filter systems.

—THE EDITOR.

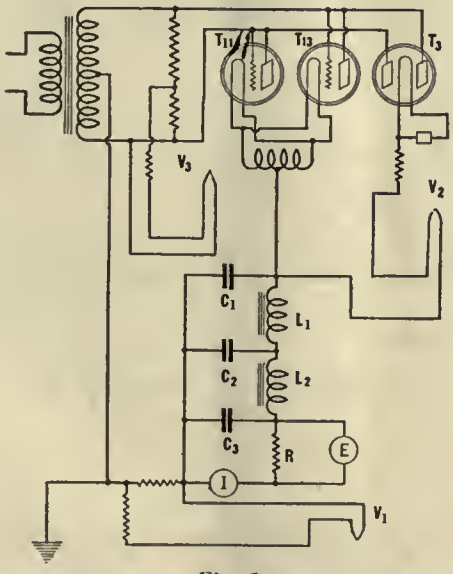


Fig. 1

(half-wave) rated at 110 mA., and 700 volts a.c. The latter two tubes have been in production only a short time, and the data presented in connection with them is subject to slight modifications.

The circuit diagram of one of the early types of rectifiers designed to use CX-301A tubes, is shown in Fig. 1. This circuit diagram also shows the placing of the oscillograph vibrators used in testing the performance of this unit as shown in the following figures. Vibrator V_3 is arranged to show the transformer secondary voltage, which, with 110 volts applied to the primary, was 230 volts r.m.s., or 115 volts per tube, the applied voltage to each rectifier being one half of the total transformer voltage because of the full-wave connection. Vibrator V_1 reads the instantaneous current through the tube, while V_2 by means of a special circuit arrangement reads the voltage across the tube only during the time it is conducting current. The back voltage across each tube is blocked off by means of the auxiliary full-wave rectifier tube, T_3 in the diagram.

With this arrangement it is possible to get a complete record of the performance of each rectifier and to determine the exact point at which overloading, due to limited filament emission, begins. The power lost in the tube can also be computed, and the efficiency determined.

In taking the records, high sensitivity vibrator elements requiring about one milliampere per millimeter deflection, were used and a 10-millimeter deflection was satisfactory for most of the work. The current required, 10 mA., could not be disregarded in taking some of the voltage readings, but the effect of this current, for instance, the current flowing through the vibrator V_2, was eliminated by making an extra exposure on the film, the vibrator V_1 being opened when V_2 was being read, and *vice versa*. Tubes T_{11} and T_{13} were CX-301A's while T_3 was a CX-380 rectifier tube.

In Fig. 2 the emission characteristics of the CX-301A tubes used in the tests on this older type of socket-power device are shown. The tubes were prepared for service by an ageing treatment so that the emission would remain entirely steady during the taking of the film. A voltage of 100 volts was applied to both plate and grid, under which voltages the full emission current of 40 to 60 milliamperes was drawn over to these electrodes. Under this very severe overload the emission dropped slowly, and after the current had dropped to 20 mA. the voltage was cut off and the filament reactivated at 7.0 volts for a few minutes. After a few cycles of this treatment the emission remained steady for a long period of operation at the high voltage.

The curves show that practically the full emission current flows when a potential of 50 volts is supplied to the anode (that is, to the grid and plate connected together as an anode) and that there is very little increase as the applied voltage is raised to 90 volts or above. The dotted line gives some data for a CX-313 tube.

When a CX-313 was substituted for the two CX-301A tubes in taking the record shown in

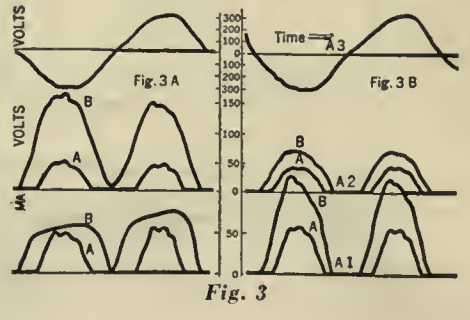


Fig. 3

Fig. 2 the emission curve of one filament and anode of this tube, shown by the dotted line, (Fig. 2) should show no evidence of saturation within the limits of the figure.

In the oscillograph record, Fig. 3, each figure contains two separate records of the performance of the socket-power unit in question. The records made by vibrators V_2 and V_1, labelled A in the figure, show in each case the performance under a load current of 20 mA. the normal maximum for this unit, while curves B show the performance at 50 mA. output. Referring to Fig. 3A, the upper record, Vibrator V_3, is that of the voltage developed across the secondary of the transformer.

Oscillograph Records

THE voltage developed across the tube is V_2 when the current indicated by V_1 is flowing. It can be noted in the curves showing the current wave form that the voltage rises rather rapidly as the current starts to flow, and then less rapidly as it reaches higher current values. This is partly due to the fact that the resistance offered by the tube to the flow of current decreases as the current increases until the full emission current flows, and partly to the less rapid increase in instantaneous transformer voltage, near the peak of the wave. The current does not begin to flow at the instant the transformer voltage increases, but lags about 40°, this lag being due to the voltage existing across the first filter condenser. In this particular case the voltage across the load was 108 volts, and the voltage across the first filter condenser was somewhat higher. At the instant the current started to flow the transformer voltage was approximately 120 volts, indicating that this value of voltage existed across this condenser. Current then flows for the next 100° of this alternation, and at the time it ceases to flow the transformer voltage is 145 volts, as a result of the charging of the condensers. During the remaining part of the alternation the rectifier is idle.

The voltage across the tube just reached the value required for full emission current, 50 volts, and the current was slightly higher than was expected from the d.c. readings, above 50 mA. On the second alternation the current reached a slightly higher value, 55 mA., but because of the higher emission given by tube, T_{13}, the peak voltage drop was 43 volts.

Conditions indicated by record B on these two vibrators were with maximum obtainable load current, 50 mA., to obtain which the output terminals were shorted except for the resistance of the vibrator.

The voltage across the tubes reached a value close to the full transformer voltage,

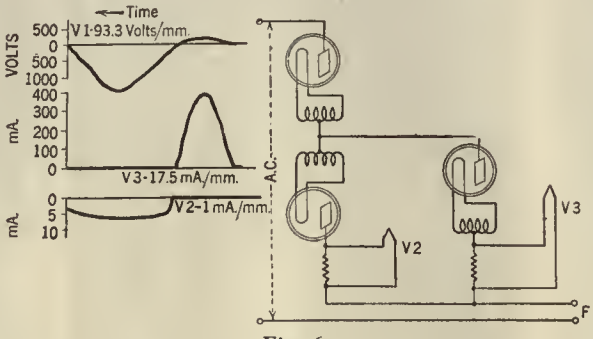


Fig. 6

the peak with tube T_{11} being 160 volts, and with T_{13} just under 150 volts. Practically all of the energy delivered by the transformer, 16 watts exclusive of the filament energy, was dissipated in the rectifier tubes, accounting for the fact that the output terminals had to be shorted to reach this current value.

At the conclusion of this test a single CX-313 was substituted for the two CX-301A's with the following results. At 20 mA. the performance is practically identical with that obtained from the CX-301A tubes, but at 50 mA., the CX-313 has ample available emission so that the saturation current is not reached, the peak value rising to 115 mA. The voltage drop across the tube is much smaller as a result, the peak being 70 volts, as compared with 160 and 150 volts, respectively, with the CX-301A tubes. Since less voltage is consumed in the tube, more power is available in the output circuit and it is no longer necessary to short the output terminals to obtain this current. The output voltage, in fact, reached 60 volts, the output current being practically the same as before, 51 mA. As a result of this increased load voltage the voltage across the first filter condenser is increased, and the current no longer starts flowing as soon as the transformer voltage begins to rise, although it does carry current earlier in the cycle than was the case with the lower load current.

The results are tabulated in Table I.

The curves shown in Figs. 4A to 4E, record the performance of a half-wave rectifier, the type used being CX-381. The transformer potential, indicated by vibrator V_3 on each record, was maintained throughout at 750 volts a.c. The load resistance was also kept constant at 5000 ohms.

Half-Wave Rectifiers

IN THE first oscillograph record, 4A, all filter elements are omitted. The peak current value was 140 mA., while a d.c. meter in the load circuit, indicating the average current, gave a reading of 47 mA. Thus, the tube's filament was called upon to supply, momentarily, three times the average load current. This is an important fact, since the filament must be made large enough to supply the emission current for the peak value. The ratio between peak and average current will be noted for each figure, in order to determine the relative load imposed by each circuit upon the tube's filament.

The second exposure, Fig. 4B, was taken after adding a 4-mfd. condenser across the load. The charging of this condenser permitted a much larger current to flow through the tube, because of the reduced load impedance and the output current not only increased greatly in value to 102 mA., but continued to flow during the alternation when the rectifier was idle. The back voltage developed across this condenser reduced the time during which the tube carried current, thus further increasing the peak current demand upon the tube which, as indicated by V_2, rose to the value of 535 mA. The ratio of peak to average current was thus increased to $\frac{5\frac{3}{4}}{1\frac{1}{2}}$ or 5.2:1.

In Fig. 4C, a 20-henry choke was placed in series with the load. The effect of the self inductance of the choke in causing the current to lag behind the voltage is quite evident on this film, and it also caused a marked decrease in the peak current to 70 mA., as well as in the average current (26 mA.). The current flowed for a longer portion of the cycle, however, and the ratio of peak tube current to average load current was reduced to the more favorable value of 2.8:1. A transient voltage was developed at the moment the current ceased to flow through the tube, caused by the self-inductance of the choke.

In the next figure of the series, 4D, the usual filter system was added, the performance being similar to that obtained with a condenser alone, except for the improved filtering of the output current. The peak tube current was practically the same as in 4B, 540 mA., the output current 102 mA., a ratio of 5.3 to 1.

In the fifth figure, 4E, the usual input condenser was omitted, resulting in greatly reduced demand on the tube and also in a marked reduction in output. The results are similar to those of Fig. 4C. except that the choke was smaller, 10 henrics, and, therefore, had a smaller effect in reducing both peak and *load* current. The peak tube current was 130 mA., and output 45 mA., a ratio of 2.9:1. The transient voltage which appeared in Fig. 4C was again present, and was sufficiently severe to result in an appreciable ripple in the output current.

This series shows quite clearly that omission of the first filter condenser in a half-wave rec-

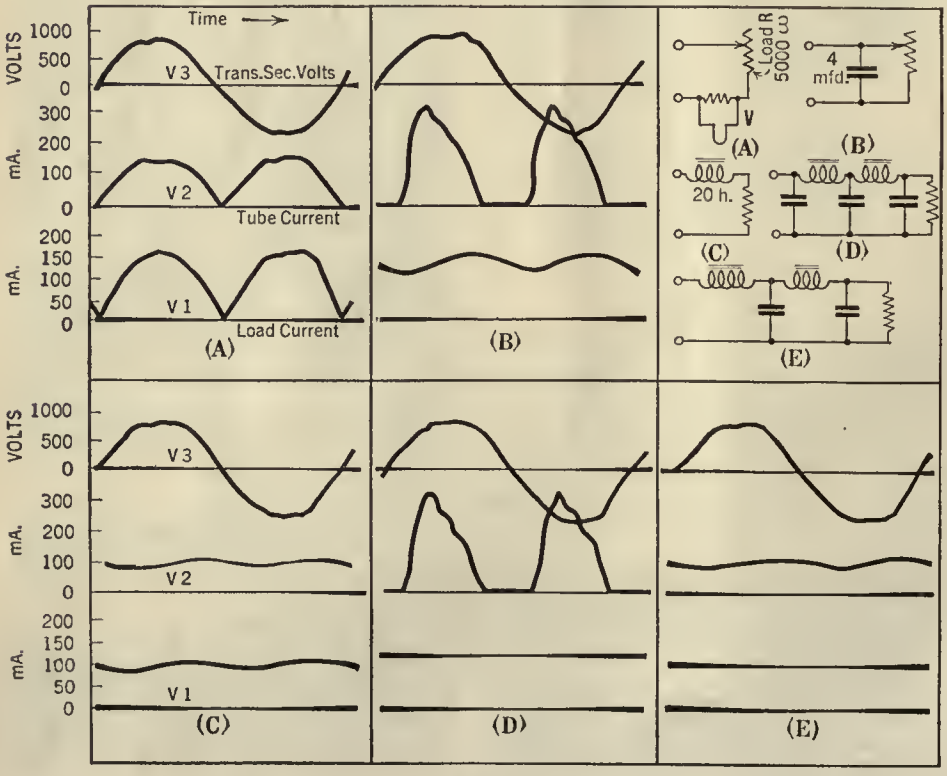


Fig. 4

tifier circuit causes an undue drop in output voltage, because of the reactive drop in the choke, to compensate which the transformer voltage would have to be greatly increased. The filter action was also impaired. The favorable factor was that this connection did result in a much lower ratio of peak tube current to average load current, reducing the maximum required emission to a low value. (See Table II)

Determining Efficiency

IN DETERMINING the overall efficiency, the transformer, the tube, and filter losses were included, but the power supplied to the filament was omitted because it remained constant and if included would have affected the readings taken with low load current, 4C and 4E, disproportionately. The reduced efficiency in these two cases was caused by the fact that the internal resistance of the tube rises rather rapidly at small plate current values. Had the transformer voltage been increased to maintain the load current at a higher value, much higher efficiency would have been obtained. It should be noted that in Figs. 4A to 4C, the power delivered to the load could not be determined from the average reading of output current and voltage because of the performance of the full-wave rectifier's irregular wave form.

Fig. 5, shows the more favorable results obtained with a full-wave rectifier tube in the same circuit combinations covered in Fig. 4. The rectifier tube was a CX-380, operating at 600 volts, or 300 volts per anode.

In Fig. 5A, with a resistance load, the load current flows during nearly the entire cycle since current is flowing through one or the other of the two tubes except at the time the transformer voltage passes through zero. The ratio of peak to average current is, therefore, reduced 50 per cent. as compared with the half-wave rectifier, being 150 and 103 mA., respectively, a ratio of 1.4:1.

In Fig. 5B, the 4-mfd. condenser is added, the increase in load current being much less marked than with the half-wave circuit, rising 19 mA., to 122 mA. The peak current through the tubes rises to 310 mA., ratio 2.4:1.

The next, Fig. 5C, shows the effect of the choke placed in series with the load. In this case it is interesting to note that the choke has quite a different effect from the condenser, since it reduces the peak current carried by the tube while it also keeps current flowing through one anode or the other during the entire cycle. The ratio of peak to load current is very low, 105 mA., to 97 mA., or 1.1:1.

Fig. 5D, shows the performance of the full-wave rectifier with the usual filter. The ratio of peak to average current is again high, 290 mA., to 118 mA., or 2.5:1.

Fig. 5E shows the performance with the first filter condenser of Fig. 4 removed. The peak current is now only 110 mA., or only 1.15 times larger than the average load current, which is 96 mA. The output voltage was only 45 volts, or 18 per cent. lower than that obtained with the usual filter, Fig. 5D, the readings being, Fig. 5D, 250 volts, Fig. 5E, 205 volts.

The various readings including, power output and efficiency, are tabulated in Table III

The ripple voltages present at the outputs of the filter arrangements shown in Figs. 4 and 5 have not been measured, but a few tests indicated that there was not a marked difference, especially if the condenser omitted at the input was added across the output of the filter. The only disadvantage noted in using the arrangement shown in Fig. 5 was the fact that the transformer voltage had to be increased 22 per cent. to obtain a load voltage equal to that obtained with the usual filter.

The very greatly reduced peak current demand on the rectifier tubes makes the use of this circuit arrangement highly desirable. Furthermore, the efficiency improves rapidly as the load current is increased, and with equal current outputs it was found that the energy dissipated in the tube was lower and the efficiency slightly higher with the filter

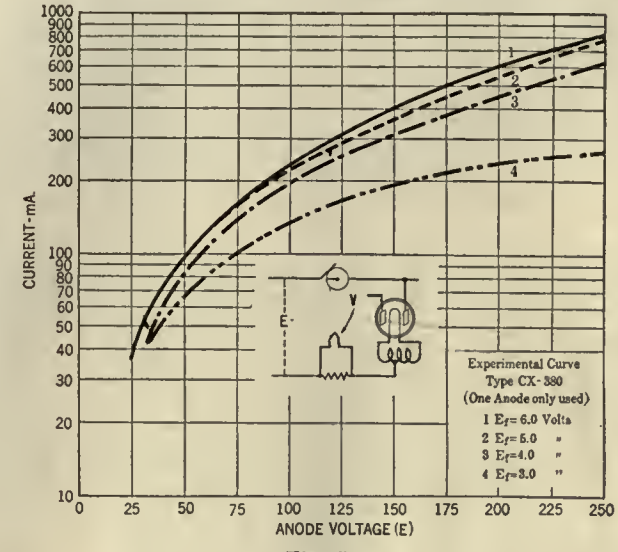


Fig. 7

arrangement shown in 5E than with that of 5D. The possibilities of this arrangement were called to our attention by Mr. J. C. Warner of the General Electric Research Laboratory, and these tests have shown clearly the advantages obtained in the full-wave rectifier circuit, Fig. 4, indicating that the arrangement is not suitable for half-wave rectifiers.

Effect of Revised Filter Circuit

THE remarks made in discussing the lower emission requirements with the revised filter arrangements shown in Fig. 4E, might lead the experimenter to believe that this change would permit much higher load currents to be obtained from the rectifier. However, the amount of energy dissipated in the tube must be considered, as that is one of the important factors limiting the output obtainable from a rectifier. Fig. 6, shows a condition which may occur if an excessive load is placed on the tube, the tube used being a CX-381.

Vibrator 1 on this figure reads the full voltage across the tube both in the conducting and in the nonconducting direction. The transformer voltage was 750 volts, and the peak approximately 1050 volts. It will be noted that the peak voltage across the tube reached a much higher value, 1400 volts, due to the fact that the voltage across the first filter condenser is added to the voltage across the tube. In the conducting direction the voltage was quite low, as would be expected, 185 volts. Vibrator V_3, shows the current through the tube, which reached a peak value of 450 milliamperes. The load current is not shown on the film, but it was 140 mA., an overload of 37 per cent. on this type tube, a value which resulted in excessive heating of the plate. As a result of the heat developed by the excessive current, the plate reached a temperature at which a slight amount of electron emission occurred which is shown on an exaggerated scale by vibrator V_1. The average value of this reversed current was 4.5 mA., and the peak value 6.8 mA. The fact that during a portion of the cycle this emission was drawn across to the filament at an instantaneous voltage of 1400 volts means that considerable energy was dissipated on the filament and the overheating of the filament became evident in a visible increase in brightness in the center. The circuit arrangement and placing of the vibrators in obtaining this record are shown in the circuit diagram, the double rectifier arranged in series with the tube under test being necessary to separate the two components of the current through the rectifier tube. A small biasing voltage, not shown in the diagram was added to prevent a circulating current between these two rectifier tubes. In taking the voltage across the

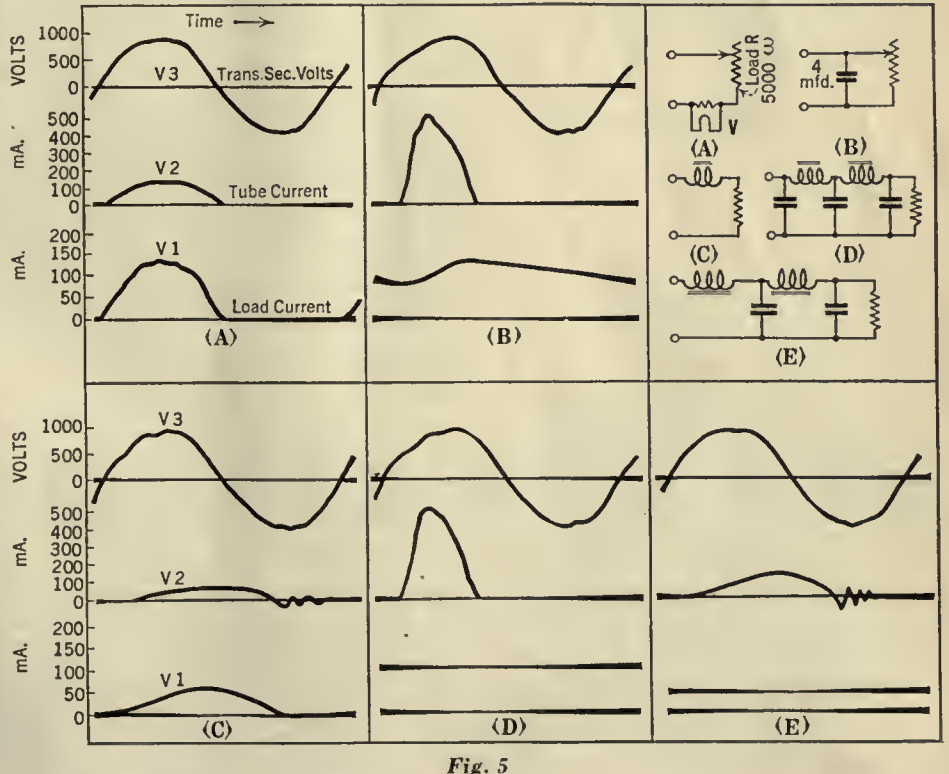


Fig. 5

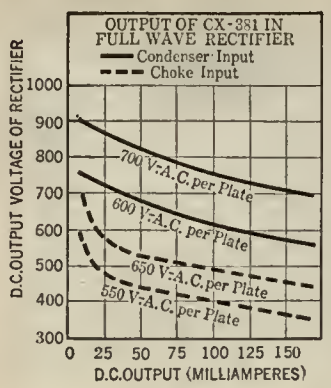


Fig. 8A

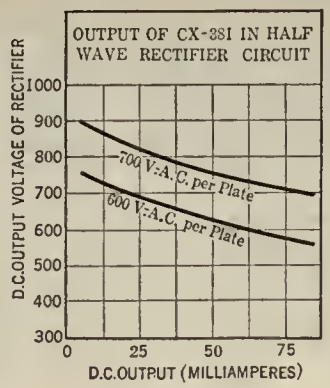


Fig. 8B

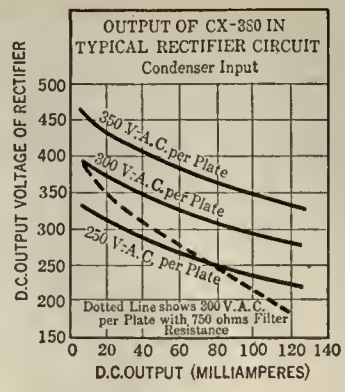


Fig. 8C

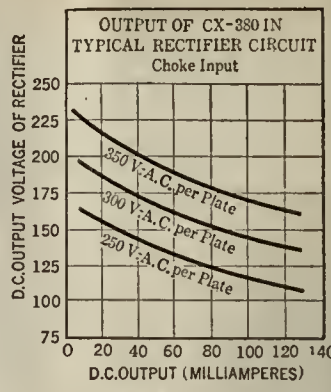


Fig. 8D

tube the vibrators recording the current through the tube were opened, as the current flowing through the voltage vibrator would have otherwise added to the reversed current. Similarly the voltage vibrator was open when the current values were being recorded.

Since the heating through the tube would be nearly as great with the improved type of filter connection, it will probably not be possible to increase the current rating of this tube to any extent when used under such conditions, even though the maximum current required is much decreased.

In Fig. 7, an experimental emission curve taken on one anode of a CX-380 tube is shown. It is not possible to read the full emission current of the tube on a d.c. test without damaging the tube as is the case with all tubes in which a large filament is used. In taking this film, voltages up to 250 volts were applied directly to the anode for a very short time at the proper intervals by means of a synchronous contact mounted on the oscillograph motor. In this way a current peak occurred at the same instant each cycle and gave a deflection on the oscillograph vibrator at a fixed point on the screen. In this way the amount of energy dissipated in the tube was kept low, and by calibrating the oscillograph vibrator the current readings were determined. The curves taken showed clearly the very satisfactory characteristics of the oxide-coated filament developed for this tube. Curve 1 shows the performance with a filament voltage of 6 volts, giving a slightly higher anode current than that obtained at 5 volts. The current was still increasing rapidly as the applied voltage was increased to the maximum used, 250 volts d.c. The filament voltage of 6 volts is not of course the normal operating voltage, and Curve 2 shows the emission obtained at the rated voltage of 5 volts, the current reaching the high value of 800 mA. with 250 volts applied. Curve 3 shows the performance at the reduced voltage of 4 volts. Even at this voltage the current was still increasing rapidly at 250 volts and was 620 mA. Curve 4 was taken with the filament voltage reduced to 3 volts, and this curve shows more definite evidence of saturation. The emission current still reached the surprisingly high value of 270 mA.

The fact that the oxide-coated filament does not give a definite saturation current is well known, and has been pointed out by many experimenters.

Performance curves of the CX-381 tube as a half- and full-wave rectifier are shown in Figs. 8A and 8B. In taking these data a large transformer having good regulation was used. The voltage was measured at the input to the filter, hence in using these data, proper allowance must be made for transformer regulation and for the IR drop in the chokes in estimating the transformer voltage required to obtain the desired voltage at the output terminals of the filter in any given case. Fig. 8B also shows in dotted lines the output voltage obtained when the first filter condenser is omitted.

Similar data is shown for type CX-380 in Figs. 8C and 8D. In these figures the latest recommendations regarding transformer voltage and rectified current output are shown. Maximum values for the CX-380 and CX-381 (Jan. 1, 1929) are:

	Rectified output	125 mA.
	Transformer voltage, per plate	350 volts
For type CX-381:		
	Rectified output	85 mA.
	Transformer voltage	700 volts

In using these values the experimenter and engineer should regard them as the limiting values rather than as the average working values, as has been done at times in the past. If, for instance, it is anticipated that an over voltage of 10 per cent., due perhaps to line voltage fluctuations, will be encountered frequently in practice, the working voltages and currents should be reduced to such an extent that the above values will not be exceeded when the higher voltage is applied to the primary of the power transformer in the equipment in question.

Note: The chokes used were rated at 10 henries, 300 mA. When used with load currents up to 125 mA. the inductance was approximately 20 henries. This difference in inductance values had only a minor effect on the results obtained.

Table I

Rectifier Tube	*Line Voltage*	*Load Resistance Ohms.*	*Load Current mA.*	*Load Volts*	*Power Delivered to load Watts.*	*Remarks*
2CX-301A	110	5400	20	108	2.2	*Max. filament emission required*
" "	"	0	50	0	0	*Tubes severely overloaded.*
1CX-313	"	5400	20	108	2.2	*Tube lightly loaded.*
1CX-313	"	1200	51	60	3.1	*Tube load 78 % of maximum.*

Table II

Circuit Connection	*Transformer Input Watts*	*Load Volts*	*Load Current mA.*	*Peak Tube Current mA.*	*Output Watts*	*Ratio Peak to Average Current*	*Overall Efficiency per cent.*
4A	43.	225	47	140	25.5	3:1	59
4B	90.	525	102	535	54.5	5.2:1	60+
4C	19.5	132	26	70	5.9	1.5:1	30
4D	90.	525	102	540	54.5	5.3:1	60
4E	25.	225	45	130	10.1	2.9:1	40

Summary of Fig. 4

Circuit Conditions:

Line Volts	110 a.c.
Transformer Volts	750 a.c.
Filter Chokes	10 Henries
Filter Condensers	4 mfd.
Load Resistance	5000 Ohms.

Table III

Circuit Connection	*Transformer Input Watts*	*Load volts*	*Load Current mA.*	*Peak Tube Current mA.*	*Output Watts*	*Ratio Peak to Average Current*	*Overall Efficiency per cent.*
5A	45.	219	103	150	23.6	1.4:1	52.5
5a	59	258	122	310	33.5	2.5:1	56.5
5C	38	204	97	105	21.2	1.1:1	55
5D	57	276	118	290	33.1	2.5:1	58
5E	38	215	96	110	20.8	1.15:1	55

Summary of Fig. 5

Circuit Conditions:

Line Volts	110 a.c.
Transformer Volts	600 a.c.
Filter Chokes	10 Henries
Filter Condensers	4 mfd.
Load Resistance	2350 ohms.

No. 19 *Radio Broadcast's Home-Study Sheets* April 1929

Fundamental Radio Theory

THERE is a simple formula that must be used very generally if one is going to plan or experiment in a quantitative way with radio circuits. Its use need not involve any tedious mathematical reductions, as the results of this formula have been reduced to tabular form. The application of this formula is so fundamental that every student of the subject should have a clear understanding of the simple manner in which it is derived. It is, in fact, the connecting link, so to speak, between two very different electrical manifestations—the alternating current that lights our homes and the faint radio waves that find their way to the antenna.

It is assumed that the reader is already possessed of an elementary knowledge of electricity and is familiar with the fundamental units involved in expressing such quantities, as voltage (E), current (I), resistance (R), capacity (C), and inductance (L). The last term is the only one that usually presents any difficulty, but it will become clear as the work proceeds.

Ohm's law, $I = \frac{E}{R}$, (See Home Study Sheet No. 3) expresses the relation of current, voltage, and

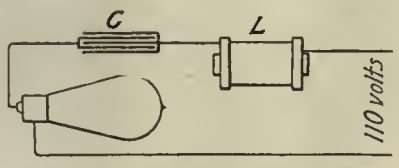


Fig. 1—Tuning 60-cycle 110-volt supply

resistance in a direct-current circuit. The corresponding formula for an alternating-current circuit is:

$$I = \frac{E}{\sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}}$$

in which f is the frequency of the alternations. Now it requires scarcely an elementary knowledge of algebra to see that if the two terms inclosed within the brackets in the denominator can be made to equal one another, their difference will be zero, and the equation becomes.

$$I = \frac{E}{\sqrt{R^2 + 0}} = \frac{E}{R}$$

which is Ohm's law. When this condition exists the circuit is said to be *tuned*. The essential point to be observed is the fact that the denominator of the equation will be a minimum, and therefore the value of the current is maximum, *only* when

$$2\pi fL = \frac{1}{2\pi fC} \text{ or when } f = \frac{1}{2\pi\sqrt{LC}}.$$

An experimental application of this important formula may be had readily if there are at hand one or two coils wound with fine wire on iron cores—the primary of an old high-ratio audio transformer, for example—and some condensers, such as are used as part of filters or by-pass equipment. Connect a ten- or fifteen-watt lamp to the 110-volt alternating-current house supply in series with a coil and a condenser, as indicated in Fig. 1. When approximately the proper values for L and C for a 60-cycle current are secured, it will be found that when the condenser is short-circuited the lamp will burn less brightly, thus indicating that less current is flowing. To arrive at appropriate values of L and C for striking results, it may be necessary to use two coils in series, or two condensers in parallel, all depending on the equipment at hand. But the experiment is quite worth while, particularly to one whose experience has been largely with direct current, as it demonstrates so clearly that a condenser, which is a non-conductor in the case of direct current, is not only a conductor for alternating current, but may actually increase the flow of current.

To apply our formula to this experiment, let it be supposed that a 1-mfd. filter condenser is used. This is one-millionth of a farad, which is the primary unit. A simple calculation will then show that for the usual frequency of 60 cycles per second an inductance of approximately 7 henries will be required to tune the circuit to produce the maximum current flow.

No matter how different it may seem, radio is simply a manifestation of an alternating current of high frequency, the difference being purely one of degree and not of kind.

The velocity at which a disturbance, say sound or light, travels depends on the medium through which it is transmitted. Thus, sound has one velocity in water (about 4900 feet per second) and another in air (about 1100 feet per second), but for either medium the velocity of all sounds is equal. That is, a note from the upper end of a piano will reach a distant observer as soon as one from the lower end. As both light and radio are dependent for their transmission on the same medium called the ether, they, in accordance with all other observed wave phenomena, travel at the same velocity. This velocity, is approximately 300,000,000 meters a second.

As the velocity of propagation is constant, and as this velocity is equal to the length of one wave multiplied by the number of waves per second, or the frequency, f, it necessarily follows that $f = \frac{300{,}000{,}000}{\text{wavelength}}$ and if $f = \frac{1}{2\pi\sqrt{LC}}$, wavelength $= 2\pi\sqrt{CL} \times 300{,}000{,}000$ or if microhenries and microfarads are used wavelength $= 1884\sqrt{LC}$ frequency in kc. $= \frac{159.2}{\sqrt{LC}}$

These relations have been worked out for a great many wavelengths, and a few are presented in the following table. Its value to the experimenter will be evident. With a given coil and condenser, it is only necessary to multiply the inductance of one by the capacity of the other, to find the wavelength to which they will respond. If a condenser of a certain capacity is at hand, a simple division will tell us what the inductance must be to tune to a given wavelength. As the experimenter begins to get his laboratory together, he will soon find himself determining the inductances and capacities of his various coils and condensers, and, with the table at hand, he may always keep informed as to the wavelength or frequency of the current he is handling.

Meters	f	L × C
100	3,000,000	0.00282
200	1,500,000	0.01126
300	1,000,000	0.0253
400	750,000	0.0450
500	600,000	0.0704
600	500,000	0.1013
700	429,000	0.1379
800	375,000	0.1801
900	333,000	0.228
1000	300,000	0.282

The experimenter will find a complete table of L C products in *Principles Underlying Radio Communication*, the Signal Corps book, and he should either get such a table or work out one for himself. The following rule will be helpful: For smaller values, divide meters by 10 and L×C by 100; for larger values, multiply meters by 10 and L×C by 100.

Mechanical Analogies

The following mechanical analogy may aid in giving a little clearer view of the phenomena involved. The weight, L, in Fig. 2 is mounted on the upper end of an arm, the lower end of which is pivoted at the floor. A spring, C, is connected to the weight and to a rigid support, and is of such a length that the weight stands directly over the pivot when the spring is neither compressed nor extended. If the weight is pulled to one side and released it will vibrate back and forth at a certain definite frequency, depending on the size of the weight and the nature of the spring. The same frequency can be obtained by making the weight heavier and shortening the spring, or by reducing the weight and lengthening the spring.

In the above example the frequency depends on the product of two factors, and this is precisely the case in radio oscillations. We can continue to tune to a certain wavelength by increasing the inductance and reducing the capacity, or *vice versa*.

The spring is a rather apt analogy for a condenser, for the reason that when the latter is charged, the electrons are supposed to be displaced from their normal positions, to which they rebound when the condenser is discharged. Similarly appropriate is weight or mass in representing inductance, which may be considered as electrical inertia. Just as mass tends to retard the beginning of motion and to continue the motion when the applied force is withdrawn, so inductance opposes a sudden increase of current after the applied voltage ceases. The analogy may be carried further by considering the resistance of the air on the weight as corresponding to electrical resistance. Let it be supposed that the spring and weight were set up in a room from which the air has been exhausted, and that a fine thread attached to the weight is intermittently pulled exactly in tune with the natural period of oscillation. After a little time the oscillations will become very violent, and if the spring were of highly elastic material, it is quite possible that the repetition of a very minute force would finally break it. In other words, the internal forces generated within the spring may many times exceed the applied force, and this is exactly what occurs in a tuned electrical circuit when the resistance is greatly reduced, the voltage across the condenser being many times the impressed voltage. Hence it is that often a condenser tested to withstand a high voltage will break down in a resonant circuit, although no high voltage was outwardly applied.

The voltage across a coil in a resonant circuit is $2\pi f L$ times the current, but, as has already been pointed out, the current in a tuned circuit is $\frac{E}{R}$, in consequence of which the voltage across the coil will be $\frac{2\pi fEL}{R}$. That is, under given conditions, the voltage developed across the coil will be greater as the ratio $\frac{L}{R}$ is increased. In other words, the desirable thing in a radio coil is to secure the most inductance per ohm of resistance.

Another point in the analogy may be mentioned. The ability of a minute force to generate oscillations in the weight and spring would obviously disappear if the resistance were greatly increased by immersing the system in water or molasses, for example. As the resistance of an electrical circuit is increased, not only will the amplitude of the oscillations diminish, but the variations due to moderate changes on the frequency of the applied force will become less and less. In other words, with increasing resistance the system loses its selectivity, precisely as in electrical circuits.

Our analogy also illustrates a point that puzzles many beginners, and that is how the current in a condenser can be said to be 90°, that is one-quarter cycle, out of phase with the voltage (see "Home Study Sheets No. 7 and 8"). It will be observed that when the weight is at the point of maximum velocity, that is at the midpoint of its path, the spring is idle, that is, it is neither extended nor compressed. And when the weight is completely at rest at either end of its path, the spring is at that moment under its greatest stress. Similarly, when the current is at its greatest value, the condenser is at the instant of changing from one polarity to the other and so has no voltage, but when the current has just ceased flowing in, the electrons in the dielectric are under their greatest stress, so that when there is no current flowing the voltage is a maximum.

Finally, it may be pointed out, the action of the weight and spring exemplifies what is referred to in radio as *damping*. Suppose the weight was quite heavy and the spring rather short. If the weight were given an initial impulse the oscillations would continue for some time, though gradually diminishing in amplitude. Now suppose the weight were made

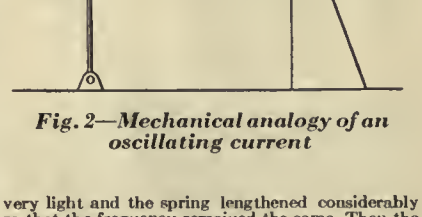


Fig. 2—Mechanical analogy of an oscillating current

very light and the spring lengthened considerably so that the frequency remained the same. Then the air resistance would increase in importance and the oscillations would die out very quickly. The corresponding change in a radio circuit would be to reduce the inductance and increase the capacity, the resistance remaining constant, and when this is done an oscillation once started is quickly damped.

To recapitulate: We have learned that the current in a radio circuit reaches its greatest value when the wavelength equals $1884\sqrt{LC}$.

That this fact is readily derivable from the fundamental equation for alternating-current circuits.

That when this condition exists, Ohm's law is applicable to the circuit.

That the voltage across the coil or condenser in a resonant circuit may very greatly exceed the applied voltage.

That the most efficient radio coil is that which has the greatest inductance per ohm resistance.

That the sharpness of tuning increases as the resistance is reduced.

No. 20 *Radio Broadcast's Home-Study Sheets* April 1929

Inductance Standards

THE applications of the principles in "Home-Study Sheet No. 19" are far-reaching and will afford an interesting field for experiment, but before this may be undertaken, certain standards must be acquired, as one cannot measure without some sort of a yardstick. This will, however, require many hours at the workbench, but before rolling up our sleeves, it would be well to dispose of the inductance standards, for the reason that for the value of these we are dependent on calculation.

Function of Inductance

The inductance of a coil has the same function in regard to the motion of the electrons that constitute an electric current, as weight has in regard to the motion of a material body. When the current is uniform, as in the case of direct current, inductance has no effect, just as the mass of a body is without effect in a mechanical motion of constant velocity. On the other hand, any change in the strength of an electric current, whether it be an increase or decrease, is opposed by inductance, and, as radio currents are continually changing with extreme rapidity from a maximum strength in one direction to a maximum in the other, inductance becomes a very important item.

A circuit is said to have an inductance of one henry when a current changing at the rate of one ampere per second induces therein an e.m.f. of one volt. In such a coil, there being no iron core, a current variation of two amperes would induce an e.m.f. of two volts. Inductance may therefore be considered as the ratio of the e.m.f. induced to current variation per second. The reason for this e.m.f. lies in the fundamental fact that a conductor has a voltage induced in it when it cuts the lines of force of a magnetic field. When the current is started

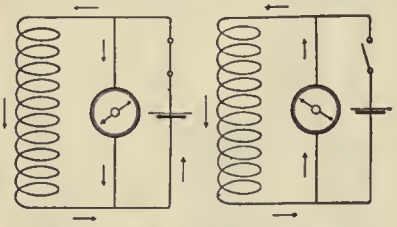


Fig. 1—Demonstrating the counter direction of the e.m.f. of self-induction.

in a coil the magnetic lines radiate outward from the center, thus cutting the turns of wire and inducing therein an e.m.f., which is always in such a direction, that it tends to delay the applied current in reaching its maximum value. Similarly, when the applied current ceases, the magnetic lines collapse towards the center, inducing an e.m.f. which now tends to maintain the current flow in the coil. By coiling a length of wire, the resulting magnetic field will be concentrated into a smaller space and, as a consequence, this counter e.m.f. increases. Inductance is a property which depends on the number of turns, size, and shape of a coil.

Laboratory Demonstrations

The counter direction of the induced current may be demonstrated by connecting up a coil, galvanometer, or compass and dry-cell battery as illustrated in Fig. 1. When the switch is closed the current will flow as indicated by the arrows in the diagram on the left. If the galvanometer needle is now restored to the zero point and held there with a pin or small weight, it will be deflected in the reverse direction when the switch is opened. This indicates a reversal of current through the galvanometer, and demonstrates the important fact that the current induced in the coil after breaking the circuit passed in the same direction through the coil as did the battery current. Obviously the reverse must have been the case when the connection was first made, as the magnetic lines proceeded outward instead of collapsing toward the center.

That the direction of a current induced when a circuit is closed is opposite to that induced when the circuit is opened may be demonstrated easily by connecting up an audio transformer to a galvanometer and dry-cell battery as illustrated in Fig. 2. When the circuit is closed the galvanometer will show a brief deflection, returning to zero when the primary current has reached its full value. When the circuit is opened, the deflection will be in the opposite direction, again returning to zero after the magnetic field has completely disappeared.

Inductance formulas have been developed for coils of a great many forms, but as our present

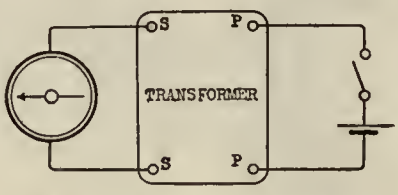


Fig. 2—Closing and opening the circuit induces two opposite currents

purpose is to acquire certain suitable standards, attention will be confined to the single-layer cylindrical form called the solenoid. The inductance of any coil of more complex winding may then be determined by comparison.

Coil Formulas

For a single-layer winding the Bureau of Standards gives the following simple formula. The significance of the terms a and b are illustrated in Fig. 3. N is the number of turns and K is a factor depending on the ratio of diameter to length, and is given in Table I.

$$L = \frac{0.03948 a^2 N^2 K \quad \text{microhenries}}{b}$$

All dimensions are in centimeters, and while they may be made in inches by changing the formula to

$$L = \frac{1.0028\ a^2 N^2 K \quad \text{microhenries}}{b}$$

such a change is not advised for the reason that the metric system is now used so generally in scientific work that the experimenter should aim to acquire some familiarity with it. If a centimeter scale is available, it is just as easy to measure in centimeters as in inches, and in any subsequent computations, there will be less chance of error in handling the decimals of the metric system than with the awkward fractions of the inch.

In planning a coil for a standard, procure a tube of durable material, as near a perfect cylinder as possible, two or three inches in diameter and about twice as long. Apply one layer of number 18 d.c.c. wire. If a winding jig is not available, attach one end of the wire securely to the wall and stretch it out full length, removing all kinks and bends by pulling it tightly through a towel held in the hands. When the free end has been fastened to the tube, the process of winding may be accomplished quickly by turning the tube with the hands, always keeping the wire under tension. Before beginning the winding, however, provide suitable means for securing the two ends of the wire in place. A satisfactory way of doing this is to bore two small holes in the tube for each end and to pass the wire through in the manner indicated in Fig. 4. Place these holes so that the winding will have a whole number of turns —no fractions. If binding posts are desired, they should be very small, as large ones will add to the distributed capacity of the coil.

Measuring Coils

In counting the turns, be careful not to start counting until after the completion of the first turn is reached. Care must also be exercised in determining the length b, which, it will be noted in Fig. 3, is not the exact physical length of the coil but the

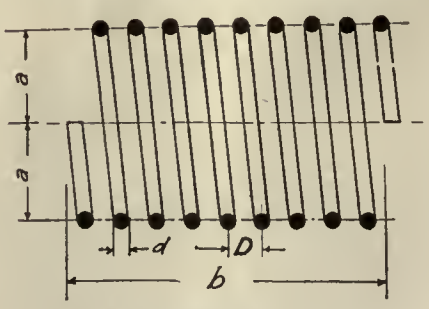


Fig. 3—Essential coil dimensions

length plus one turn, or the number of complete turns multiplied by the distance between the turns, that is b-N × D

For an inductance standard based on computation it is usually best to have the coil long rather than short, although the inductance will not be quite so great. The reason for this is that the formula may be applied more accurately, and the distributed capacity will not be as large. For this latter reason also, the coil should not be coated with any liquid preparation.

Usually the experimenter will have on hand one or more single-layer coils, and by applying the formula to these their inductance may be readily determined. These will then serve as standards until one's requirements become known more definitely through further experiment.

Accuracy

It must be borne in mind that the accuracy of the determination cannot be greater than that with which the physical measurements of the coil are taken, and among these the diameter will probably present the greatest trouble, particularly if the tube is not truly cylindrical. Under these conditions it is a good plan to wrap a strip of smooth thin paper tightly around the tube until the ends overlap. A sharp knife point should then be made to pierce the two overlapping ends, after which the strip may be laid flat and the distance between the two marks made may be measured accurately. By repeating the process after the tube is wound, the outside circumference may be determined, and then by taking an average of the two, the required diameter may be computed.



Fig. 4—Securing the end of the wire

Spaced Turns

It is sometimes desirable to reduce the distributed capacity to a minimum by using a spaced winding, which may be accomplished by cutting a shallow thread on the cylinder or by winding a string between the turns. If a high degree of accuracy is desired in the computation of the inductance of a spaced winding, a slight correction may be made for the spacing by adjusting the value calculated by the formula given above by an amount equal to —.01257Na (A + B) the proper values of A and B are given on page 284 of the Bureau of Standards Circular Number 74, *Radio Instruments and Measurements.*

In planning a coil, the experimenter will now be in a position to calculate the inductance quite closely in advance. If the wire is already at hand, estimate the total number of turns by counting the number that can be wound on one inch of the length of a lead pencil. If the size of wire has been determined, the number of turns that will go into a certain space may be estimated by referring to a wire table. Estimates obtained from wire tables are necessarily approximate as there are slight variations in the specified sizes of bare wire and in the thickness of the insulation, and further differences may result according to the tension under which the wire is wound.

Conclusion

Before leaving the present subject, the reader should be impressed with the necessity of maintaining a laboratory notebook in which to enter his calculations and observations in a clear and orderly manner. As the work proceeds, two facts will become evident: one will frequently have occasion to refer to some earlier record, and that memory cannot be trusted to retain experimental data.

Table I—Values of K

Diameter length	K	Diameter length	K
0.1	0.9588	0.7	0.7609
0.2	0.9201	0.8	0.8351
0.3	0.8838	0.9	0.7710
0.4	0.8499	1.0	0.6884
0.5	0.8181	1.5	0.5950
0.6	0.7885	2.0	0.5255

An Engineer's Explanation

REAL VERSUS APPARENT SELECTIVITY

By KENNETH W. JARVIS

Engineer, Crosley Radio Corporation

A RADIO set without selectivity is like a ship without a rudder, buffetted by every wind, and heeding the strongest wave and current. Some sets are selective—some are not; and broadcast transmitters and guileless amateurs are reviled alike. There is wailing and gnashing of teeth because of the radio engineers' inability to bring about the near impossible, and all because most of us do not quite understand what "selectivity" really means.

Imagine the conglomerate mess of the radiated energy of all the broadcasting stations on earth, all of the commercial transmitters, all of the amateurs, and all of the natural and man-made static, swirling, fading, crossing and recrossing the bare wire of your antenna, each inducing a voltage therein. You sit down below, more or less patiently attempting to bear the beautiful strains of the "Serenade" originating a thousand miles away, all uninterrupted and unimpeded by the myriad of unwanted impulses in your antenna. The selectivity is that property of your receiver which makes for order out of this chaos.

As we are interested in the usual broadcast reception, we need to consider only a comparatively small range of the frequencies in the whole spectrum, that is the band between 550 kc. and 1500 kc. Stations broadcasting in this range are known by their "carrier," i.e., the fundamental frequency of their radiation. Due to the frequencies needed on either side of the carrier for proper transmission, each carrier is spaced 10 kc. apart. Thus there is room for only 96 stations in the allotted broadcast-frequency range. In the new allocation plan, various stations either divide time or are located geographically so that they can use the same frequency without interference. For our purpose we can, therefore, consider that there are only 96 stations, one on each 10-kc. band of the broadcast range.

In explaining the mechanism of transmission, use is made of the "side-band theory" which says that in addition to the carrier frequencies, a broadcasting station radiates additional frequencies corresponding to the audio tones. If, as is approximately true, the frequency distribution and percentage modulation as based on these side bands is the same for all stations, we can neglect the side waves and consider only the relations of the various carrier frequencies.

What is Selectivity?

OBVIOUSLY, we are interested in selecting the energy of some one carrier frequency out of all the number present at the antenna. The strength of the signal (or carrier) at the antenna will influence the degree of selectivity. This strength is measured in microvolts (millionths of a volt). The bigger the antenna, the more microvolts it will pick up. The field strength of the signal is, therefore, rated in microvolts per meter, and the field strength, multiplied by the effective height of the antenna in meters, gives the actual voltage induced in the antenna. Thus a signal of 100 microvolts per meter acting on a four-meter antenna will produce an input voltage to the set of 400 millionths of a volt.

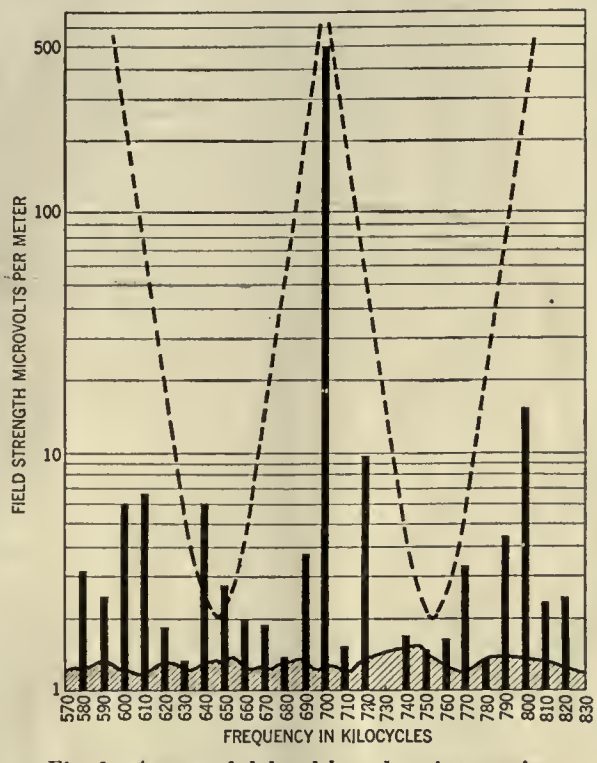


Fig. 1—A powerful local broadcasting station often presents a peculiar selectivity problem. In the case illustrated above, it is impossible to receive stations between 650 kc. and 750 kc. without interference from the powerful local

Before making use of this relation of field strength, a brief view of the nature of selectivity is necessary. Fundamentally, selectivity means a greater response to one frequency than to any other. This leads to the idea of resonance. If a circuit or system is quite responsive to some one frequency, it is said to be resonant to that frequency. Forms of mechanical resonance are familiar to everyone. The piano and violin strings tuned to the same note are in resonance. If the piano note is sounded, the sound waves will travel through the air and start the violin string vibrating and emitting sound. The pendulum of a clock oscillates back and forth at a definite frequency. The pendulum system is resonant to that frequency.

Sometimes a road has small ripples at regular intervals. If an automobile is driven at the proper speed over these little ripples, the car will begin to surge up and down with greatly increasing movement. If the car be driven faster, the springs take up the movement of the wheels and the chassis stays almost still. Driving slower allows the car slowly to follow up and down the ripples without any great movement. But at some particular speed, the weight of the car and the elasticity of the springs are "resonant" at the frequency of the ripples of the road surface and a terrific movement results.

Obviously the bigger the ripples, the greater will be the car movement. This is equivalent to increasing the force applied. The nearer the car runs at the "resonant" speed, the greater will be the movement. If there are "snubbers" on the car or there is a lot of resistance to the motion, the amplitude will not be so great.

Electrical circuits exhibit the same sort of resonance to electrical forces as the mechanical systems show. The condensers in the circuit correspond to the elasticity of the springs while the inductance corresponds to the mass of the car. Therefore it follows that a similar relation is obtained between the force and resistance in electrical circuits as in mechanical systems.

This article by Mr. Jarvis, a member of the engineering staff of the Crosley Radio Corporation, attempts to interpret the real meaning of selectivity in the light of our present-day reception problems. How much selectivity is desirable, what compromises in set design must be made to attain optimum selectivity at reasonable cost, and how the problem is solved in the design of present-day sets—all this Mr. Jarvis covers. To dealers, attempting to answer customer-questions this analysis should be useful as well as to many others of our readers desiring to follow a general investigation of the subject.

—THE EDITOR.

Electrical Equivalent

THIS may be illustrated in curve A of Fig. 2 where the height of the curve at any particular point represents the current flowing in the circuit at the frequency applied, the voltage remaining constant. It is obvious that this circuit has the property of "selectivity" and gives the greatest response at some particular frequency. Usually a single circuit does not have sufficient selectivity and two or more such resonant circuits are needed. The amplification might be adjusted to give the same maximum current in the last resonant circuit and then the system would have a curve like B, of Fig. 1.

Having obtained some idea of why a receiver is selective, a little different viewpoint is now necessary. A receiver should be sufficiently selective just *not* to hear any interfering station. Obviously this depends on the strength and frequency of this would-be interfering station. Therefore, the usual selectivity curve is drawn as in Fig. 3. Here the height represents the field strength in microvolts per meter necessary to apply to the receiver an output just loud enough to be heard. The receiver is tuned to 1000 kc. and obviously it takes less voltage to hear an output at this frequency, only 2 microvolts. At 10 kilocycles off resonance, the input would have to be 3.5 microvolts, while at 20 kilo-

cycles off resonance, the input must he ahout 10 microvolts, or five times as much as at resonance.

In Fig. 4 is shown the ficld strength pattern at a particular antcnna, where the heights of the lines represent the amplitudes of the "carriers" on each channcl frequency. The wavy shaded portion represents the "static level," or the voltages introduced in the antenna due to static and unwanted noisc.

This graph also contains the curve of Fig. 3 (curve A). The stations heard will he the one at 1000 kc., at which the set is tuned, and also the station on the adjacent channel, 1010 kc. The relative strengths of the signals will he about in proportion to the height of the field-strength lines *above the selectivity curve.* Thus the station on 1000 kc. will he about 4 times as loud as that at 1010 kc. The field strength of the station at 980 kc. is even greater than that at 1000 kc., hut due to the selectivity of the circuit it cannot even hc heard. The station at 990 kc. could never he heard with this set even if it were tuned right on 990 kc. A more sensitive set would he necessary, and even then the reception might not be good, due to the static and interfering signals.

Now assume that the receiver used had poorer selectivity as shown in Fig. 5. (Hereafter only the superimposed diagrams are given.) It is apparent that three stations are heard at once quite strongly and a fourth, at 1020 kilocycles, can just barely he heard. A simple way to visualize this is to imagine the selectivity curve, such as in Fig. 3, is cut down into a shest of cardboard, and then laid over top of the field strength picture. Sliding this cardboard horizontally along the frequency scale corresponds to tuning the receiver, and the stations you can see projecting up ahove the slot in the cardhoard are those which you will hear. If you cut out such a cardhoard cover having the selectivity curve shown in Fig. 1, and slide it hack and forth as suggested, you will see that it will hc impossihle to get any one station without interference from some other station. This is too often true with many radio receivers.

Effect of Tuning

A VIEW of the selectivity field strength charts will show a well-known fact. Detuning the receiver will reduce the output, and therefore, this method is often used to control the volume of a set. There are several ohjections to this practice. The rcsonance response to some interfering frequency is increased greatly, thus decreasing the selectivity and increasing the noise. In addition this detuning invariably changes the quality of reception. The receiver should he tuned directly on the station desired and the output regulated with the volume control.

There are many other peculiar cases of selectivity, some of which are illustrated here.

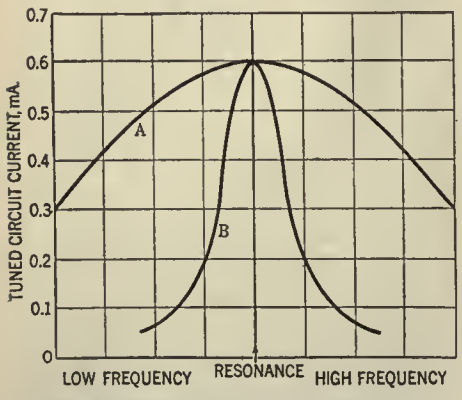


Fig. 2—Selectivity is improved by conneeting two or more resonant circuits in series. Curve A shows the selectivity of a single eireuit, curve B of a series of circuits

Take as an cxample the case of a strong local station. Such a station may have a ficld strength of as much as 10,000 microvolts, per meter, which is far heyond the range of the cross-section sheets used here. For illustration, take the curve of Fig. 1. Notice that the horizontal scale of frequencies is smaller than hefore. The selectivity is the same as in Fig. 5. Assuming we are using the cardboard covers again, they must be placed in the positions shown in order to avoid hearing the strong local station. This means that no station hetwcen 650 and 750 kc. can be heard without interference from the local.

It may he that before the local station raised its power, the radio set could satisfactorily receive the station on 720 kc. Therefore, when such reception can no longer he ohtained, the local transmitter is hlamed. The transmittcr is "hroad" and it "spreads all over the dial" and many are the protests against the design. However, the only crime of which the station can bc accused rightfully is that of attempting to increase its scrvice area and providing the henefits of static-free reception to a grcater numher. Investigation of such complaints has shown almost always that they have originated with the owners of ohsolete receivers, at least from the selectivity standpoint. As higger and hetter transmittcrs are huilt, receiver design must necessarily conform. It is unfortunate that advancement in radio service must render ohsolete the inefficient type of receiver and act to the

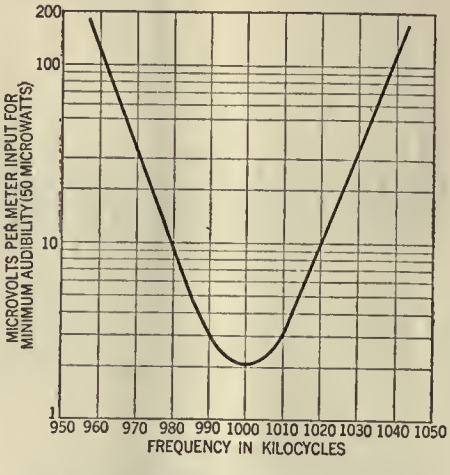


Fig. 3—The selectivity eharaeteristic of a receiver is usually drawn in the manner indieated in the above graph

detriment of its owners, but it's the same old story of serving the majority.

Having thus shown that the lack of selectivity is inherent in the receiver, a closer study of rceeiver selectivity is justified. And it is at this point that the meaning of the subject of this paper will hecome apparent. To an engineer, *selectivity is represented by the curve shape, and the ratio of the signal field strength needed at any frequency to that needed at resonance to produce an audible signal.* This is a very real thing, expressihle in numhcrs, and is a factor which can he calculated as a ratio. To the user, the selectivity of a receiver is apparently the way in which stations can he scparated. The rclation can hest he shown by the use of our cardhoard covers and a field-strength diagram. This is shown in Fig. 6.

The sclectivity curves of two sets, A and B, are drawn. The *real* selectivity of the two sets is exactly the same. For simplicity, the field strengths of five adjacent stations are shown having equal amplitude. By sliding the cover markcd A, it is obvious that any one station, to the exclusion of all others, may he selected. By sliding B along the frequency scale, it is apparent that at least three stations will

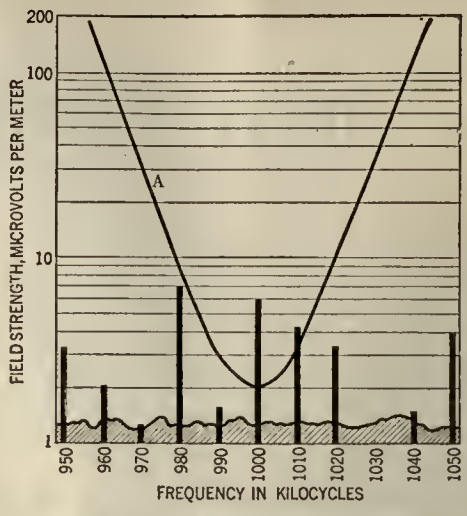


Fig. 4—In this graph the selectivity curve (Fig. 3) is superimposed over the field-strength pattern at a partieular antenna. Vertical lines indieate amplitudes of carriers and shaded area indicates the "static level"

be heard at all times! The difference between real selectivity and apparent selectivity is quite clear!

Selectivity vs. Sensitivity

PROPERLY understood, this fact is no detriment. By hacking off the volume control on the more sensitive set until the two sets havc equal sensitivity, the apparent selectivity will he equal. In general it may he said that *the greater the sensitivity of a radio receiver, the less will be the apparent selectivity.* (Noticc that this *does not* say that the set having the least apparent selectivity will he the most sensitive.) In demonstrating a very sensitive receiver, a salesman will often turn the volume control full on, showing how many stations can he reccived. While not saying "Yes, all at once," the prospective customer may react against the set due to the apparent lack of selectivity. It is so simple to reduce the volume control and thus increase the apparent selectivity that all this discussion seems out of place. Yet so many operators of good radio receivers will unhesitatingly blame the poor selectivity of his receiver upon conditions entirely irrevelant, when a proper consideration of the true factors will clear up a lot of trouhle. Ask any radio dealer how much trouhle has hcen caused and how many radio sets have "suddenly gone wrong" due to a change in power, frcquency, or location of the customary vendor of entertainment. Before leaving this point, it is well to drop a word of warning to any prospective purchasers. In the demonstrations of selectivity *make sure the fine apparent selectivity of a set is due to the real selectivity of the circuits and not due to simply a lack of sensitivity.*

The selectivity of a receiver depends on the size of the coils and condensers, the resistance, circuit coupling, and many other circuit factors. As the set is tuned from one end of the hroadcast-frequcncy range hy changing the condensers or the inductancc of the coils, the real selectivity changes.

Fig. 7 shows three selectivity curves taken on the same receiver. (The scnsitivity in cach case was adjusted to interference output with two microvolts per meter input.) The selectivity at 550 kc. is quite good, while that at 1500 kc. is poor. This means that instead of having a constant selectivity, and thus a cardboard shield of constant shape, the gap must open up gradually as the set is tuned to a high frcquency.

As the usual receiver varies greatly in

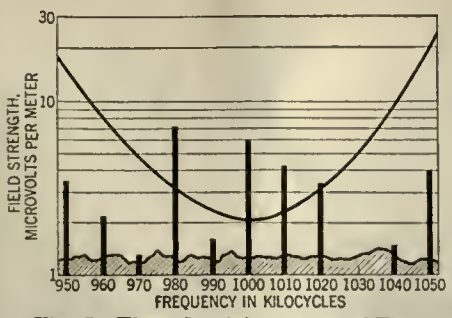


Fig. 5—The selectivity curve of Fig. 2A superimposed over the field-strength pattern of Fig. 4. Note that the signals of four stations are heard at once due to the poor selectivity of the circuit

sensitivity in different parts of the frequency range, and as the real selectivity (as per Fig. 7) also varies greatly, the apparent selectivity is quite a complicated result. This elementary discussion should help considerably, however, in understanding the action of the receiver.

Other Considerations

THE real and apparent selectivity so far have been considered only on the electrical basis on which they operate. To the user of a particular set, there are mechanical factors contributing to the apparent selectivity almost as important as the electrical characteristics. A large frequency-control knob tends to make tuning easier and increases the apparent selectivity. The vernier drive and the large illuminated drum dials are contributors to the same idea. To the operator, who cannot "see" the field strength pattern at his antenna, the selectivity is estimated by the dial movement necessary to eliminate any particular station. This basis for judging selectivity is as inaccurate as it is common. The "results" obtained depend upon the frequency range covered by the entire dial movement and the rate of frequency change at any operating point. Assume two sets, both having a dial movement of half way around, one tuning from 540 kc. to 1520 kc., and the other tuning from 570 kc. to 1350 kc. It is evident that the apparent selectivity would be greater on the first set as a given movement would shift the resonance frequency faster.

The shape of the condenser blades greatly influences the apparent selectivity. If the blades are semi-circular, a given angular rotation will cause a greater change in resonance frequency at the high frequencies than at the low frequencies. This results (as based on dial movement) in the apparent selectivity being greater at high frequencies, and thereby (to the user's mind) compensates the decrease in real selectivity as indicated in Fig. 7. If the condenser blades are shaped so as to give uniform change in frequency with uniform rotation (so called straight-line-frequency type) the apparent selectivity will be the same as the real selectivity.

One more factor is responsible for a huge misunderstanding in judging the sensitivity of a radio receiver. That is distribution of the broadcasting stations themselves. The new allocation has placed a great number of small stations on the same, or closely adjacent bands. A sensitive receiver will pick up a great many of these stations, and owing to their proximity, several stations may be heard at once. Such stations are usually so close together that they interfere or "beat" with each other and produce a strong continuous audio note. This note is not due to the modulation of either station, but is the "beat" of the two carriers. Such interference is quite common and is usually understood by those who have a technical knowledge of the reasons why, but to a novice or to one who doesn't care to know why, such interference is charged against the receiver's selectivity. Most radio users know that the selectivity of a receiver enables them to eliminate those signals they do not want, and they automatically class those cases of station interference against the receiver also.

Another type of station interference which occurs in some receivers is that obtained due to modulation in the receiver. Two signals may be heard at once, but only when tuned to either one of the stations. The signals of the two stations "modulate" each other in the r.f. end of the set and both modulation frequencies are superimposed on each carrier frequency. Obviously "selectivity" can do nothing to help such cases. Fortunately such cases are rare as they occur only when the volume control is in the audio end of the set, or where extremely strong signals are impressed on an untuned input. This kind of "cross talk" can best be eliminated by using a wave trap tuned to one of the two stations interfering. This may be an important point in selectivity

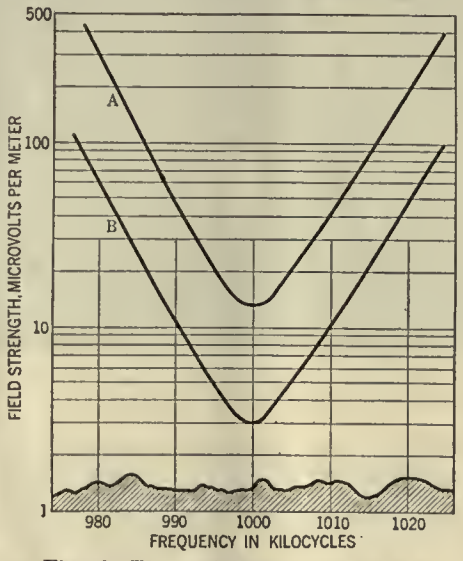


Fig. 6—The real selectivity of the two curves above is exactly the same, but the apparent selectivity of A is much greater

demonstrations and the real selectivity impaired because of this fact.

Conclusions

WHAT conclusions of value to the set user may be drawn from the above discussion? First, and probably the most important, is the fact that the apparent selectivity can be increased greatly by decreasing the sensitivity of the receiver, and then tuning accurately on to the frequency of the station desired. Try it. You will be surprised at the big improvement in selectivity when the volume control is reduced just enough to eliminate the undesired station.

Another valuable conclusion is in regard to the size of the antenna. With higher-powered transmitters rapidly coming on the air and "interference" reports on the increase, it is standard practice for the radio editors and engineers to say "Use a smaller antenna." It is obvious that this accomplishes the result. In Fig. 6, the apparent selectivity of set B will increase just as much by reducing the input to 7 microvolts, as it will by changing the sensitivity to correspond to the set A. However, reducing the size of the antenna to improve the selectivity *decreases* the distance-getting ability of the set. As previously shown, intelligent use of the volume control gives the same control of the apparent selectivity without permanently reducing the efficiency of the set. Here's one more vote for longer and higher antennas. On clear, cold nights you can use the extra sensitivity a little brain work will provide.

How selective should a set be? An ideal set should have sharp cut-off and a flat response the width of one broadcast band. To date no commercial set of this type has been built, and the problems involved indicate that such a receiver will not be available for some time to come. Just remember, in demanding "knife-edge selectivity," that, like lots of other things in life, selectivity is a compromise. Too broad a selectivity curve, and interference results. Too sharp a selectivity curve and the quality is impaired greatly by the loss of the high notes. A good engineering compromise, plus a little intelligent operation, will provide for many hours of interference-free entertainment.

WARD LEONARD'S AUTOMATIC VOLTAGE REGULATOR

UNSATISFACTORY receiver performance, and short tube life due to excessive line voltage—this has been one of the most pressing problems associated with the a.c. receiver and has probably been one of the major causes of consumer dissatisfaction with sets of this type. It appears, however, that the problem has now been solved completely and in a very satisfactory manner by the Ward Leonard Company. This company has perfected a new device (that many manufacturers will probably include in their receivers this fall) which performs the double function of power transformer and line-voltage regulator. This device makes the operation of the set independent of ordinary variations in line voltage. It takes the place of the power transformer ordinarily used in a receiver and it functions, not only to supply all the voltages required for the set's operation, but also to compensate variations in line voltage. With this new device in the set the line voltage can vary from say 90 to 150 volts and the actual voltages applied to the tubes in the set will vary a negligible amount.

We were present when the Ward Leonard Company demonstrated this device which was installed in a Crosley set. By means of an auto transformer connected to the a.c. line, the engineers varied the line potential from 90 to 150 volts. The voltage applied to the filaments of the tubes varied less than a tenth of a volt! The device works entirely on magnetic principles—it contains no moving parts, resistors, thermal units, etc. The Ward Leonard engineer responsible for the design is H. K. Kouyoumjian. H. E. R.

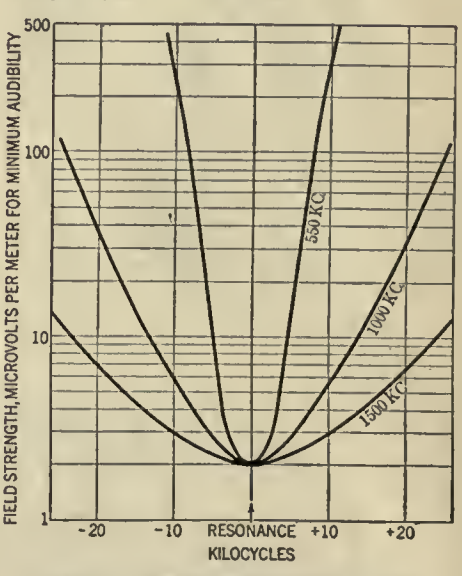
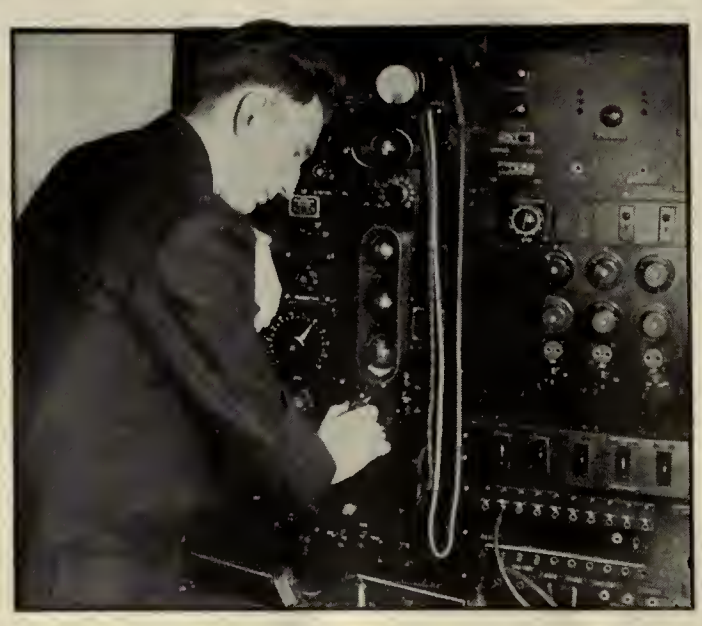


Fig. 7—The selectivity of the usual receiver varies with the frequency to which the circuits are tuned as illustrated in the above curves

BROADCAST ENGINEERING

BY CARL DREHER

Loud Speaker Frequency Peak Correction



Clarence R. Clark, chief engineer for KJR, is pictured above at the controls of KJR's new 5000-watt transmitter

SOMETIMES, in broadcast monitoring or other operations involving judgment of quality, loud speakers are encountered which would be suitable for the purpose except for a marked peak in response somewhere in the audio-frequency range. This undesired sensitiveness may readily be reduced to any desired degree by the application of an audio-frequency filter, which, in the form described below, is simply the familiar radio-frequency "rejector" designed to function at a lower frequency, i.e., an audio frequency, the alternating-current principles remaining the same.

Fig. 1 shows a radio-frequency rejector circuit intended to eliminate interference at a given frequency, f, to which the combination of inductance and capacity, L_rC_r, is tuned. This path then presents a minimum impedance to incoming waves of frequency f, and the receiver tuning elements, L_aC_a, may be set for some other desired frequency without interference, the currents of frequency f passing to earth by way of the rejector path and hence causing no interference.

Fig. 2 shows a loud-speaker characteristic, assumed to have been secured by such methods as those described by Wolff and Ringel: "Loud Speaker Testing Methods," *Proc.* I.R.E., Vol. 15, No. 5, May 1927; or Bostwick: "Acoustic Considerations Involved in Steady State Loud-Speaker Measurements," *Bell System Technical Journal*, Vol. 8, No. 1, January, 1929, and in numerous other articles. At 1000 cycles, it will be noted, there is a peak about 10 DB above the general level of response at other frequencies. By an audio-frequency filter circuit such as that represented by the elements L_f, C_f, and R_f in Fig. 3, connected in parallel with the audio coil of the loud speaker, such a peak in response may be smoothed out. The constants assumed are given only for purposes of illustration, although they are in the general range encountered in practice.

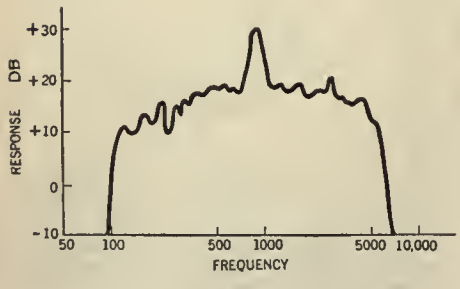


Fig. 2

The decrease in loud-speaker current required at 1000 cycles is first calculated from

$$\text{Response DB} = 20 \log \frac{I_1}{I_2}$$

It is found that for a 10 DB decrease the ratio between the two currents must be 3.16, or, approximately, the initial current should be

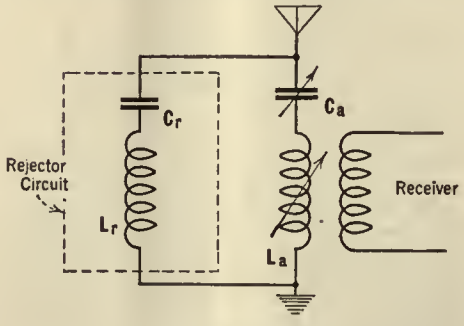


Fig. 1

reduced to one-third. This means that in the filter branch of Fig. 3 the current at 1000 cycles must be twice the current through the loud speaker voice coil. It is known that if the loud speaker impedance at 1000 cycles is Z_s, and the filter impedance Z_f, the current from the amplifier will divide in the ratio

$$\frac{I_s}{I_f} = \frac{Z_f}{Z_s} \qquad (2)$$

It follows that at 1000 cycles, for the purpose in question, the filter circuit in Fig. 3 should have only half the impedance of the loud speaker.

The latter quantity is determined by measurement on an inductance bridge, or by some other standard method (see, for example, Ramsey: *Experimental Radio*), in which, however, care must be taken to feed the measurement circuit from a 1000-cycle source and to adjust the current through the loud speaker so that it will have substantially the same constants as under normal operating conditions. If we assume that the 1000-cycle impedance is found to be 20 ohms, then the filter must have an impedance of 10 ohms at the same frequency. Part of this 10 ohms will be in the coil L_f, the resistance of which may be measured with d.c. on a Wheatstone Bridge; the remainder is made up in the separate resistance R_f.

All that remains is to calculate L_f and C_f to resonate at 1000 cycles. The formula used is

$$f = \frac{5033}{\sqrt{L\,C}} \qquad (3)$$

where f is in cycles per second, L in millihenries, and C in microfarads. The conditions will be satisfied approximately by a mica condenser with a capacity of 2.5 microfarad, and a 10-millihenry coil of the honeycomb type, or by a 1.0-microfarad condenser and a 25-millihenry coil. The resistance of the coil being measured, as outlined above, the proper series resistance may be added to smooth out the 10 DB peak in the loud-speaker response.

Generally speaking, the sharpness of tuning of such audio-frequency rejectors matches the sharpness of peaks in the loud-speaker response curve, so that there is not much chance of doing damage to the frequency characteristic of the loud speaker by introducing troughs on either side of the peak which is eliminated. Above the resonant frequency the filter has an inductive reactance, which soon rises to several hundred ohms as the frequency is increased, while below the resonant frequency the same effect takes place with a capacitive reactance. Thus the filter serves to cut off the peak at the frequency for which it is designed, and has little effect on the response at other points in the band.

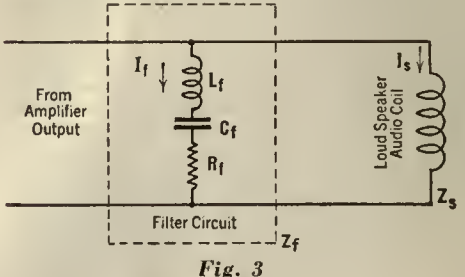
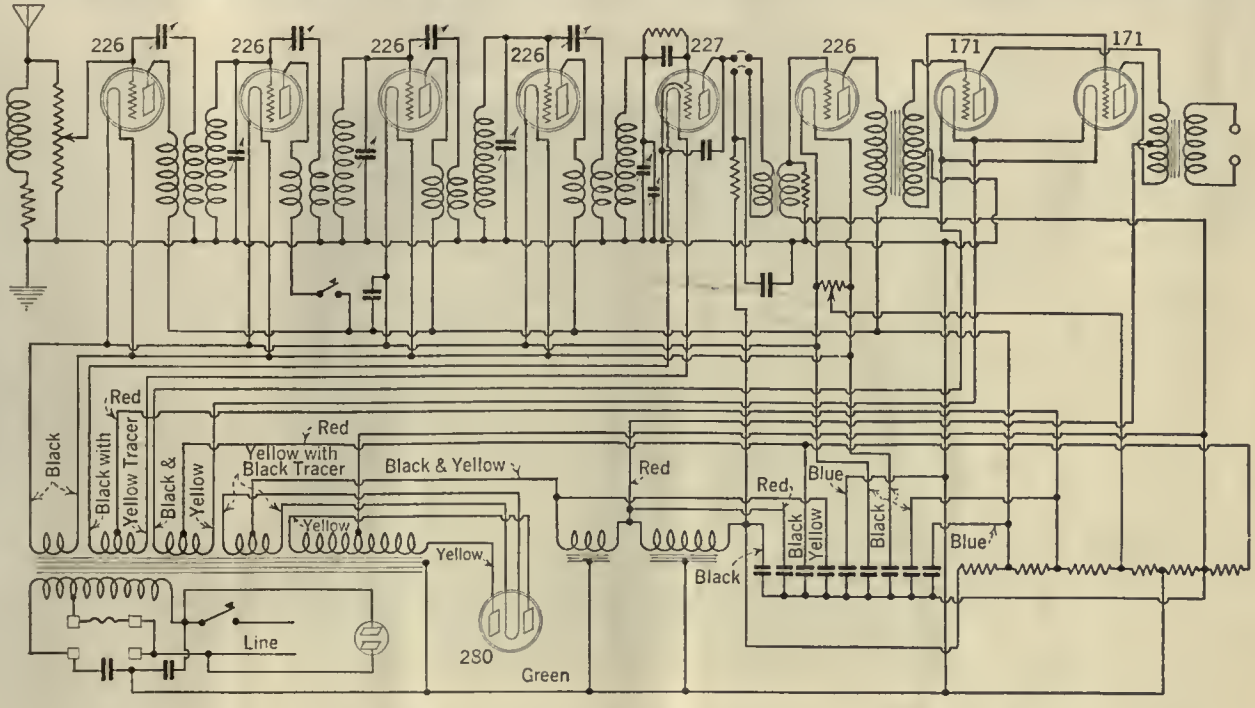


Fig. 3

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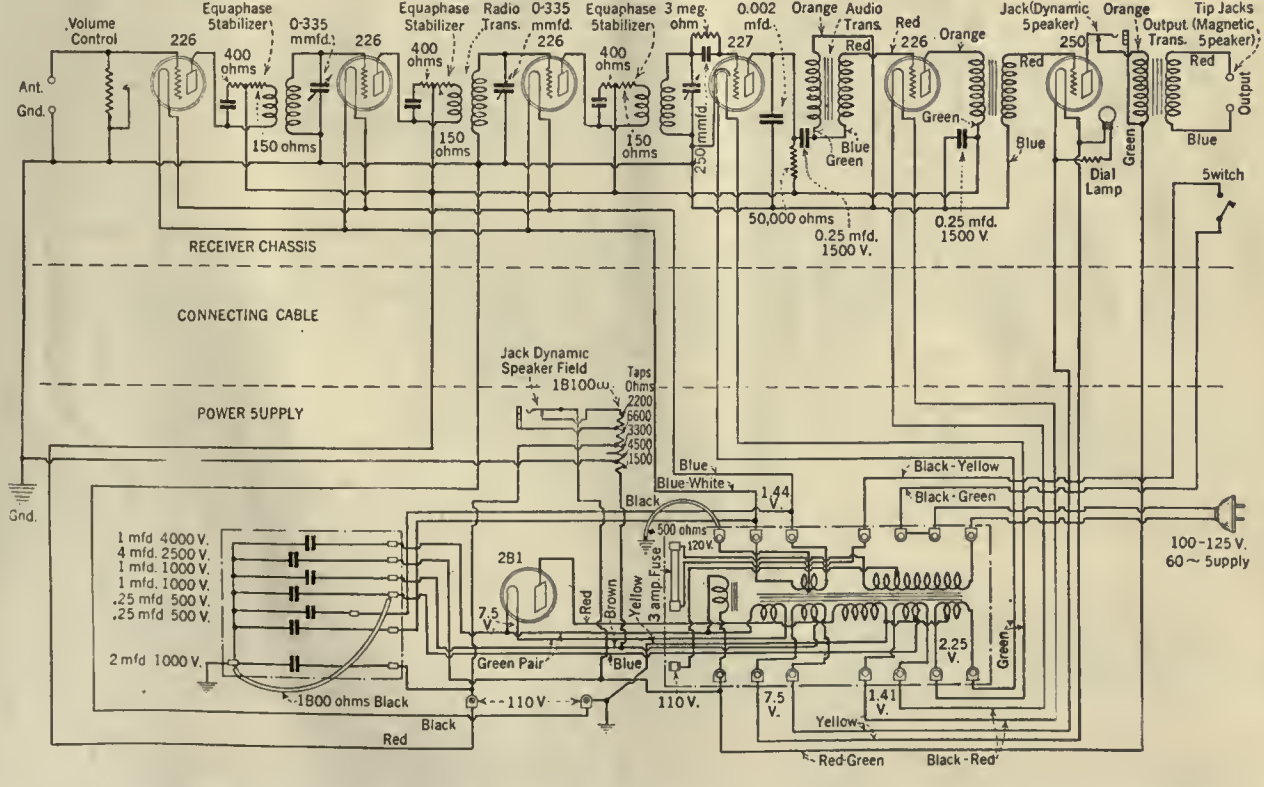
THE DAY-FAN 8-AC POWER SET

This receiver is completely light-socket operated and uses five 226-type tubes, one 227-type tube and two 171A-type tubes. It should be noted that each r.f. transformer contains three coils, the third winding being used for neutralizing purposes to prevent the amplifier from oscillating. A jack in the plate circuit of the detector permits the use of a phonograph pick-up unit.



THE FRESHMAN MODEL 2N-12 RECEIVER

This Freshman receiver utilizes the Equaphase circuit in which an Equaphase stabilizer is used in each plate circuit of the r.f. amplifier tubes. These stabilizers tend to make the plate circuit non-reactive, thus making it impossible for the tubes to oscillate. The output circuit of the set has been arranged to permit the use of either ordinary cone loud speakers or moving-coil loud speakers.

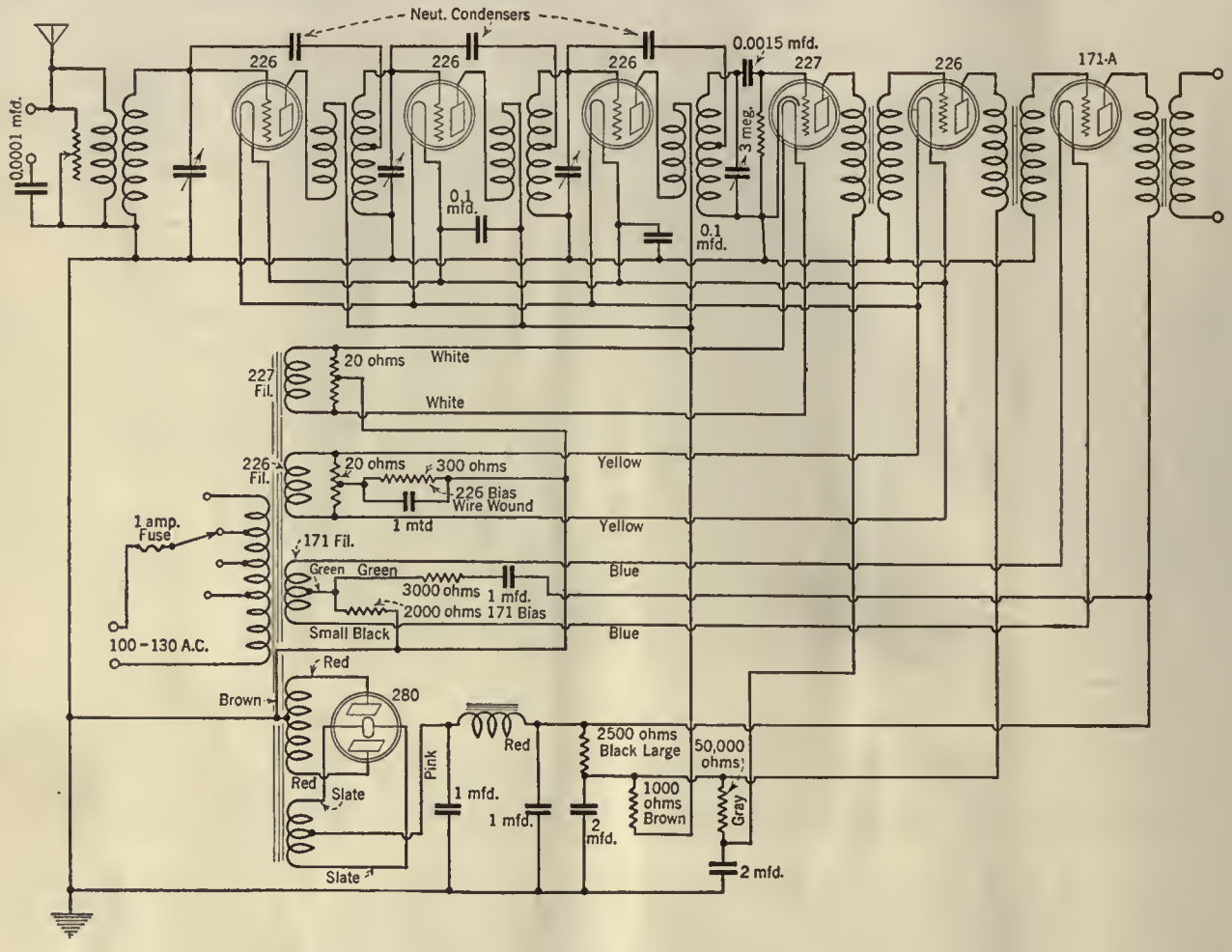


The data which has been given in the description of the receiver in previous "Set Data Sheets" has been lettered on the above diagrams

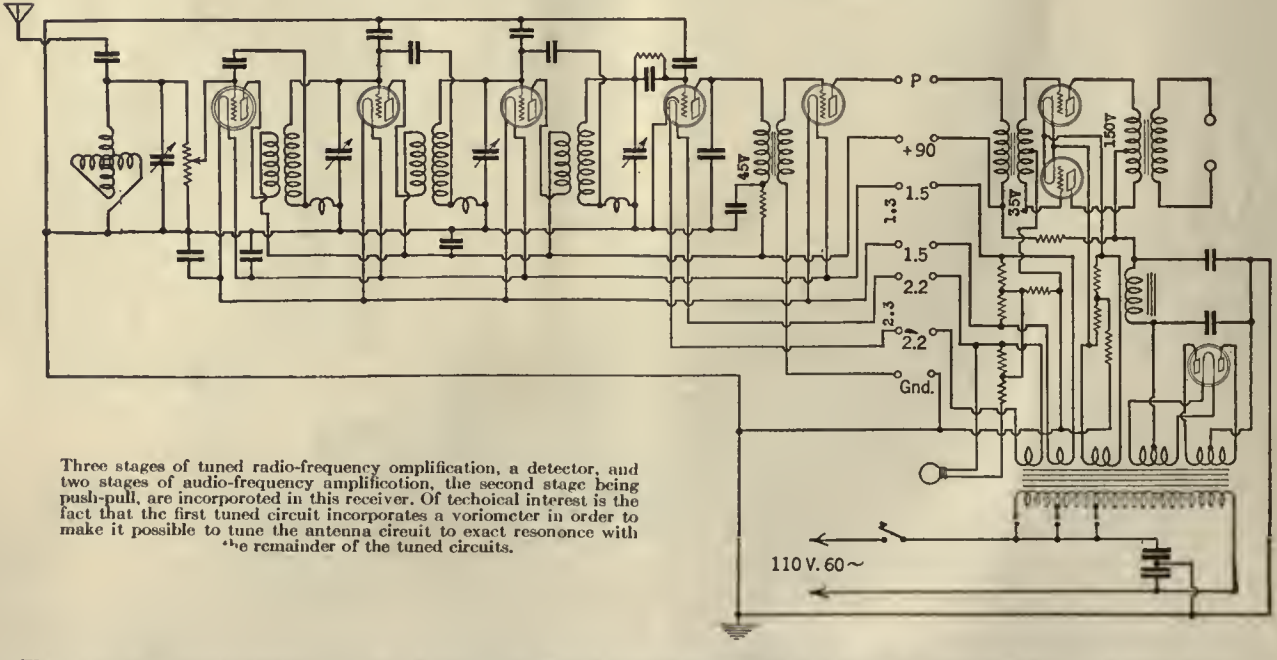
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THE KING MODEL H RECEIVER

This receiver utilizes o conventional circuit consisting of two stages of r.f., detector, and two stages of a.f. amplificatioo. The volume control consists of a variable resistor conoected between antenna and ground. It should be noted that the power transformer contains four taps to permit the use of the set on any line voltages between 100 and 130 volts a.e. The rectifier is a 280-type tube.



THE BOSCH MODEL 28 RECEIVER



Three stages of tuned radio-frequency omplification, a detector, and two stages of audio-frequency amplificotion, the second stage being push-pull, are incorporoted in this receiver. Of techoical interest is the fact that the first tuned circuit incorporates a voriometer in order to make it possible to tune the antenna circuit to exact resonoce with the remainder of the tuned circuits.

The data which has been given in the description of the receiver in previous "Set Data Sheets" has been lettered on the above diagram.

AN EXAMINATION FOR RADIO SERVICEMEN

By J. F. B. MEACHAM



Employers of radio servicemen have found that the most satisfactory means of selecting highly trained men is by submitting all applicants to a written examination

RADIO dealers and others who regularly engage new men for their service staffs must cull out the good men from the poor and how to do it well is a problem that has not been generally solved. Many men charged with the task of hiring and firing have learned to their sorrow that not all who call themselves "radio experts" are really qualified. The first requisite for a good serviceman is that he have a good practical background of electrical and radio knowledge. One excellent way to find out if the applicant has this knowledge is to set an inclusive and formal examination which he must pass.

The sample examination for servicemen which appears below is one which has been used with excellent results by the Q R V Radio Service, Inc., of New York. This examination attempts to determine the general knowledge of the applicant and does not go into all the problems which arise in the servicing of a.c. receivers. It has been found that men who can pass an examination of the scope of this one are usually quite capable of intelligently solving most service problems which they meet in the field.

We present this sample examination with the suggestion that it may be helpful as a guide to other organizations who hire servicemen. We should like to hear from our readers who are using formal examinations of this type and would be glad to see copies of similar examinations which they are using.

Section I—Fundamentals
(TEN CREDITS)

(Give the formula in each case and show your arithmetic.)

1. (a) If you desire to furnish a current of 3.5 amperes to a load through a resistance of 8 ohms, what must be the voltage drop across the resistance? (b) How much power is consumed in the resistance, in watts?

2. (a) If a voltage of 7 volts is impressed across a resistance of 125 ohms, what current will flow, in amperes? (b) In milliamperes?

3. (a) If a potential of 20 volts causes a current of 5 amperes to flow through a circuit, what is the resistance of the circuit, in ohms? (b) If a potential of 200 volts causes a current of 0.5 milliampere to flow through a grid-leak, what is the resistance of the leak, in megohms?

4. (a) What is the total resistance in ohms of three rheostats whose separate resistances are 3, 5, and 9 ohms, when connected in series? (b) When connected in parallel?

5. (a) What is the total capacity in microfarads of three condensers whose separate capacities are 0.5, 2 and 3 mfd. when connected in series? (b) When connected in parallel?

Section III—Tubes
(FOUR CREDITS)

1. (a) What is the important difference between a 199-type tube and a 120-type tube? (b) Between a 201A and a 112? (c) Between a 112 and a 171? (d) Between a 171 and a 210?

Section IV—Batteries
(TEN CREDITS)

1. (a) Is it better to test the voltage of a dry cell under no load or under load? (b) Why? (c) What should be the no load voltage of a fresh dry cell? (d) Of a fresh 45-volt B battery? (e) How long may the average 45-volt battery be satisfactorily used? (f) Why can it not be satisfactorily used longer than that?

2. (Questions under 2 apply only to lead cells) (a) Is a voltage reading a sufficient indication of the condition of a storage battery? (b) Why? (c) Is a hydrometer reading sufficient? (d) Why? (e) If you know only the voltage and the ampere hour capacity of a storage battery, how would you compute the normal discharge and initial charging rate? (f) Of what is the electrolyte of a lead cell composed? (g) Why does the specific gravity of the electrolyte change during charge and discharge? (h) At what height should the surface of the electrolyte in a lead cell be maintained? (i) What trickle charge rate would be approximately correct for a set using five 201A tubes and one 112 tube which is operated for an average of four hours per day, the charger operating 20 hours?

Section V—A.C. Power Units
(TEN CREDITS)

1. (a) Can the voltage delivered to a set by a B-power unit be accurately measured by the ordinary battery-testing voltmeter? (b) Why? (c) Name an exception to your answer to (a). (d) What effect would be produced on the terminal voltage of the average B-power unit by the substitution of a 171-type tube for a 112-type tube in a set to which the power unit is connected? (e) Why?

Section VI—Servicing
(FIFTY CREDITS)

(In those of the following questions which refer to broadcast receivers, when no particular set is mentioned you may assume it to be an average five-tube factory-built set.)

1. In what order would you conduct a routine test of a broadcast receiver, assuming the entire pick-up system to be ok.? Answer briefly. Letter your answers as: (a), (b), etc.

2. If a set is noisy, and you do not recognize its source by the character of the sound, how can you determine readily whether it is in the set itself or is being picked up by the antenna-ground system?

3. (a) Which is most liable to open, the secondary winding or the primary winding of an audio-frequency transformer? (b) Why?

4. (a) What would be the effect on the output of an open in the grid circuit of the second r.f. tube in a broadcast receiver? (b) Of the first a.f.?

5. If one of the leads to a tuning condenser in a broadcast set is open, what is the effect?

6. (a) How would you determine the total plate current drain of a broadcast receiver? (b) Approximately what would the drain be of a set using four 201A's and one 112 tube, with the correct plate potentials and grid potentials applied? (c) If a test shows half the current you would expect under the conditions of (b) what is the most probable trouble, assuming the batteries ok.?

7. (a) When a low-pitched steady hum or howl is set up in a set, regardless of tuning condenser settings, what is the most probable trouble? (b) What is the cause of that trouble? (c) Name two remedies.

8. (a) If, in a broadcast receiver, one of the audio tubes appears to be burning with a brilliancy much greater than normal, what is the trouble? (b) Would the same condition produce the same brilliancy in an r.f. tube? (c) Why?

9. If the signal strength of a receiver was far below normal, but you could not find any trouble in the set itself, or the tubes or batteries, or loud speaker, what would be the sequence of your next tests, in detail? Let your answers be lettered as: (a), (b), etc.

10. If, with the tuned circuits of a set all out of resonance, an intermittent hissing and frying noise is audible in the loud speaker, what is the most probable trouble?

11. (a) If you find the plate potentials furnished to a set by a B-power unit to be very low, with the plate current to the set also very low, and you notice that the plate of the power-unit rectifier is running red hot, what is the most probable trouble? (b) If you found the plate voltages very low, but the plate current, measured in the minus B lead between the power unit and set terminals, abnormally high, what is the most probable trouble?

12. With the filaments of a set at normal brilliancy, approximately what potential should 90 volts of B battery produce at the plate of the first a.f. tube?

13. If a test shows normal potential from the B post of an audio transformer to filament, but none from the plate—of the tube whose output goes to that transformer—to filament, what is the trouble?

Section VII—Diagrams
(TEN CREDITS)

1. Draw a circuit diagram of a five-tube set, tuned and neutralized r.f., with detector regeneration, transformer-coupled audio, 171-type tube in last stage, with storage A, a. c. trickle charger, B-power unit, and automatic relay. Power-unit rectifier may be either thermionic or gaseous type.

2. Draw a circuit diagram of a super-heterodyne having two stages of "intermediate" r.f., omitting the a.f. stages.

Section II—Tubes
(SIX CREDITS)

1. Give data for the following tubes, for normal operation.

TYPE	USE	FIL. V.	PLATE V.	GRID V.	FIL. CURRENT	PLATE CURRENT	PLATE RES.	AMPL. CONSTANT
199	amplifier	.....	.....	.....	.....	.....	.....	.....
199	detector	omit....	.....	.....	.....	.....	.....	.....
120	amplifier	omit	.....	.....	.....	.....	.....	.....
201A	amplifier	.....	.....	.....	.....	.....	.....	.....
201A	detector	omit	.....	.....	.....	.....	.....	.....
200A	detector	.....	.....	.....	.....	.....	.....	.....
112	amplifier	.....	.....	.....	.....	.....	.....	.....
171	a.f. ampl.	.....	.....	.....	.....	.....	.....	.....
210	a.f. ampl.	.....	.....	.....	.....	.....	.....	.....

IN THE RADIO MARKETPLACE

News, Useful Data, and Information on the Offerings of the Manufacturer

New Receivers Announced

THE Crosley Radio Corporation has announced two new receivers; the Gemchest and the Showchest. The Showchest is a console model with a built-in Dynacone loud speaker. The receiver itself is an eight-tube a.c. set employing three stages of tuned r.f., detector, and two stages of audio, the output stage of which is push-pull using two 171A-type tubes. The Gemchest utilizes two stages of r.f., a regenerative detector, and two stages of a.f.

THE ATWATER-KENT COMPANY has announced two new receivers. One is the table model 46 set using seven a.c. tubes and one rectifier. This set is priced at $83.

The second receiver is the console model 53, priced at $117. The chassis is housed in a metal console together with the new Atwater Kent dynamic-type loud speaker. The price of the new dynamic loud speaker when sold separately is $34.

THE COLUMBIA PHONOGRAPH COMPANY'S latest product is the model 950 phonograph-radio combination. This combination includes a Columbia electrical phonograph and a Kolster radio receiver. The price is $450.

THE SPARKS-WITHINGTON COMPANY has announced a new Sparton console receiver, type 930, priced at $189.50. This new receiver utilizes the same band-selector circuit used in previous Sparton Equasonne receivers. In the console is also included a Magnavox dynamic-type loud speaker. Tubes are included as standard equipment without added cost. According to Captain Sparks, president of the company, production during the past season was nearly three times as great as during the preceding season.

AN A.C.-222-TYPE TUBE is used in the new Series K receivers produced by the Federal Radio Corporation. This set will be available in both table and console models. The lowest priced model will cost $127.50. A 227-type tube is used in the first r.f. stage and in the second r.f. stage a new 222-type a.c. tube is used. In the detector and first-audio stages 227-type tubes are used and in the output there are two 171A-type tubes.

Miscellaneous New Products

THE new Y-227-type detector tube manufactured by the Sonatron Tube Company reaches its proper operating temperature within five to seven seconds after the power has been turned on. This time lag is quite short in comparison with the 15- to 30-second lapse for most other heater-type tubes. This company also has a new type 171-AC. tube selling at $3.50.

THE C. E. JACOBS MANUFACTURING COMPANY, of 2802–10 N. Kedzie Avenue, Chicago, has developed a new product, the "Repleno" rectifier for use as a replacement unit in electrolytic rectifiers. The list price is $1.00 per jar. These rectifiers are said to be suitable for use in the electrolytic B-power units made by Philco, Willard, Exide, Vesta, etc.

THE R. C. BURT SCIENTIFIC LABORATORIES, of Pasadena, California, are the manufacturers of two devices useful in radio engineering. One is the standard Burt Photo-Cell, which, according to the makers, is a highly sensitive photo-electric cell giving a current of 1 microampere per 100 foot candle and a linear relation between 0.1 and 1000 foot candles. The Burt cell is not affected by fatigue.

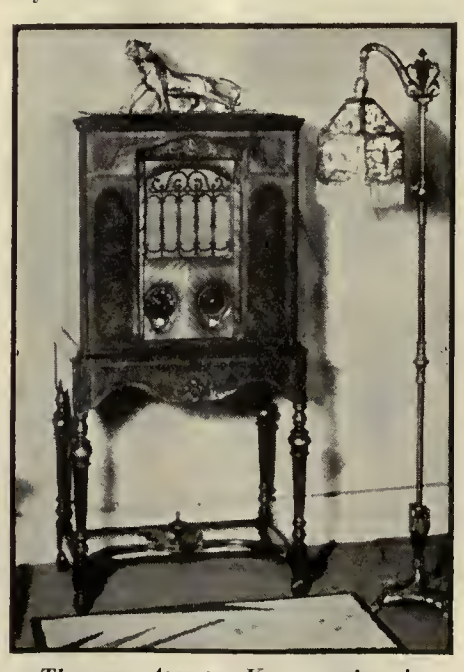
The second device is the Bedell-Reich Stabilized Oscilloscope. The oscilloscope may be used in the varied fields of investigation in which the vibrating mirror or cathode-ray oscillograph is used.

THE TRUTONE RADIO SALES COMPANY, 114–116 Worth Street, New York City, has placed on the market the "Si-lenser," a device for use between the light socket and the radio set to eliminate line noises.

A NEW DYNAMIC loud speaker switch is being made by the Therm-A-trol Manufacturing Company. This device is designed for use in conjunction with a.c. receivers which are being operated in conjunction with a separate a.c. dynamic loud speaker. By the use of this special switch the power input to both the set and the dynamic loud speaker can be controlled by means of the single switch on the receiver.

FERRANTI, INCORPORATED, makes two output transformers designed to connect between the moving coil of a dynamic loud speaker and a power tube. The type OP-2C is designed for use with single tubes of all types and the OP-4C is for use in push-pull circuits. An article telling how and when to use such transformers will be found on page 194 of RADIO BROADCAST for January, 1929.

PROBABLY THE SIMPLEST way to make it posible to get more output from a radio set without overloading the last tube is to place two power tubes in parallel in the output stage. A device to permit this to be accomplished readily is being manufactured by Arthur H. Lynch, Inc., and is called the Lynch Tubadapta. It consists of two tube sockets mounted in a convenient holder that can be plugged into the power-tube socket of any receiver.



The new Atwater Kent receiver in a console cabinet with built-in loud speaker

NEW LOUD SPEAKERS known by the trade name of Conamic are being made by the Operadio Manufacturing Company. Various models are available ranging in price from $28.00 to $32.50. Special loud speaker chassis are available for use in manufactured receivers.

THE EXCELLO PRODUCTS CORPORATION, of 4820 West 16th Street, Cicero, Illinois, are manufacturers of Excello cabinets for use with all types of radio receivers. There are available also special cabinets designed especially for well-known receivers such as the Atwater Kent, Crosley, Radiola, etc.

THE NEW S-M dynamic loud speaker units are being offered in two models; the type 850 for a.c., and the type 851 for d.c. field excitation. Hum in the a.c. model has been eliminated by supplying the field with 120 volts from a 280-type full-wave rectifier. Across the output of the rectifier is connected a 2-mfd. filter condenser which, in conjunction with the field coil, completely filters the output so that only pure d.c. flows through the field winding. The loud speaker is equipped with a 229-type coupling transformer so that the loud speaker may be used with all types of tubes. The 850-type a.c. unit is priced at $58.50 and the 851-type d.c. unit at $48.50. Only the loud speaker unit itself can be obtained, i.e., they are not sold in cabinets.

Radio Industry Briefs

WITH the sale of station WABC to the Columbia Broadcasting chain, the New York offices of A. H. Grebe and Co. have been moved from West 57th Street, New York, where they were combined with the offices and studio of WABC. The Grebe executive offices are now at the factory in Richmond Hill, Long Island, New York.

HAL P. SHEARER, formerly general manager of the Splitdorf Radio Corp., of Newark, N. J., has been chosen vice-president and general manager of the new Sleeper Radio and Mfg. Corp., Long Island City, N. Y. A. N. Clifton, formerly sales manager of the Alden Manufacturing Company, is sales manager of the reorganized Sleeper Company.

GUY C. KOWFELDT, 529 South 7th Street, Minneapolis, Minn., and E. F. Coughlin, 10 High Street, Boston, Mass., were recently appointed district managers for the de-Forest Radio Company. They will coöperate with jobbers and dealers in their territories.

ALBERT L. SCOTT, formerly with the Girard Phonograph Company, Edison distributor in Philadelphia, has been appointed manager of the Atlanta, Ga., branch of the Edison Distributing Corp.

MERWYN HEALD is the new chief engineer of the Thordarson Mfg. Co., of Chicago. Mr. Heald was formerly chief engineer of the Robertson-Davis Co., of Chicago. The new Thordarson executive was graduated in E. E. from Northwestern where he was a member of both Signa Xi and Phi Beta Kappa. Thordarson has also announced an increase in their factory space and additional research and production is now contemplated.

THE GENERAL CONTRACT PURCHASE CORP., New York, has issued the third edition of their catalog of R. C. A.

licensed receivers, prices, and number and type of tubes employed. Among the licensed sets listed, the following companies not themselves holding an R.C.A. license are shown to supply sets: Brunswick Phonograph Co., Buckingham Radio Corp., Bush & Lane Piano Co., S. Freshman, Graybar Electric Co., National Carbon Co., Sonora Phonograph Co., and Victor Talking Machine Co.

THE SPRING MEETING of the National Electrical Manufacturers Association will be held at the Homestead, Hot Springs, Va., May 20–25, 1929.

A CLEVELAND BRANCH of the Thordarson Manufacturing Co., has been opened at 520 Citizens Bldg., with C. M. Hendricks in charge.

THE MANUFACTURING activities of the Chas. Freshman Co. and the Freed-Eisemann Radio Corp., will be combined in a new factory to be located in Clifton, N. J., 12 miles from New York, according to a recent announcement of C. A. Earl, head of the two concerns.

THE KELLOGG SWITCHBOARD AND SUPPLY CO., of Chicago is now licensed under the patents of the Radio Corporation to make receivers. The license was granted as of January 1, 1929. A complete list of RCA set licensees will appear in a subsequent issue of this magazine.

THE BREMER-TULLY MANFACTURING CO., has just received a receiver license under the Hazletine and LaTour patents.

THE NEW RECEIVER manufacturing plant of the Temple-Sleeper Corp., is located at 5253 West 65th Street, Chicago. A. Marchev is president of the new company.

THE FACTORY OF Colin B. Kennedy, Inc., is being moved from Highland, Ill., to South Bend, Ind. It is said that the Kennedy company has merged with the Studebaker Co., of South Bend and plans to market sets through mail order channels.

THE EBERT FURNITURE CO, Red Lion, Pa., is now offering a line of high-quality cabinets at popular prices. A. Irving Witz and M. J. Polikoff have been appointed national sales agents. Mr. Witz was formerly eastern representative for Bremer-Tully and the Webster Co., of Chicago, and the Fidelity Radio Corp., of Salt Lake City. He is now also vice president and sales manager of the Argon Tube Corporation, Newark N. J.

PRICE reductions on ten types of R.C.A. tubes were announced on February 15th by the Radio Corporation of America. Radiotron UX-226 is reduced to $2.00, UY-227 to $3.00, UX-280 to $3.50, UX-281 to $7.25, UX-112A to $2.50, UX-250 to $11.00, UX-199 to $2.00, UX-171A to $2.50, UX-200A to $3.50, and UX-201A to $1.40.

Technical Notes

VARIABLE condensers of all types for use in the manufacture of receivers are made by the Precise Products, Inc. Single or gang condensers can be obtained with maximum capacities of 0.0005, 0.00035, or 0.00025 mfd. Relative to the accuracy of these condensers, the following data was received from A. deFord, sales manager.

"We hold the accuracy of our condenser to within three mmfd. plus or minus over the entire range. All of our production condensers are calibrated in five different positions using the resonance method. The tolerance we have specified above is closer than some manufacturers demand.

"We are building group condensers with as many as 5 to a gang, and the returns on these condensers have been less than one half of one per cent."

PRODUCTION TESTS ON Durham Metallized Resistors have been made more severe to make certain that the units have an ample safety factor. According to a recent release from the International Resistance Company, all Durham Metallized Resistors are "flash" tested for five minutes at a load of twice the normal rating of the unit.

The Radio Dealer's Note Book—No. 2 Voltage-Control Devices

ACCURATE summaries of useful information are constantly of value to those radio folk who deal with the public. This sheet, one of many such on various subjects to follow, sets down collected information on voltage-control devices. The dealer or serviceman can remove this part of the page for his notebook or he can have it photostated in any number of copies.

A.C. line voltages throughout the country are not constant. When an a.c. set is installed the dealer must make whatever adjustments are necessary to permit the set to operate at maximum efficiency at the particular value of voltage at the socket to which the set is connected.

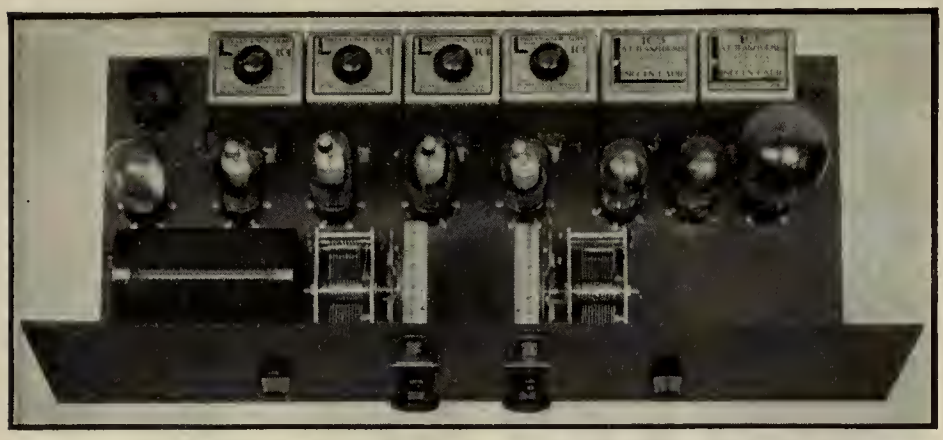
This adjustment may be accomplished readily with those sets supplied with several taps on the power transformer. In such a case the proper procedure is to make measurements with an a.c. voltmeter to determine the maximum voltage at the light socket. The tap on the transformer is then adjusted for operation at this voltage.

All receivers are not supplied with taps on the power transformer and in other cases it may be found that the taps available do not in some instances permit a wide enough adjustment; for example, a set might have taps to permit operation on line voltages up to 115 volts but by test it may be found that the line voltage is at times as high as 125 volts. In such a case it is necessary to install some device to reduce the line voltage to 115 volts. A complete list of the adjustable line voltage control devices made for this purpose is given in the table below.

These devices which are either fixed or variable resistors are generally mounted in some convenient manner so that they may be connected readily between the light socket and the power lead from the set. Whether a fixed or variable resistor is used depends upon various factors. Most radio owners are not particularly interested in the mechanics of the set and don't want to be bothered by having to adjust a line voltage control device from time to time. For this reason a fixed resistance of the proper value should be used whenever possible. This is quite satisfactory where the voltmeter test of the line voltage shows the supply to be high but uniform. If the test shows that the voltage varies over wide limits, sometimes being high, sometimes normal and at other times quite low, it is best to install one of the devices containing a variable resistance so that the amount of line-voltage compensation can be adjusted as necessary by the owner of the set. The second thing to do if the line voltage is found to undergo wide variations is to write a good stiff complaint to the power company.

Space limitations do not permit us to go into detail regarding how to determine what size resistance to use under different conditions but fortunately the various companies manufacturing these devices can supply excellent charts showing just what resistance to use. This information should be in the hands of all dealers and servicemen. A note to RADIO BROADCAST written on your business stationery will bring to you complete data on all the devices listed in the following table.

Mfgr.	Type No.	Price	Characteristics				Remarks
			Fixed Resistor		Variable Resistor		
			Ohms	Wattage	Ohms	Wattage	
Aerovox	997	1.50	3 to 75	60			
Central Radio Laboratories	Control Box	3.00					Mounted in a metal box with socket and input power lead
Clarostat Mfg. Co.	Power Clarostat	3.50			0–10 25 to 500	40 40	
DeJur-Amsco Corp.	Voltage Regulator No. 360	12.50					Mounted in a metal box with socket, input lead, and a.c. voltmeter to permit accurate adjustment to 110 volts
Insuline Corp. of America	Resistovolt Light-Duty Resistovolt Heavy-Duty	1.75		125 250			
Thermatrol Mfg. Co.	Voltage Control	1.75			30	75	Consists of small device to plug into light socket. Four adjustments for voltages from 110 to 125 volts
Ward Leonard Mfg. Co.	507–63 507–59 507–83 507–96 507–39 507–41 507–43 507–44 507–45 507–97 507–98 507–99 507–100 507–101	5.50 5.50 5.50 2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00	 2.5 3.5 5.0 7.0 10 12.5 15.0 22 31 45 62	 60 60 60 60 60 60 60 60 60 60 60	50 20 12.5	60 60 60	Which size resistor is used depends upon the line voltage and the current drawn by the set. A complete chart is available indicating what resistor to use.
Wirt Company	No. 211 No. 211-n	2.25 3.25				65 150	Mounted in a convenient unit to plug into the light socket
X-L Radio Labs.	X-L Link	5.75					Mounted in a metal box with socket and input power lead



Interior view of the new Hollister a.c.-operated super-heterodyne

Licensees of the Technidyne Corporation

THE Technidyne Corporation, 644 Broadway, New York, headed by Lester Jones, has informed RADIO BROADCAST of the following licensees under their patents:

RECEIVER CIRCUITS

Continental Radio Corporation, Fort Wayne, Ind., makers of Slagle Receivers. Sets made by this company embody the so-called "feed-forward" Technidyne circuit.

Sparks-Withington Company, Jackson, Michigan, makers of the Sparton Receiver. Sets made by this company employ the Jones "Equase" circuit.

The A-C Dayton Company, Dayton, Ohio. A new Technidyne licensee who plan to market a set with the "Equase" circuit during 1929.

OTHER LICENSEES

Electrad, Inc., New York, manufacturers of the "Royalty" variable resistor under Technidyne patents. A new type of variable resistor developed by the Technidyne Corp. will be marketed by Electrad also.

Electro-Motive Engineering Corp., New York, makers of Elmenco fixed resistors.

De Jur-Amsco Corporation, New York, makers of fixed resistors under Jones patents.

The Hollister AC8 Super-Heterodyne Kit Receiver

IN CIRCUIT and general layout the Lincoln Radio Corporation's new kit, the Hollister AC8, is similar to the former Lincoln 8-80 except that the new kit is designed for complete a.c. operation, the original 8-80 being a d.c.-operated set. The Lincoln Corporation advises us that they have obtained excellent results from this set, finding it possible from their location in Chicago to tune-in a station at practically every degree on the dial. A description of the new AC8 has been received from the Lincoln Corporation and the essential details of the circuit are given below.

The receiver is tuned by variable condensers independently operated by two illuminated drum dials. All wiring is done beneath subbase, which is composed of bakelite, eliminating possible shorts, and creating good insullation for all component parts. Substantial double-contact sockets are assembled in bakelite base ready for wiring.

The tubes employed are as follows: oscillator, 227-type; first detector, a.c. screen-grid tube, 222 a.c.-type; three intermediate stages, a.c. screen-grid tubes, 222 a.c.-type; second detector, 227-type; first audio, 227-type; second audio, 210- or 250-type.

The type-101 tunable intermediate transformers are used in the a.f. stages. Heavy copper shells house the transformer windings



The new Conamic loud speaker manufactured by the Operadio Manufacturing Co.

and variable condenser. The Clough system is used in the audio amplifier.

An output transformer—Lincoln No. 107—may be mounted at right-hand side of base when the set is used with a loud speaker that is not equipped with an output transformer. The output transformer is not included in the standard kit, as the majority of dynamic loud speakers already have an output transformer incorporated in them.

The power equipment for the Hollister AC8 is in a very compact crystalline-finished case and it supplies 45 volts, 135 volts, and 450 volts B; 7½ volts a.c., and 2½ volts a.c. One 281-type tube is used as rectifier.

The operation of the set is simple. The two dials track evenly throughout the broadcast range. A single volume control, composed of a 3000-ohm potentiometer controlling the 45 volts applied to the screen-grid tubes, is the only other adjustment necessary for tuning.

List of Parts

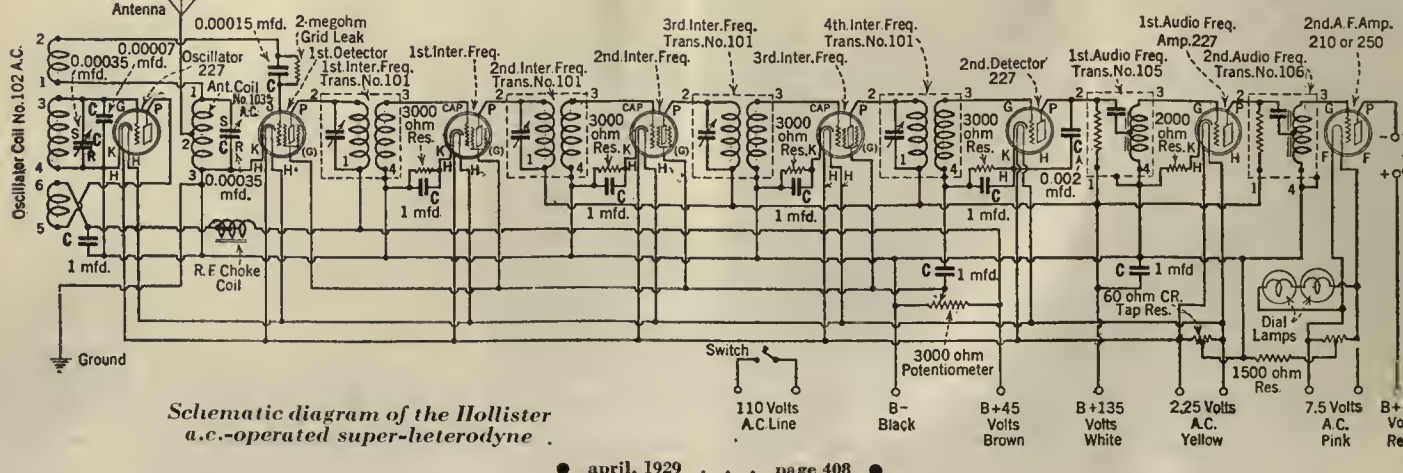
One No. 102AC oscillator;
One No. 103AC antenna;
Four No. 101 i.f. transformers;
One No. 105 a.f. transformer;
One No. 106 a.f. transformer;
Two .00035-mfd. condenser, Precise;
One Sub-base and socket assembly, completely drilled;
Two Sub-base supports;
Two Illuminated drum dials and windows;
One Front Lithographed panel;
Two Binding posts;
Seven 1-mfd. condensers;
One TP-3-M 3000-ohm potentiometer, Carter;
Four 3000-Ohm resistors, Electrad;
One 2000-Ohm resistors, Electrad;
One 1500-Ohm resistor, Yaxley;
Two CU60 center-tapped resistors, Carter;
One S-M No. 275 choke;
One .00015-mfd. condenser with clips, Aerovox;
One 2-Megohm grid leak. Aerovox;
One Sangamo .00007-mfd. condenser;
One .002-mfd. by-pass condenser, Aerovox;
One Carter 110-volt a.c. switch;
Two Tip Jacks;
One Terminal strip, Jones;
One Battery cable, Jones;
Two Knobs for potentiometer and switch;
One Set hardware and wire;
One Set of blueprints;
One Small panel for console (optional).

The kit of parts for the Hollister AC8 list at $110. The power unit for the set lists at $60.

The S-M Screen-Grid A.C. Kit Receiver

THE S-M model 720AC Screen-Grid Six is the newest kit being manufactured by the Silver-Marshall Company. H. R. Randall of this company has supplied us with the following details regarding this new receiver.

The model 720 AC is a six-tube a.c.-operated screen-grid receiver, available either as a kit for home assembly or as a custom-built set. It employs three r.f. stages, each using one of the new 224-type a.c. screen-grid tubes, a 227-type detector tube, and two stages of Clough-system a.f. amplification. In the second a.f. stage is found the new 245-type power tube delivering over 1.6 watts of undistorted power output. Four tuned circuits, effectively shielded, and controlled by two tuning dials (the antenna-stage condenser is separate from the three-gang condenser tuning the second, third, and detector stages) enables all tubes to be operated at full efficiency and eliminates the loss (or, at best, small gain) attendant upon the usual untuned "dummy" r.f. stage used to permit single-control operation. As both dials track very closely, the two dial feature is not a drawback to simple operation, while it is a very great



Schematic diagram of the Hollister a.c.-operated super-heterodyne

THE NEW CROSLEY GEMCHEST



Chinese Chippendale Cabinet design in three colors, Mandarin Red, Manchu Black and Nanking Green. Contains seven-tube Gembox shielded receiver (three tubes radio amplification, detector, two audio tubes and rectifier) and the dynamic Crosley Dynacone power speaker (built on a different principle of armature actuation.) Without tubes $94.

THE CROSLEY RADIO CORP.
POWEL CROSLEY JR., Pres. CINCINNATI, O.

Owners of WLW, the Nation's Station
West of Rockies Prices Slightly Higher

POWER IS MUSIC

to Radio Engineers



THE radio listening public is entitled to powerful volume plus undistorted *quality* output. Radio engineers and radio set manufacturers have worked steadily toward this result, constantly endeavoring to simplify radio construction. Simplicity without the loss of effectiveness is the keynote of engineering progress.

Now Arcturus announces two new tubes that definitely improve both volume and tone quality. They add new power to any A-C set, yet keep the reproduction clear and undistorted.

These two tubes are the No. 122 Shield Grid Tube and the No. 145 Power Tube. Both operate from a 2.5 volt a.c. filament heater potential. A specially prepared technical bulletin on these new tubes will be sent on request.

[Engineering Facts Have a Utility Significance to the Broadcast Listener]

ARCTURUS
BLUE A-C LONG-LIFE TUBES
ARCTURUS RADIO TUBE COMPANY ~ Newark, N. J.

Cunningham RADIO TUBES

Always keep a spare tube with your radio



Standard Since 1915

E. T. CUNNINGHAM, Inc.
New York Chicago San Francisco

FOR THE SERVICE LABORATORY



To the service man who prides himself on thoroughness a portable source of radio-frequency signals is indispensable. The aligning of tandem controlled condensers, the neutralizing of receiver or the tuning of the intermediate-frequency amplifier in a superheterodyne receiver all require a dependable test signal.

The Type 320 Test Oscillator supplies a modulated signal at 1,400 and 640 kilocycles in the broadcast band and at 180 kilocycles for testing of an intermediate-frequency amplifier.

Licensed under U. S. Patent 1,113,149

Bulletin T Describes It

GENERAL RADIO COMPANY

30 State Street
Cambridge, Massachusetts

274 Brannan Street
San Francisco, California

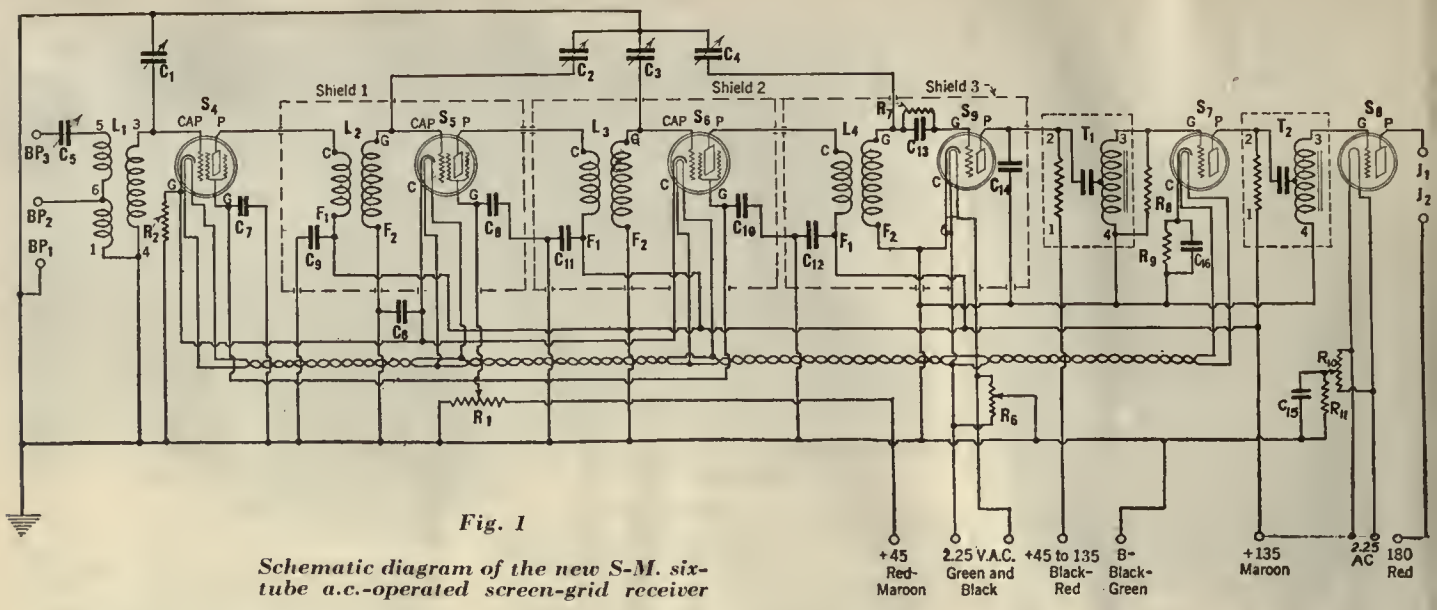


Fig. 1

Schematic diagram of the new S-M. six-tube a.c.-operated screen-grid receiver

aid in obtaining maximum results in the way of sensitivity and selectivity.

Actual measurements on a single r.f. stage show a gain of about 14 at 550 kc. and about 28 at 1500 kc. Each r.f. stage employs one 224-type a.c. screen-grid tube, together with an r.f. transformer consisting of a secondary of 98½ turns of No. 29 enamelled wire wound upon a threaded moulded-bakelite form 1½" in diameter and 1½" long, with a primary consisting of 35 turns of No. 38 enamelled wire upon a 1¼" tube located at the filament end of the secondary. From the antenna coupling system a voltage gain of about 60 is obtained.

From the picture, the r.f. amplifier section is seen to consist of a large antenna coil tuned by a single .00035-mfd. condenser and provided with a tapped primary and with a 75-mmfd. antenna series condenser for selectivity control. This coupler feeds the grid circuit of the first screen-grid r.f. amplifier which, in turn, feeds into three almost identical shielded r.f. circuits, each housed in a small copper can. Each of these stages employs the small r.f. transformer described above which is tuned by a section (equipped with individual compensator) of the three-gang die-cast condenser. In the two left-hand shields are the second and third screen-grid r.f. amplifiers, and in the right-hand shield the 227-type detector. By-pass condensers are contained in each stage shield to localize r.f. current paths. Volume control for the receiver is affected by means of a 3000-ohm potentiometer arranged to control the screen-grid potential of the three 224-type r.f. amplifier tubes.

The heaters of screen-grid and detector tubes are operated in parallel and are fed from a 2.5-volt winding of the transformer contained in the power supply for the receiver, and which furnishes A, B, and C power to the entire set.

The audio amplifier employs the well-known Clough audio system in two stages with a 227-type tube in the first stage, and a 245-type tube in the output stage. In its frequency-versus-amplification curve, as given on this page, it will be seen that it is extremely satisfactory over the frequency range involved in reproduction of music and speech.

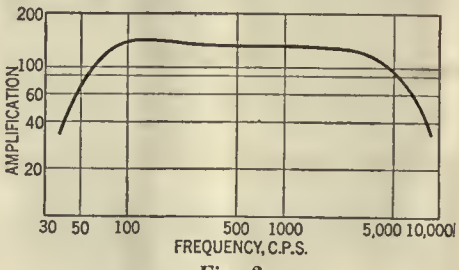


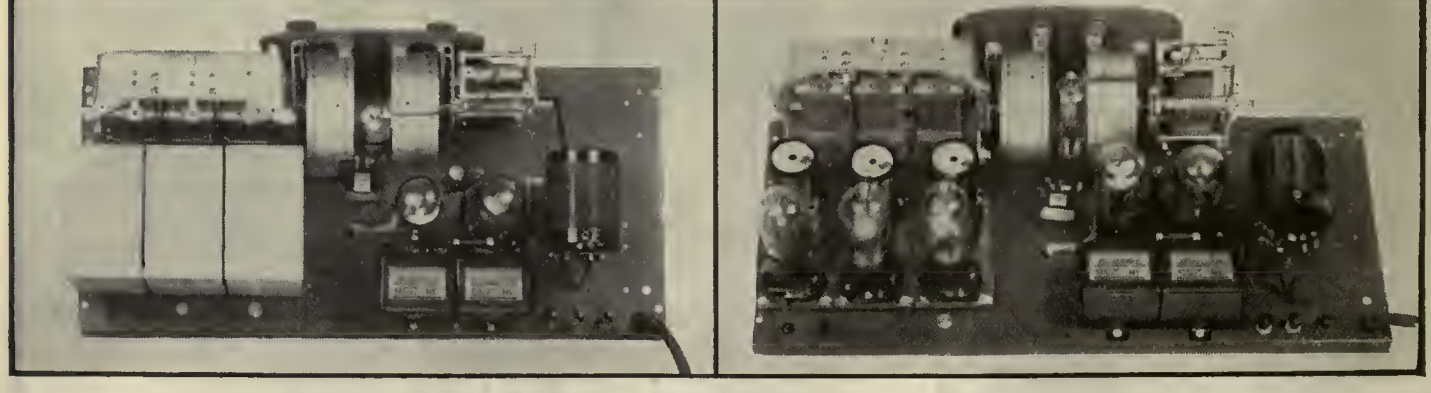
Fig. 2

No output transformer is supplied in the receiver, though space is left for the inclusion of such a device. This omission is justified on the ground that the builder will generally employ one of the better types of dynamic loud speakers, and such loud speakers are ordinarily equipped with output transformers. Should this not be the case, and should a magnetic loud speaker, or other type not equipped with output transformer, be used with the set, an output-coupling device, such as a transformer or choke and condenser filter, must be connected between set and loud speaker to prevent the high plate current of the 245-type power tube from damaging the loud-speaker windings. The undistorted power output of 1.6 watts is sufficient to provide adequate fidelity and sufficient volume.

Inasmuch as complete construotional data for this receiver may be had from the manufacturer offering the kit, space will not be taken to present it here. Constructional pamphlets may be had upon application directly to this magazine. The parts required for the construction of the receiver are as follows:

List of Parts

C_1 One S-M condenser, 0.00035-mfd., type 320B;
C_2, C_3, C_4 One S-M three-gang condenser, 0.00035-mfd., type 323;
C_5 One S-M midget condenser, 0.000075-mfd., type 342B;
C_6, C_{15} Two Potter condensers, 1-mfd., type 104;
C_7-C_{12}, C_{16} Seven Sprague condensers, 0.25-mfd.;
C_{13}, One Polymet grid condenser, 0.00015-mfd.;
C_{14} One Polymet by-pass condenser, 0.002-mfd.;
L_1 One S-M antenna coil, type 140;
L_2, L_3, L_4 Three S-M plug-in r.f. transformers, type 132A;
S_1-S_7, S_9 Eight S-M tube sockets, five-prong, type 512;
S_8 One S-M tube socket, four-prong, type 511;
T_1 One S-M a.f. transformer, first-stage, type 255;
T_2 One S-M a.f. transformer, second-stage, type 256;
J_1, J_2 Two Yaxley tip jacks, insulated, type 420;
R_1 One Yaxley midget potentiometer, 3000-ohm, type 53000;
R_2 One Yaxley resistor, 150-ohm;
R_8 One Carter sub-base rheostat, type A6;
R_7 One Polymet grid leak, 2-megohm;
R_3 One Durham resistor, 0.15-megohm;
R_9 One Yaxley resistor, 1500-ohm;
R_{10} One Yaxley resistor, center-tapped, type 840C;
R_{11} One Ohmite resistor, 1500-ohm;
One S-M universal pierced chassis, type 701;
One S-M dual-control escutcheon, type 809;
Two S-M vernier drum dials (one left and one right), type 806;
Three S-M copper stage shields, type 132A;
Three moulded binding posts;
Miscellaneous hardware, battery cable, hook-up wire, etc.



Chassis views of the S-M Screen-Grid Six receiver with and without shields in place

REAL One-Dial Control



The sections of Hammarlund "Battleship" Multiple Condensers are matched to within ¼ of one per cent. Absolute precision can be obtained by attaching a Hammarlund Equalizing Condenser to each section. Recesses in the frame provide for this.

That means REAL One-Dial Control, with every circuit accurately tuned.

Made in 350 mmfd. and 500 mmfd. sizes in two, three and four gangs. Your dealer sells them. *Write for Descriptive Folder.*

HAMMARLUND MFG. CO.
424-438 W. 33rd St. New York

For Better Radio
Hammarlund
PRECISION
PRODUCTS

Reliable
Short-Wave Reception



This tested screen grid tuner will give dependable short-wave reception. Simple to assemble. Easy to Tune. Stations can be logged. Does not radiate.



NATIONAL
SHORT WAVE TUNER
Send for Bulletin No. 132-RB.
NATIONAL CO., Inc., MALDEN, MASS.

HERE IS A COUNTER TUBE CHECKER
Which Requires NO BATTERIES

Model 533



Operates direct from the A.C. LIGHT SOCKET

Or any other A. C.—60 cycle—90 to 130 volt source of supply

Proper Voltage Regulation

is quickly obtained by means of the Voltage Adjusting Dial and the Voltage Indicator.

Will test every type of tube

A. C. or D. C.—having filament voltages of 1.5, 2.5, 3.3, 5 or 7.5 volts, including filament type rectifying tubes.

Check Tubes at Time of Sale

It prevents comebacks and *makes satisfied customers.*

Your jobber will supply you, or write direct to:

Weston Electrical Instrument Corp.
604 Frelinghuysen Ave., Newark, N. J.

WESTON RADIO INSTRUMENTS



and Polymet makes them"

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Prepared by Official Examining Officer

The author, **G. E. Sterling,** is Radio Inspector and Examining Officer, Radio Division, U. S. Dept. of Commerce. The book has been edited in detail by **Robert S. Kruse** for five years Technical Editor of QST., the Magazine of the Radio Relay League. Many other experts assisted them.

16 Chapters Cover: Elementary Electricity and Magnetism; Motors and Generators; Storage Batteries and Charging Circuits; The Vacuum Tube; Circuits Employed in Vacuum Tube Transmitters; Modulating Systems; Wavemeters; Piezo-Electric Oscillators; Wave Traps; Marine Vacuum Tube Transmitters; Radio Broadcasting Equipment; Arc Transmitters; Spark Transmitters; Commercial Radio Receivers; Radio Beacons and Direction Finders; Radio Laws and Regulations; Handling and Abstracting Traffic.

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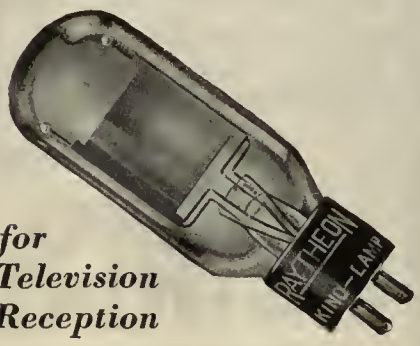
(Radio Broadcast 4-29)

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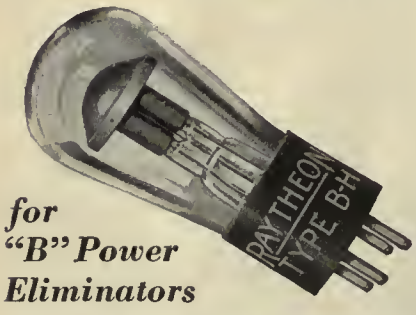


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The *Radio Broadcast* LABORATORY INFORMATION SHEETS

By HOWARD E. RHODES

THE aim of the Radio Broadcast Laboratory Information Sheets is to present, in a convenient form, concise and accurate information in the field of radio and closely allied sciences. It is not the purpose of the Sheets to include only new information, but to present practical data, whether new or old, that may be of value to the experimenter, engineer, or serviceman. In order to make the Sheets easier to refer to, they are arranged so that they may be cut from the magazine and preserved, either in a blank book or on 4″ x 6″ filing cards. The cards should be arranged in numerical order.

Since they began, in June, 1926, the popularity of the Information Sheets has increased so greatly that it has been decided to reprint the first one hundred and ninety of them (June, 1926-May, 1928) in a single substantially bound volume. This volume, "Radio Broadcast's Data Sheets," may now be bought on the newsstands, or from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Inside each volume is a credit coupon which is worth $1.00 toward the subscription price of this magazine. In other words, a year's subscription to RADIO BROADCAST, accompanied by this $1.00 credit coupon, gives you RADIO BROADCAST for one year for $3.00, instead of the usual subscription price of $4.00.

—THE EDITOR.

No. 273 RADIO BROADCAST Laboratory Information Sheet **April, 1929**

Neutralizing and Compensating R. F. Circuits

PROBABLY two of the most common tasks which servicemen are called upon to perform are the adjustment of the neutralizing and compensating condensers in tuned r.f. receivers. These tasks are exceedingly important although not especially difficult.

If a set is not neutralized properly it will oscillate on some wavelengths, especially down around 200 or 300 meters. Therefore, if a set does oscillate it is necessary to reneutralize the various stages. This should be done in an orderly fashion, starting with the stage nearest the antenna and following with the other stages in order. Also, all servicemen should be equipped to perform these adjustments quickly on all receivers, and in this connection specially prepared tubes of the types used in r.f. amplifiers, the 201A, 226, and 227, are a great aid. These tubes are prepared by cutting off as close to the base as possible one of the filament prongs, in the case of a 201A or 226-type tube, and one of the center prongs in the case of the 227-type tube.

In adjusting a receiver tune-in a strong local station broadcasting on some wavelength between 200 and 300 meters, carefully tuning the dials to exact resonance. Then, with the prepared tube placed in the first r.f. socket in place of the good tube, carefully adjust the first neutralizing condenser to that position which gives the minimum signal from the loud speaker. Then remove the prepared tube, and replace the good tube. Now put the prepared tube in the second r.f. stage and repeat the operation, etc.

The compensating condensers in a receiver are placed across the main tuning condensers and function to compensate the slight differences in capacity between the various stages so that all the tuned circuits will be in exact resonance. Compensation should also be done with the set tuned to some station around 250 meters. When compensating a set it is best to tune-in some weak station, since slight changes in volume will then be noticeable more readily. The exact procedure is as follows. First tune-in a weak signal to maximum volume and then adjust all the compensating condensers to give the maximum signal strength. Retune the main dial to the point of maximum volume and then readjust the compensating condensers again.

No. 274 RADIO BROADCAST Laboratory Information Sheet **April, 1929**

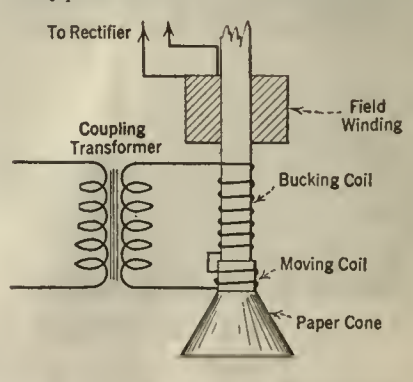
Bucking Coils in Dynamic Loud Speakers

MANY a.c. dynamic loud speakers use "bucking coils" to reduce the hum due to the use of rectified but poorly filtered a.c. to supply the field current. This bucking coil functions as follows.

Referring to the diagram, the bucking coil is connected in series with the moving coil and the secondary of the coupling transformer. The moving coil is, of course, fastened to the diaphragm. The bucking coil is wound around the pole piece of the electro magnet.

Now, since the rectifier supplies to the field a pulsating current, it follows that the magnetic flux produced by this current will also fluctuate. Since the moving coil is in the field of this flux, there will be a reaction between it and the varying magnetic flux and the coil will tend to move—and its movements would have the same frequency as that of the field current. If the diaphragm moves, sound is produced and as a result we would get an audible hum. The effect of the pulsating field current is, however, nullified (more or less) by the bucking coil. The coil is also in the magnetic field and it, therefore, has induced in it a voltage corresponding in frequency to that of the pulsating field current. This voltage induced in the bucking coil sends a current around the circuit consisting of the transformer, the moving coil, and the bucking coil. The magnitude of this current is such that its effect on the moving coil is equal and opposite to that produced directly on the moving coil by the flux. Since the two effects are equal and opposite they nullify each other and the hum is prevented.

It is evident that the important thing is to get into the moving-coil system a voltage that will nullify the forces tending to make the coil move and thereby produce hum.



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baffle boards will not vibrate at any audible frequency or produce any resonant effects.

Celotex will also prevent reflection of sound waves.

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HELPFUL TECHNICAL INFORMATION

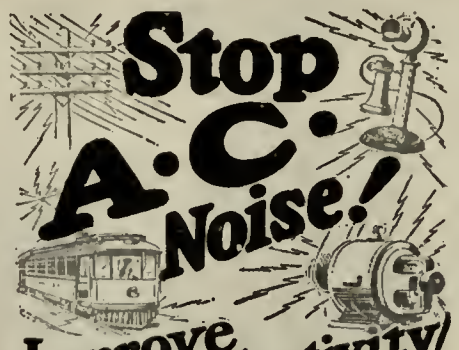
A regular feature of RADIO BROADCAST is the series of Laboratory Information Sheets, which cover a wide range of information of immediate value to every radio worker, presented in a form making it easy to preserve them. To insure your having every issue, send your check for $4.00 for one year's subscription to

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ROBERT S. KRUSE

Consultant and Technical Writer

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and that is just what it is—a well organized department of our business just to help you. We make no charge for this service it is freely given with Amplion's compliments and a background of 42 years of success in the acoustic field.

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2-stage (210 tubes in P.P. in last stage) (17x14x9)	125.00
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Cabinets contain 2 turntable electric motors, Amplion electric pick-up and control board for fading one piece of music into another, or making instantaneous switches.

P.M.S. 2 std. (30x40x46)	$300.00
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Write for profitable Amplion proposition to competent Engineers

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Back in April 19 28!



CeCo Announced This Type AC-22 Screen Grid Tube

Five prong tube of the separate heater type operating directly on alternating current.

—now recognized as the most outstandingly successful amplifying tube of the season.

CeCo pioneered—and did its pioneering without the fanfare of trumpets. But it is pleasing to know that an increasing number of radio engineers and experts look with confidence to the CeCo laboratories for each new development in the tube industry...a reward not measured in dollars and profits.

Do not miss CeCo's entertaining radio broadcast each Monday evening at 8:30 Eastern time (7:30 Central time) over the Columbia Broadcasting System.

CeCo Mfg. Co., Inc., Providence, R. I.

CeCo Radio Tubes

No. 275 Radio Broadcast Laboratory Information Sheet **April, 1929**

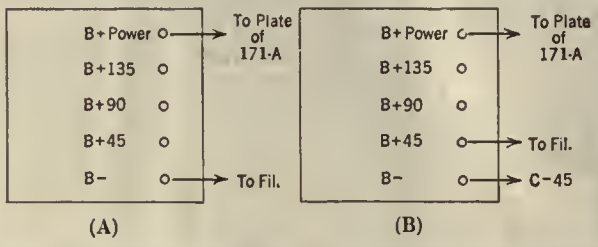
Obtaining Grid Bias from B-Power Units

BOTH B and C potentials for a 171A tube may be obtained readily from a simple B-power unit without adding any resistors or condensers to the circuit; it is simply necessary to change a few connections.

Sketch A on the sheet shows an ordinary B-power unit and the connections which would be made to it if it were to supply only plate potential to the 171A power tube. Sketch B shows the connections if it is to supply C potential as well.

In these diagrams it should be noted that the connection of negative filament from the regular B-minus terminal on the power unit has been changed to the + 45-volt terminal. With this arrangement the + 45-volt terminal then becomes B minus, the plus 90 volt terminal becomes plus 45 and so on, each terminal supplying 45 volts less than it is marked. The regular B-minus terminal is now 45 volts lower in potential than the new B-minus terminal, and, therefore, from the regular B-minus terminal we are able to secure a negative potential of 45 volts which we can apply to the grid of the 171A-type tube. In this way we have, by a simple circuit change, made it possible to obtain C bias for the power tube.

Forty-five volts is slightly higher than normal, but not sufficiently so to affect seriously the output from the tube. This slightly higher than normal bias will help to lengthen the life of the tube.



The arrangement described above can be applied only to those B-power units capable of supplying under load a maximum of about 225 volts. This much voltage is necessary because 180 volts are required on the plate and 45 volts are used to supply C bias. With this arrangement 45 volts are obtained from the tap that normally supplied 90 volts and 90 volts are obtained from the tap that ordinarily supplied 135 volts.

No. 276 Radio Broadcast Laboratory Information Sheet **April, 1929**

Simple Two-Way Telephone Set

IN THE country friends who live some miles apart often wish to establish a telephone communication channel without the expense of installing a regular pole line. Lieutenant W. H. Wenstrom, U. S. A., suggests the following simple method of building such a communication system.

As can be seen from the diagram given in Laboratory Sheet No. 277 the set is simplicity itself. It is essentially a radio receiving tube (a 199-type tube is satisfactory) provided with input and output transformers. The best ratios are somewhere around 1:6 for the input and 3:1 for the output. The microphone may be an old, discarded telephone "mike."

Two sets are, of course, required for one communication channel. Due to the economy of apparatus, radiophone practice must be used in operation. A definite time for communication is arranged in advance. At this time "A" calls and "B" listens. When "A" finishes calling, both operators throw their switches, and "B" then answers "A." The procedure might be compared to two unusual people carrying on a conversation where each one politely waits until the other has finished before he himself begins.

Because two stages of audio-frequency amplification are used in the talking circuit, one at the sending end and one at the receiving end, the connecting wire line may be very much poorer than a standard telephone line. Continuous fence wire, or any medium-resistance metal circuit fairly well insulated from the ground may serve as one conductor, with the ground as the other conductor.

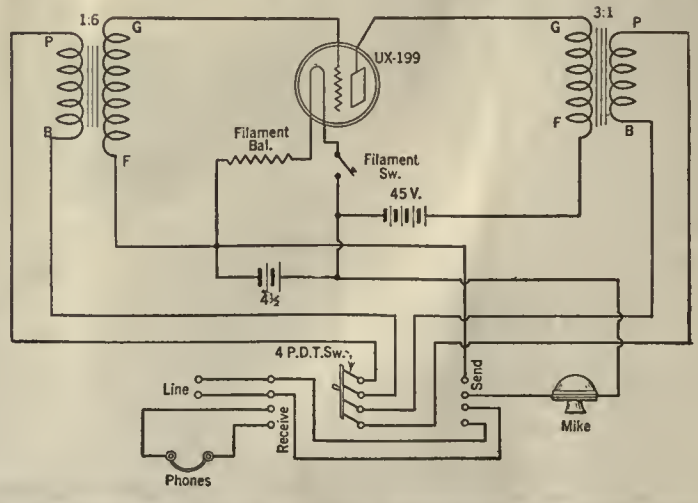
Parts Required

1 Audio transformer, 6:1-ratio
1 Audio transformer, 3:1-ratio. (connected reversed)
1 Four-pole double-throw switch
1 Microphone, telephone-type
1 Pair of headphones
1 199-type tube and socket
A battery, fil. ballast and fil. switch
B battery, 45 volts

The four-pole double-throw switch changes the set from "send" to "receive." It saves expense by permitting the use of the same tube and transformers for both operations.

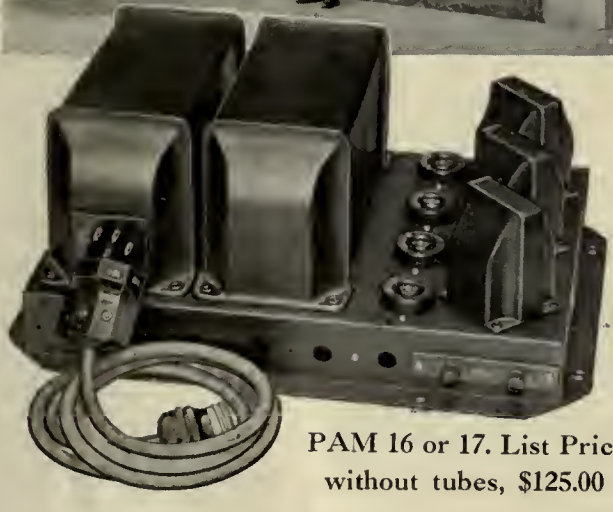
No. 277 Radio Broadcast Laboratory Information Sheet **April, 1929**

Simple Two-Way Telephone Set









PAM 16 or 17. List Price without tubes, $125.00

The installation, the dealer and the PRODUCT

Foreseeing the business possibilities of educational broadcasts, Harold Batchelder, proprietor of the Garden City Radio Company, Newtonville, Massachusetts, installed in the Frank A. Day Junior High School, Newtonville, a receiving set and "PAM" amplifier, which proved to be the forerunner of many other school installations he has made.

Other radio dealers have foreseen the possibilities of "PAM" amplifiers not only for this use, but for many other purposes, and are working hard on this *profit-making non seasonal item.*

What do you foresee?

The PAM-17 is identical with the PAM-16 except that it furnishes in addition field current for a dynamic speaker designed to have its field energized by 90 to 165 volts direct current. For all other types of speakers, including dynamics, having their field energized from storage battery or AC 110-volt, 60-cycle, use the PAM-16. Both amplifiers are designed to operate from 105 to 120 volts, 50 or 60 cycles AC.

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RADIOTRON UX-200-A
Detector Only

RADIOTRON UX-120
Power Amplifier Last Audio Stage Only

RADIOTRON UX-222
Screen Grid Radio Frequency Amplifier

RADIOTRON UX-112-A
Power Amplifier

RADIOTRON UX-171-A
Power Amplifier Last Audio Stage Only

RADIOTRON UX-210
Power Amplifier Oscillator

RADIOTRON UX-240
Detector Amplifier for Resistance-coupled Amplification

RADIOTRON UX-250
Power Amplifier

RADIOTRON UX-226
A.C. Filament

RADIOTRON UY-227
A.C. Heater

RADIOTRON UX-280
Full-Wave Rectifier

RADIOTRON UX-281
Half-Wave Rectifier

RADIOTRON UX-874
Voltage Regulator Tube

RADIOTRON UV-876
Ballast Tube

RADIOTRON UV-886
Ballast Tube

The standard by which other vacuum tubes are rated

Look for this mark on every Radiotron



ALFRED H. GREBE
President, A. H. GREBE & Co., Inc., says:



"In replacing worn vacuum tubes we strongly advise all owners of Grebe Receiving sets to use RCA Radiotrons. Our laboratory tests have proved that they give the best results with Grebe instruments."

Used for laboratory tests and for initial equipment and strongly recommended for replacement by all makers of quality radio sets, RCA Radiotrons will improve the reception of your set. When you need new tubes do not put them in with old ones. Put a new RCA Radiotron in every socket and notice the difference in performance.

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Make the occasional tube customer a regular by showing him that you carry the full line of RCA Radiotrons —and are never out of stock. A radio customer who has had to waste his time shopping from dealer to dealer for tubes is glad to find a store that can always be depended upon to be stocked with the complete line of RCA Radiotrons.



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