APRIL 26th 1930

15 Cents Per Copy

# RADIO WORLD

REG. U.S. PAT. OFF.

The First and Only National Radio Weekly

*422nd Consecutive Issue—NINTH YEAR*

RF Gain Debated

What Selectivity Is *Not.*

Do Sidebands Exist?

Dynamic's Theory

Six-Circuit Tuner

# Use of Tube for Accurate Matching of Parts

RADIO WORLD, published by Hennessy Radio Publications Corporation. Roland Burke Hennessy, editor; Herman Bernard, managing editor and business manager, all of 145 West 45th Street, New York, N. Y.

# Long Distance Reception Guaranteed!

The Balkite A5 neutrodyne, in real walnut table model cabinet by Berkey & Gay. Volume control at left, AC switch at right, drum dial at center, with space to mark in call letters.

You want DX—the more DX the merrier! But why take any chances? We positively guarantee that the Balkite Neutrodyne, made by Gilfillan, will get you all the DX you could desire! Try the set for five days. If not completely satisfied, return it in that time for prompt refund of purchase price!

Three stages of tuned RF, neutralized, so there's no squealing; easy tuning; operation on short piece of wire indoors perfectly satisfactory; no repeat tuning points; no hum; phonograph pickup jack built in; excellent tone quality; good selectivity. These are outstanding points of the receiver, ONE OF THE MOST SENSITIVE BROADCAST RECEIVERS EVER DEVELOPED. The receiver alone lists for $135. Here you get the set, speaker and tubes at $9.50 less than half the list price of the receiver alone!

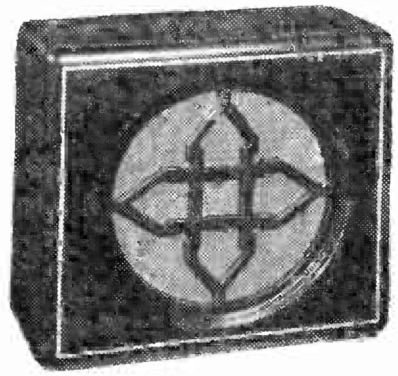
## 8-Tube Push-Pull AC Balkite Neutrodyne with Matched Speaker and All Tubes, Complete . . . . . . . . . . . $57.50

A good many bargains in radio receivers are available today, because set manufacturers overproduced, and had to let their stock go at sacrifice prices. It does not follow that all sacrificed receivers are worth even the cut price. We turned down many "opportunities" to obtain large quantities of "sacrificed" receivers. When the Balkite was offered to us we tested its performance for five days and were delighted. We took the set apart completely to see what calibre of parts was used and how the wiring was done. When we tell you all the parts were ace-high and the wiring the best we've seen, you will know this is an extraordinary receiver. The tubes used are five 227, two 112A and one 280. The undistorted maximum power output is 780 milliwatts.

The line input must be 50-60 cycles, 105 to 120 volts. There is a voltage adjuster built in. The magnetic speaker has a matched impedance for the output of the receiver, and is itself housed in a real walnut cabinet with marqueterie inlay.

Receiver, in cabinet, less tubes and speaker, $46.00

FIVE-DAY MONEY-BACK GUARANTEE ON RECEIVER, TUBES AND SPEAKER!



The speaker is of hand-rubbed genuine walnut and its list alone is $35.00.

**Guaranty Radio Goods Co., 143 West 45th Street, New York, N. Y.**

---

### NEW DRAKE'S ENCYCLOPEDIA

1,680 Alphabetical Headings from A-battery to Zero Beat; 1,025 Illustrations, 920 Pages, 240 Combinations for Receiver Layouts. Price, $6.00. Radio World, 145 W. 45th St., N. Y C.

### MICROPHONE LIGHTERS

For cigars or cigarettes, with button switch at top. Press switch, and lighter acts instantaneously. $1.00. Model B lighter on tray, $1.50. Radio World, 145 W. 45th St., N. Y. C.

### LOOK AT YOUR WRAPPER

You will see by the date thereon when your subscription for Radio World expires. If the subscription is about to run out, please send us renewal so that you will not miss any copies. Subscription Department, RADIO WORLD, 145 West 45th St., N. Y. City.

### TWO FOR PRICE OF ONE!

Radio World, 52 issues, and Radio News, 12 issues, in combination for special $7 subscription price. Radio World, 145 W. 45th St., N. Y. City.

## Two for the price of *One*

**Get a FREE one-year subscription for any ONE of these magazines:**

- ☐ CITIZENS RADIO CALL BOOK AND SCIENTIFIC DIGEST (quarterly, four issues).
- ☐ RADIO (monthly, 12 issues; exclusively trade magazine).
- ☐ RADIO ENGINEERING (monthly, 12 issues; technical and trade magazine).
- ☐ RADIO INDEX ((monthly, 12 issues) Stations, programs, etc.
- ☐ SCIENCE & INVENTION (monthly, 12 issues; scientific magazine, with some radio technical articles).
- ☐ AMERICAN BOY—YOUTH'S COMPANION (monthly, 12 issues; popular magazine).
- ☐ BOYS' LIFE (monthly, 12 issues; popular magazine).

Select any one of these magazines and get it FREE for an entire year by sending in a year's subscription for RADIO WORLD at the regular price, $6.00. Cash in now on this opportunity to get RADIO WORLD WEEKLY, 52 weeks, at the standard price for such subscription, plus a full year's subscription for any ONE of the other enumerated magazines FREE! Put a cross in the square next to the magazine of your choice, in the above list, fill out the coupon below, and mail $6 check, money order or stamps to RADIO WORLD, 145 West 45th Street, New York, N. Y. (Just East of Broadway).

**DOUBLE VALUE!**

Your Name ................................................

Your Street Address ................................................

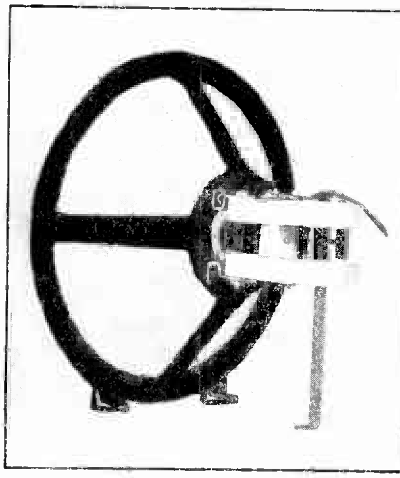
City ................................................ State......................

☐ If renewing an existing or expiring subscription for RADIO WORLD, please put a cross in square at beginning of this sentence.

☐ If renewing an existing or expiring subscription for other magazine, please put a cross in square at the beginning of this sentence.

**RADIO WORLD, 145 West 45th Street, New York, N. Y. (Just East of Broadway)**

## FARRAND INDUCTOR



REQUIRING no source of voltage except that furnished by the receiver itself, the Farrand Inductor gives true dynamic performance. It is one of the most sensitive loudspeakers.

Model 10-G for 171, 171A, 245, 210 or 250 single output tube, or any of these tubes paired in push-pull, where receiver has push-pull output transformer.................$11.50

Model 10-G-CA for 171, 171A, or 245 push-pull, requiring no output transformer, but tipped leads connected direct to plates, yellow center TAP lead to B+.............. 12.50

Model 6-G (slightly smaller, otherwise same as 10-G)................................ 8.00

Model 6-G-CT (slightly smaller than 10-G-CT)................................ 11.00

Model 6-R for 112 or 112A single output or 112A push-pull where receiver has output filter................................ 8.50

Model 6-R-CT for 112A push-pull, requiring no output filter................................ 11.00

**GUARANTY RADIO GOODS CO.**
143 West 45th St. (Just E. of B'way)
New York City


Vol. XVII, No. 6 Whole No. 422
April 26th, 1930
15c per Copy, $6.00 per Year
[Entered as second-class matter, March 1922, at the Post Office at New York. N. Y., under act of March, 1879.]

Latest Circuits and News
Technical Accuracy Second to None
NINTH YEAR

A Weekly Paper published by Hennessy Radio Publications Corporation, from Publication Office, 145 West 45th Street, New York, N. Y.
(Just East of Broadway)
Telephone, BRYant 0558 and 0559

RADIO WORLD, owned and published by Hennessy Radio Publications Corporations, 145 West 45th Street, New York, N. Y. Roland Burke Hennessy, president and treasurer, 145 West 45th Street, New York, N. Y.; M. B. Hennessy, vice-president, 145 West 45th Street, New York, N. Y.; Herman Bernard, secretary, 145 West 45th Street, New York, N. Y. Roland Burke Hennessy, editor; Herman Bernard, business manager and managing editor; J. E. Anderson, technical editor

# What Selectivity Is Not

## Dial Indication a Poor Criterion of Discrimination

*By Percy Warren*

IN the operation of a broadcast receiver all that is required, as to selectivity, is that the set tune in the desired station to the exclusion of all other stations. This exclusion refers particularly to stations on channels near the one desired and also to very powerful locals that may be several hundred kilocycles removed. When both these requirements are satisfied the listener is satisfied, for he does not suffer interference. However, both requirements are in fact the same requirement. There is no difference between the ability to put an effective damper on a station 300 kilocycles off resonance, that has an enormous field strength about the receiving antenna, and to tune out a station of small field strength that is only 10 kc off resonance.

The usual method used by listeners at large to determine whether a set is selective is to turn the dial. In these days of single dial sets the test seems easy. Tune in, turn and watch how many degrees are required to tune out a strong local and restore silence. Even two receivers are compared in this way, as to their selectivity.

### Without Benefit of These

While the method has its uses, in that it affords some indication under proper conditions, without resort to measuring devices both costly to obtain and inconvenient to carry, its weakness lies in the fact that the test is made without regard to the field strength of the station used as test, or the amplification property of the receiver.

If a given field strength were used in each instance, and the same amplification prevailed in all receivers tested, the visual method would be acceptable, provided one were assured that the tuned circuits were properly equalized. A very superior receiver that had one of its capacity compensators knocked out of adjustment in shipment would make a poor showing indeed when compared to an inferior receiver that had the benefit of original line adjustment being retained.

As a visual indication, as obtained in general practice, has little or no real value, so the statement that a receiver has a degree of selectivity, expressed as "very high" or "great" selectivity, has little or no significance. How high? How great? Selectivity can not be expressed verbally in height or greatness. It is most conveniently shown by a curve, and comparisons between receivers effected by superimposing the curves for the *same* input.

One method of stating selectivity in relative values is to divide the inductive reactance by the resistance, but who will know offhand what the inductive reactance is, much less the R.F. resistance? Therefore selectivity can not be simply told in words, only in diagram. We have to discuss in words a subject that does not lend itself very well to that treatment.

### Some Sidelights on Selectivity

Selectivity is not only the ability of a receiver to receive anyone particular frequency to the exclusion of all other frequencies, for if that were true the selectivity of most receivers would be nearly zero.

Operate a receiver on the peak of a mountain, 500 miles from the nearest broadcast station, and enjoy what is termed 10 kc. separation, for indeed all stations are separated, even those 10 kc. apart, without a trace of interference. The receiver has some selectivity, to be sure, but it does not have to meet the burden of large differences, with high maxima, in the energy delivered to it by the antenna-ground system. The field strength of all received stations is tiny indeed, and the receiver can reach out to almost incredible distances if it is fairly sensitive, e.g., 10 microvolts

Move this receiver to a location twenty miles outside of New York City. At once WOR, formerly tuned in and out within one division of the dial, overrides ten divisions, and WABC does likewise, so that one station about three-quarters of the way up on the dial, and another half way up, blanket distant stations for as much as 200 kc. apiece, at the extreme, and the receiver seems to have suffered greatly from the rigors of the journey. Yet the receiver has not changed at all. It used to have "10 kc. selectivity" and now it has only "50 kc. selectivity," the owner may tell you, but if he makes such a statement he is drawing on his imagination and psychology to cover up a lack of understanding of the real situation.

### Down to "O kc Selectivity!"

Now move the receiver to the same building in which one of the large metropolitan stations has its antenna. Lo and behold! The station with its aerial on the roof comes in literally all over the dial, and when that station is on the air, no other station can be received! The former "10 kc. selectivity" seems to have become "0 kc. selectivity," and yet the receiver is just as selective in one place as in another, and nothing has been changed in any particular whatsoever except the input as derived from the aerial.

In the example of "0 kc. selectivity" the vicious condition of the station on the roof coming in all over the dial may prevail even when no antenna or ground is used, but of course the coils of the receiver and the wire used to make the connections from part to part act as loops and capacity aerials, so there has been a mere substitution of the form of pickup that produces the ultimate response.

The receiver may be compared to a person who is far-sighted. Put a test chart 10 feet away from him and he may not be able to read the smallest letters, but move the chart 20 feet farther away and his vision will separate the smallest letters. The smallest letters have too strong a field of energy for his eyes to be able to select letter from letter to constitute a readable sequence. Move the chart farther away, and the input is lessened, whereupon his selectivity in vision becomes effective. He ceases to be subject to visual blanketing.

### Relationship of Sensitivity

So when we are told that a receiver has a certain selectivity rating, we must be told the energy input, otherwise the rating lacks significance, or where comparisons are made, they must be for the same input, as in curves.

Hence, reports on receiver performance in different parts of the country and under totally different geographical conditions, not to mention weather and humidity, will vary greatly, although exactly the same receiver may be used on all tests.

There is a relationship between sensitivity and selectivity that is of the utmost importance.

Consider the three-circuit tuner, used for operating a one-tube set. Use earphones. You need an external aerial to be able to hear signals. You may need an excellent ground and a long aerial to be able to hear a considerable number of stations loud enough to afford enjoyment. Disconnect the aerial and you hear no stations. Add two stages of audio frequency amplification and hook up the loudspeaker. Given stations may occupy a wider stretch on the dial. With aerial off, still you hear no signals. The best you can do is to produce a squeal now and again, but never can you resolve those squeals into reproduced signals.

Add a stage of tuned radio frequency amplification. Now you can get a faint audible response from the loudest station without

(*Continued from preceding page.*)

Add another stage of TRF. The pickup without antenna or ground connected is large enough to afford fair volume on a few locals.

You have been increasing the sensitivity as you increased the stages of radio frequency amplification. Have you been increasing the selectivity at as fast a pace? No.

There is a strong companionship between sensitivity and selectivity. As the radio frequency amplification is increased, the necessity for greater selectivity arises, principally because of the characteristics of the loudspeaker and the human ear

### Where Speaker and Ear Come In

Let us return for a moment to the visual indication as afforded by the receiver's tuning dial as a basis of selectivity judgment. In the example of the one-tube set the strongest receivable station, let us say WOR, comes in at 65, at 60 and 70 can not be heard at all. Compare this with a receiver having three stages of screen grid radio frequency amplification and detection. Exactly the same dial result may obtain—five divisions on either side of resonance will get rid of the strong local. Now, is the one-tube set just as selective as the screen grid set, and if not, why not?

Loudspeakers do not respond to every feeble impulse, nor does the human ear so respond. It takes a definite quantity of sound to actuate the ear. This is called the threshold of hearing. So first the reproducer's threshold has to be attained and the speaker's radiation has to be large enough to reach the minimum realm of registration of the ear. It used to be thought that the limitation existed in the detector tube—that a certain quantity of input was required to make the detector detect—but we have since come to respect the vacuum tube as an instrumentality far superior in keenness to the human ear, and we assign the limitations to the sluggish loudspeaker and the sluggish human ear, undependable and inaccurate instruments both!

### Brought Up to Ear Detecting Point

Receivers therefore are directly connected to a loudspeaker and indirectly connected to human ears, and any system of interference, because impulses too insignificant to move the speaker, hence gain any aural response, become magnified to the point of speaker reproduction and audibility. Therefore if the amplification increases at a faster pace than the selective ability, the receiver with multitubes will give as "broad" a dial indication as the one-tube set, however, the volume will be enormously greater.

Now suppose interference suffered from a multi-tube receiver is rather severe, such a cross-talk, and we want to make some makeshift comparison between this set and the one-tube design. Since both now bring in that pernicious local over 10 degrees of the dial, both receivers are equally non-selective, it seems, although this seeming is about to come to an end.

Let us reduce the output volumes to the same level, not by putting a resistor in series with the speaker, but by putting a condenser in series with the antenna, a tiny condenser, say, .00005 mfd. Assume the output values, in quantity of signal, are the same. Now let's see. Why, the multi-tube set is indeed more selective than the one-tube set, and even the dial indication shows that. The big receiver not only tunes out that powerful local nicely, but effaces it completely within one division of the dial, just as was done on the mountain-top!

### Conclusions Reached

These considerations have been presented thus far:

(1)—Receivers equal in selectivity will have unequal discriminating ability at unequal field strengths.

(2)—Greatly increased sensitivity requires a relatively greater selectivity to retain the original degree of segregation, because the amplification increase will apply to adjacent frequencies, and introduce interference into the audibility region, whereas it was formerly present but not audible.

(3)—Audio frequency amplification tends to decrease the apparent selectivity, since without benefit of selectivity it increases the amplitude of interfering signals possibly to the point of audibility, where the interference was inaudible before.

(4)—The total volume of the output is to be considered in connection with any visual dial tests of apparent selectivity.

(5)—A receiver has a certain definite absolute selectivity, and this selectivity is independent of the input or output, being the same at maximum input or at zero input, so long as the receiver is in operation. In other words, a receiver's selectivity is absolute, but its apparent selectivity, that which we determine from unscientific eye and ear tests, is relative. Apparent selectivity is a fictitious quantity.

(6)—All receivers receive all frequencies, but the disproportion of response is the selectivity.

### Must Be Carefully Shielded

From these considerations it is logical to draw the conclusion that any receiver that gets outside the bounds of low sensitivity must have its coils shielded, for even the tiny pickup that coils make, due to their action as stray loops, will be enough to gain a response in the speaker. Also, inferior tuning benefit will be enjoyed by the stray pickup because the pickup is accidental, and tuning is intentional, so much of the pickup will escape most of the tuning. It is also logical to assume that a receiver that rates in the ultra-sensitivity class must be shielded even against pickup by the wires used for internal connections, hence a shielding subpanel, with a shield bottom piece, is required. The ultimate test is that the receiver must pick up no signals unless some external aerial is attached to the antenna post, no matter if that aerial be a piece of wire only a few inches long! Every other shielding precaution must be taken, even as to the leads to the caps of screen grid tubes, lest here too we encounter a stray and undesired antenna, or a group of such antennas, enemies of selectivity, all!

---

# Jansky Gives Remedy for Follow-Through Interference

*Prof. C. M. Jansky, Jr., investigating WMCA-WGBS interference in New York City, made several observations, three of which follow:*

Observation No. 7 was made a 5:45 p. m., at a fire station located at 78-80 Main Street, Astoria, New York City. This location is three-eighths of a mile east of WGBS. The intensity from WGBS the next day was found to be 82,500 mv. p. m., that from WMCA 2,300 mv. p. m., the ratio being 35.6. The receiving set in use was a Radiola 18 which, according to information I have received, was manufactured in 1926. The receiver uses three tuned circuits. The coils are shielded but the condensers are not.

Using the antenna as installed it was not possible to receive WMCA without interference from WGBS. However, it is of interest to note that even after I had disconnected both antenna and ground and removed the first two tubes from the receiver, satisfactory reception from WGBS could still be obtained. This proved conclusively that the radio frequency as received was not passing through the various stages of the radio frequency amplifier and therefore the receiving set was not in proper operating condition.

This was the one location at which I was unable to secure reception from WMCA without interference from WGBS. The faults in the receiver as installed or designed were such that they could not be corrected without completely disassembling the set. The Radiola 18 was one of the very first alternating current sets placed on the market and, as I have pointed out, was built over three years ago. However, there is no question but that had this set been up to standard no interference would have been experienced.

Observation No. 8 was made at 8:30 p. m., at the home of B. S. Drew, 31-21 29th Street, Astoria, New York City. No field intensity observations were made at this location which is three-quarters of a mile southeast from the transmitter. The receiving set in use is a Freshman Masterpiece, the first three circuit, single dial receiver manufactured by this company. The receiver uses three tuned circuits, neither condensers nor coils being shielded, and is operated from a B eliminator. This set was manufactured several years ago and in my opinion is far below the average standard of receivers in use to-day.

A type of interference was expected which, since it is rather interesting, I will discuss in some detail. WGBS could be received in great volume. As a dial reading was changed to detune WGBS the signal from WGBS disappeared entirely. However, in tuning in WMCA signals from WGBS would appear simultaneously. The same phenomenon was experienced in tuning in any of the other New York stations even those removed several hundred kilocycles from WGBS. It was particularly noticeable in tuning in WABC operating on 860 kc., separated from WGBS by 260 kc. That is, in tuning in WABC, signals from WGBS would also appear, although at all points between the dial reading for WABC and that for WGBS signals from WGBS could not be heard at all.

I experienced this type of interference in a large number of receiving sets in studies which I made in 1926. Investigation has shown that it is due to the flow of grid current which is produced in the radio frequency amplifier tubes.

It can be entirely eliminated if a grid battery is inserted. It being impossible for me to insert a grid battery in this receiver, I increased the plate voltage to the receiver. This tends to decrease grid current and in fact completely eliminated the interference. Apparently the receiving set had not been used with too low plate voltage. Increasing the plate voltage not only eliminating the interference but gave more satisfactory operation of the receiving set in other ways.

Observation No. 9 was made at 10 p. m., at the home of Mr. Charles Ketcliffe, 2302 29th Avenue, Astoria, New York City. The receiving set in use was a home-made three circuit receiver in which neither the coils nor the condensers were shielded. This set and one set at the home of Mr. Drew may be considered as having selectivity characteristics far below the average. The antenna in used had a length of approximately 50 feet. WMCA could be received without any interference from WGBS whatsoever. This receiver location is five-eighths of a mile east from the transmitter.

# Dynamic Sound Waves

## Complex Pressures Handled in System That Capitalizes the Even Harmonics

By *John C. Williams*

*[The following article is the seventh of a consecutive series on dynamic speakers which began with the March 15th issue wherein "Designs of Dynamic Speakers" was discussed. The pot magnet or field coil, the voice coil and the baffle were treated. The second article, "A Comparative Test of Dynamic Results," appeared in the March 22nd issue, in which comparisons were made between magnetic and dynamic speakers. In the March 29th issue, "Hum Reduction in Dynamic Speakers" was discussed. Reverse wound coils and condenser-choke systems were included. In the April 5th issue, "Wave Forms of Hum Reducers" was the topic. The use of the bucking coil and some remedies for hum were discussed. In the April 12th issue the subject was "Why Coils Have Lag and Condensers Lead." The effect of potential difference in atomic stability was shown. The subject of the article in the April 19th issue was, "What Makes a Dynamic Speaker Sound So Well." The effect of baffles, cone stiffness and dampers were among the mechanical means analyzed.—Editor.]*

SOME sound curves of musical instruments are reproduced herewith. Years ago the importance of the study of sound, while consistently advocated as a profitable branch of study and intensively worked at by some students, was generally more or less neglected by the greater number of students of physics for electrical subjects in general, and only recently has the subject of sound come into its own with the advent of talking movies. Sound measuring problems associated with them, and color features, too, share in the new interest.

There are three types of wave motion, (1) by water, (2) by light and radio and (3) by sound. In the previous article the water waves were used as a basis of analogy mostly, but now we shall describe the *difference* in order to clear up a point.

### Radial Propagation of Water Waves

Water waves are propagated radially outward from the exciting source's axis as a result of an initial depression caused say by a stone dropping in. The stone falls to the bottom of the lake, but the surrounding water tends to *fill the depression* due to the stone's previous displacement, and the water rushes in so fast that the hollow area actually *overflows* momentarily. This requires water which is supplied by the surrounding area.

As the water tends to establish a stable level again the original disturbance travels radially outward in pursuance of this effect of gravitation and the amplitude of the original wave disturbance gradually grows less at a considerable distance radially (as compared to the original amplitude of the wave) and finally dies out, due to the inertia of the water, a considerable time later. Now, if a sound were directed so as to travel through the water, rather than on the surface, the time of transit will be very much less, because the under surface compressibility of water is nil, compared to the compressibility of the surface.

Light and radio waves are essentially electro-magnetic disturbances and are propagated through space by virtue of their effect in displacing the atomic structure of the ether. It will be remembered in this connection that the charge or difference of potential between the terminals of a *charged* condenser was shown to be due to a temporary rearrangement of the constituent parts of the atomic structure of the condenser dielectric. The approximate radial direction of propagation is the natural consequence of energy at high levels seeking a common level.

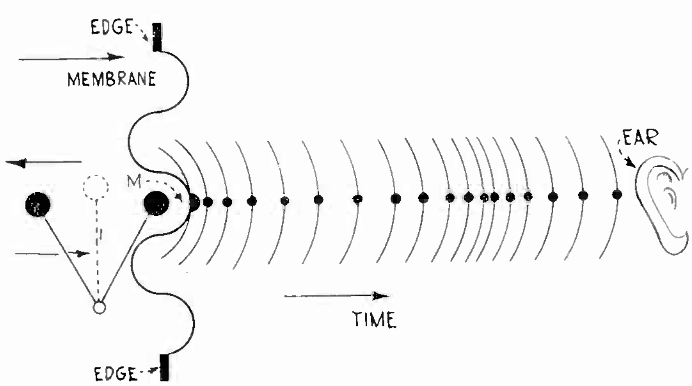



FIG 1
SOUND WAVES MOVE AWAY FROM A VIBRATING MEMBRANE.

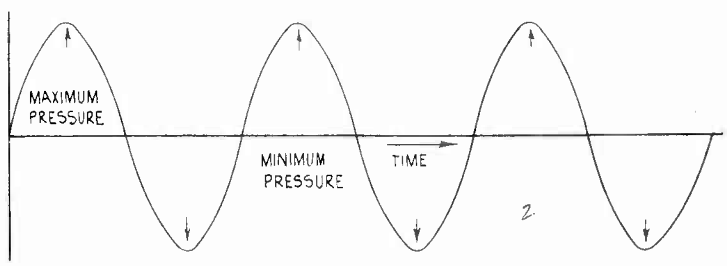



FIG 2
THE CONNECTION BETWEEN SOUND WAVE MOTION IN AIR, AND ITS REPRESENTATION AS A CURVE OF SINE WAVE CONTOUR.

### Pressure Variations of Atmosphere

Sound waves are really nothing more than atmospheric pressure variations, and because increasing air pressures are due to the air being compressed, and decreasing air pressure is due to the air being removed or rarified, the sound wave is said to consist of compressions and rarefactions and these two terms are sometimes condensed to the expression "sound-pressure."

It was seen previously that water waves were an up-and-down motion, but sound waves are a two-and-fro motion, (described last week as a pass-it-along system). The air particles involved in sound wave transmission merely move back and forth as the compressions and rarefactions advance from their source, but it is impossible to make a readily understandable graph of a sound wave by representing the exact state of things, therefore we have to resort to an artifice which while not exact, is a convenient and universally used fiction. So if we look at Fig. 1 we see a sound wave due to a membrane being struck, and the same sound wave again in Fig. 2, with its sine wave counterpart.

Inspection shows that the maximum pressure point of the sine wave curve corresponds to the point on the sound wave representation where the dots (which represent air particles) are closest together. We know that when air particles are closest together the pressure is highest. Thus is the compression. Where they are farthest apart is the point of vacuum or rarefaction, shown by the bottom loops of the curve.

### Lateral Cut and Hill-Dale Records

Now it was previously mentioned that there was a connection between the sine wave outline on a phonograph record and the actual sound wave output of the source, hence if a comparison of the two wave records as detailed in Fig. 2 be made, the connection ought to be apparent. Of course it is understood that between the cut sine wave sound record and sound wave pressure source there is a train of electrical receiving, amplifying and recording apparatus which is incidental to the making of the sine wave sound record. The Victor records are transverse cut (lateral type) and the old Edison cylinder and disk records were vertically cut (hill-and-dale type).

So much for connected ideas in this respect. But we cannot hope always to think and deal with simple sound effects. Progress in this, as with other things, always leads to the necessity of the study of the more complex state of the art and accordingly we must make a resumè of sound quality as applied to people's voices, loudspeakers, or any other two similar sound sources.

By this time it is probably apparent that if we all talked alike a sound analysis of our several voices would look exactly the same, and under these conditions your voice would sound exactly like mine and a third person could not tell who was talking. Now, this would be the case if there were no such thing as sound quality, *i.e.*, it is this quality that makes your voice sound different from mine. Likewise it is the main reason why two loudspeakers normally do not sound alike either. We customarily deal with complex sound waves and the various effects they can be made to produce or reproduce.

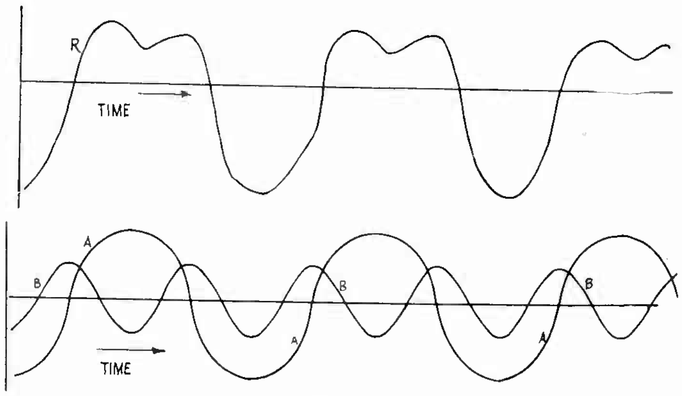



FIG 3
THE COMPLEX RESULTANT OF TWO SIMPLE WAVES. THE UPPER ONE IS THE RESULTANT.

### Overtones Make for Quality

The basis of sound quality, the property that makes one complex sound pleasant to listen to, and another complex sound unpleasant, is the presence of *overtones* (or sound frequencies that accompany the principal sound wave but bear a certain positive or negative relation to it), and their relative amplitude to the fundamental.

Overtones that are pleasant to listen to are those that bear a simple relation to the fundamental, such as all even harmonics. The major and minor chords are whole fractions of the fundamental tone to which they are related. But odd harmonics don't mix well psychologically or otherwise and as a consequence they have no place in symphonic compositions, jazz or pleasant loudspeaker reproduction, but as there is always a use for so-called waste products, so there is for the odd harmonic and they find their best and most forceful expression in the auto horn and other warning devices. A portrayal of sound wave output of an automobile horn was made and proved very jagged.

As non-harmonious sounds are not interesting generally, and their study in relation to what I have in mind not specially useful, at this point I shall return to the subject of complex harmonious tones.

### The Simple Tones Analyzed

Fig. 3 shows two simple musical tones that are sounding simultaneously. The upper curve is what you hear because of the mixture of the two waves below. This is only a single instance of the resultant of acoustic mixture, but represents, in principle at any rate, the additive process by which we hear complex sound effects. The upper curved line is obtained from the lower by adding successive parallel positions of the two curves in the following manner:

Inspection will show that the axis A is common to both sound curves. Now, if I measure the distance of the starting points of curves A and B at similar instants of time along the time axis I will find places where the two curves lie below the time axis, while at other points the curves are above. At still other places there is as much of A curve value below the axis as there is B curve value above.

Now, these pressure changes vary in such way with one another that their combined or resultant effect, as it is called, tends to produce the irregular curve R. The successive points of curve R therefore are obtained by adding up all the plotted values of A and B.

We can start at the extreme left hand end on the curves A and B. Here these are both seen to be below the axis, and since this is so the sum of the two points below the axis gives a single value for the R at the same time, nearly twice as far below its axis (the upper curve). The simplest plan is to divide the two times axes into the same number of equal time intervals by placing dots along each axis to designate the similar instants of time. Then, using a scale graduated in any convenient units of length, the distances of A and B above or below the line can be read easily, and it is necessary to remember only that in places where the A curve is farther below the axis than B is above, the resultant curve position will be below its axis, and in the reverse case, if A curve position at a given time is above the axis farther than B curve is below, the resultant curve position will be above. Thus the addition of these curves is seen to be algebraic and we hear only sound that curve R represents, when the two simple sounds A and B are sounding together.

### Union of Amplexities

I suppose someone will now ask: "What kind of a resultant pressure curve would exist if two complex sound pressure curves were added up?" or, "What would simple and complex sound pressure curves produce when added up?" Each is another of those easy-to-ask and hard-to-answer questions. Since the question is assumed to have been asked, it must be answered.

The resultant of two complex sounds always will be a discord, unless the two complex sounds each contain some simply related harmonics. The second case will produce the same effect as the first moderated by the respective amplitude of the single tone and its harmonic counterpart in the complex wave form.

The addition of sound waves is an everyday occurrence and it is also most natural and therefore the condition under which we transmit and receive sound intelligence. After all, sound wave transmission would be very irksome to listen to if composed of simple tone frequencies alone. In last week's article the influence of harmonics was only briefly discussed but now it can be gone into at greater length.

### Variable Air Column

We talked about the effects that could be obtained with organ pipes. Those were the result of standing waves in an air column. But the air column was fixed and the fundamental tones and harmonics obtainable were directly due to the manner in which the organist caused the pipes to be blown. Let us consider for a moment the case of a variable air column, the slide trombone. Here the sound frequencies are due mainly to the length of the tube, which is controllable. The farther the slide is moved out, the lower the pitch of the emitted sound. The trombone provides a continuously variable source of fundamental tones and usually three *prominent* associated harmonics, all of which are higher than the fundamental. There are lower harmonics, too, but their influence is not as prominent.

Another instrument rich in harmonics is the clarinet. It lends acoustical color and brilliance to an orchestra. The organ was cited previously as a source of simple tones, but this is mainly a property of the larger pipes so blown, that they speak their fundamental. Some organ pipes approach the upper limits of audibility and intervening combinations of pipes are very rich in harmonics also, but organ quality is largely in the hands of the organist, upon whose skill depends whether he pleases you or not, whereas an expert trombonist never can make a poor trombone sound well, as a trombone is not subject to being retuned readily.

The oboe also produces a note of almost sine wave contour, and its quality is very much at the control of the player. Of course this controllability is somewhat necessary whenever any musical instrument is played.

### Components Determined

The analysis of complex sound waves is undertaken when it is desired to investigate and determine the value of components that make up a complex tone. Addition of sound waves, or synthesis,

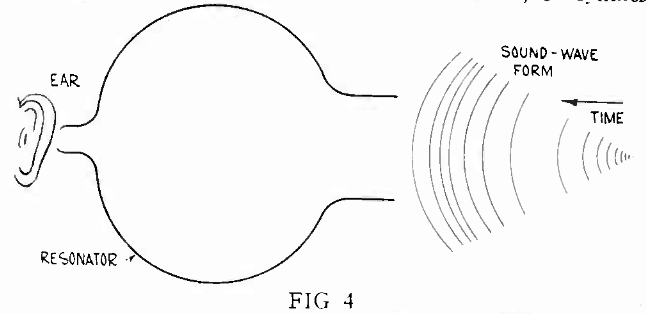



FIG 4
A SECTIONAL VIEW OF A HELMHOLTZ RESONATOR.

is easy, but subtraction, or analysis, is very difficult and lengthy. Some readily understood methods of sound analysis will be presented for the benefit of those to whom this phase of the subject is new.

Fig. 4 shows a section of a semi-spherical hollow light-weight oval ball, with a large opening at one end and a small opening that fits the aural cavity more or less. The air column enclosed by the ball is resonant to a given acoustic frequency. Now, you are supposedly equipped with a number of these "resonators" and you listen to various components of a complex sound wave (provided the selected source is sounding continuously) you can pick out various resonant frequencies. The operation of this device, called the Helmholtz resonator, is not affected by normal differences in the user's hearing, because he is interested only in the relative amplitude, or loudness, of the sound frequency he hears as he listens through the resonator. This is a simple way of demonstrating sound analysis and it depends mainly on the use of a tuned cavity to detect the presence of resonant sound frequencies in much the same way that you tune your radio set to respond to a desired broadcasting station. In truth you are obtaining by analysis the desired frequency from a welter of sound frequencies, as the radio listener selects the desired frequency from those that abound in the ether!

### Harmonic Analyzer

A more exact method of analysis of complex sound wave pressure recordings in sine wave form is the use of the harmonic analyzer. This method is mechanical and depends for its operation mainly upon the experience and skill of the operator and the accuracy of the curve analyzed. Loudspeaker cone responses may be analyzed by mechanical means also, and accurate results obtained, but a more popular method is to measure the sound-pressure where a determination of the amplitude of various cone vibrations is to be studied. This method was outlined in the first article of this series and can be referred to.

A simple and direct way of studying the vibration of a sounding body at constant frequency is to arrange a series of light carbon granule-type microphones in expanding spiro-planar or conical spiro-planar form, and arrange each to be connected to an amplifying device in such order that the microphone nearest the cone center is connected at the extreme right and all the others in succeeding order are situated so that the end of the "line up" is the microphone connection nearest the left-hand end.

This forms a sort of reversed series and if the cone now be placed in vibration and successive readings of the amplified voltage be recorded as ordinates of a curve, a wavy line of voltage variations will result which will mirror the standing waves set up on the cone. The shape of this curved line will determine whether the vibration response frequency of the cone contains harmonics, and if so, whether odd or even. This method does not measure longitudinal waves.

### Flat Surface Radiation

The next part of our story is concerned with the radiation of sound waves by a flat surface. Roughly speaking, flat membranes (or surfaces) when vibrating as shown, propagate sound energy away from the source, and the principal wave front is located on or near the axis of the vibrating portion of the membrane, which is its source. Now, this state of affairs is all right just as long as the plate vibrates under conditions of equal atmospheric pressure (on either side of the plate) and the vibrations set up by the hammer are simple in character, as depicted. But suppose, to begin with, that the plate is vibrated by five smaller hammers instead of the single big one. Will the picture change in any way? To save time I'll say no. But if the plate now be struck on the edge, that is, at right angles to the plane of the paper, the membrane will emit a very different sound. It will be higher in pitch and will seem not to possess the marked planar transmission characteristics that the first system of excitation did.

This is called longitudinal vibration and it can be shown that

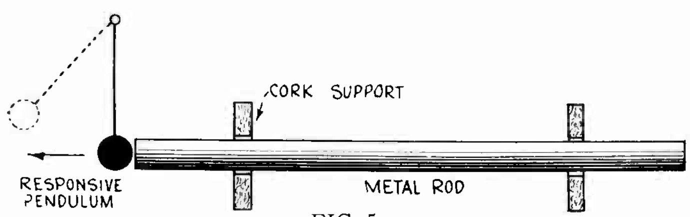



FIG 5
APPARATUS TO DEMONSTRATE THE PRESENCE OF LONGITUDINAL WAVES.

the membrane vibrates in a very peculiar manner when struck in this way.

If a nearly uniform coating of lycopodium powder or fine sand be dusted over the surface of the membrane and then the edge be tapped squarely, the particles will assume a variety of different curves at once, with a small circle in the center, then four irregular lines joining the corners, then four semicircular lines on each edge, then four semicircular lines on each edge are formed.

If the plate be bowed, the plate will be vibrated differently, but the outline of the various lines traced by the particles on the plate never will be remotely outlined like the form of and when the plate is vibrating transversely.

But even though the transverse and longitudinal modes of vibration are so very different, the influence of the longitudinal wave on the quality of reproduction of a speaker cone is not slight, because reflection effects in the cone material produce high frequency background noises and influence the pitch of the speaker, as differentiated by the influence, or distortion, produced by the operating transformer, and the rate of transverse propagation on the cone.

### Longitudinal Pressure Detected

Fig. 5 shows a way of detecting the presence of longitudinal waves in a metal rod. The body of the responsive pendulum is just touching the metal rod, and the rod is securely held between two cork supports, and may be rubbed firmly with a rosin-coated flannel cloth. The rod will emit a high-pitched singing note and the pendulum will vibrate vigorously. Also the rod may be tapped lightly and a direct pulse will travel through. The pendulum will move again. If the bar be given a transverse knock with the hammer the pendulum will not swing, proving that we had end-to-end vibration in the first place.

Fig. 6 shows the material of a speaker cone (greatly magnified) under a condition of vibration. Previous mention has been made of the fact that a speaker was louder in front of the cone than behind but no complete wave form was given. Here it is now. The compressions from various equi-radial points converge to produce a sound image by interference and this resultant wave front seems to come from the apex of the cone, but this is easily seen not to be true, actually. Similarly other parts of the cone produce images seemingly centered on the apex of the cone, and thus the sound waves radiated by a cone give the illusion that the source of sound is the center of the cone. That is, good speakers do. It is one of the problems of the designing engineer to create this property of illusion to its fullest extent.

The effect of longitudinal vibration in the cone is to create the background noises, which are very helpful in creating illusion.

### Measured by Comparison

Perhaps someone will want to ask whether longitudinal sound effects can be measured usefully. They can, but only indirectly, from observations of the transverse radiator. If you could be sure that the cone edges moved outward radially, it would be easy to mount the edge of the cone or microphones (carbon granule type) and see how the registered variations at this edge would compare with those due to the transverse vibrations.

The interesting feature about all sound output measurements in which conical membranes are involved is the great diversity of results obtained, and on this account one can amass a wealth of experience in a very short time. Someone will ask: "Do speaker cones emit simple tones, as for instance, like those of the big organ, when the pipes are blown, so as to sound the fundamental frequency?" The answer is yes. All loudspeakers have a fundamental frequency. In most modern speakers this fundamental is near 100 cycles, although it is not absolutely pure, having weak higher frequency harmonics, or inharmonic higher frequency tones mixed in with it, which vary in prominence according to the amplitude of the fundamental.

The desired loudspeaker is one that will radiate all uniformly-impressed electrical audio frequencies as uniform acoustic frequencies, *i.e.,* will have a flat response output characteristic. The ideal may be approached but never can be attained. Most of us want a lot of *boom* in our speakers, *i.e.,* a large response at between 80 to 120 cycles, and are even willing to forego a certain amount of realism in reproduction by excluding by means of filtering devices all frequencies above 4,000 cycles.

### Listener's Range of Hearing

The audibility range is subject to more than one definition as to its limits but judging by the reactions of some radio enthusiasts, especially as regards their taste in loudspeaker reproduction, their audibility range must be between the points where their hearing is best! It would be very serious for the rest of us if some of these folks were sound frequency censors.

The *energy of harmonics* plays a big role in the analysis of loudspeaker cone output. This topic may be found fully treated in Professor Dayton C. Miller's "The Science of Musical Sounds." This particular curve relates to the analysis of an organ tone produced by blowing a large organ pipe so that it produces a lot of harmonics—the analyzed curves follow below the resultant in numerical harmonic order and the 8th and 12th harmonic are seen to have a very considerable portion of the energy of the whole tone. In a loudspeaker the same thing is true to a degree—except that the harmonic is dictated largely by the period of the associated baffle device—being influenced more by box-like baffles than by large flat boards.

Fig. 7 shows the essential arrangement of a device to project the resultant wave form of the output of a sounding body on a screen. The diagram is practically self-explanatory but a brief resumé will be given.

### How Phonodeik Works

A brilliant source of light (arc light) is placed behind a condenser lens which transforms the radially impinging light rays to parallel rays, and these in turn pass through the lens system and strike a small light-weight mirror, which is rotatably mounted on a light-weight steel pivoted axle. A quartz fibre is attached to the diaphragm and passes around the axle two or three times and is attached to the spring, which places the whole moving system under a slight tension.

The light beam, already focused on the small rotatably mounted mirror, is reflected to the four-sided rotating mirror shown, and this mirror is now started, resulting in an arc of light being projected on the whole screen. Next the organ pipe is sounded by blowing it easily, and the arc of white light on the screen assumes the form of the curve shown in Fig. 2. Thus we can see what our organ pipe tone looks like. Also, tuning forks, violins and voices are easily projected. *(Continued Next Week)*

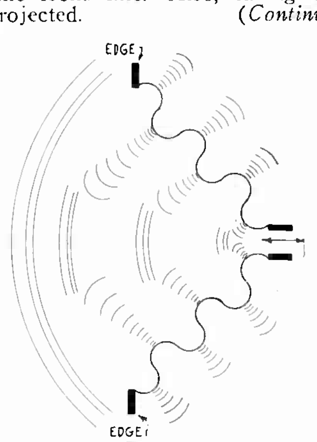



FIG 6
SOUND-EFFECTS DUE TO TRANSVERSE VIBRATION OF A CONE.

# An Accurate Method of Ma

## Vacuum Tube Voltmeter, Much Keener Than Human

By Capt. Peter

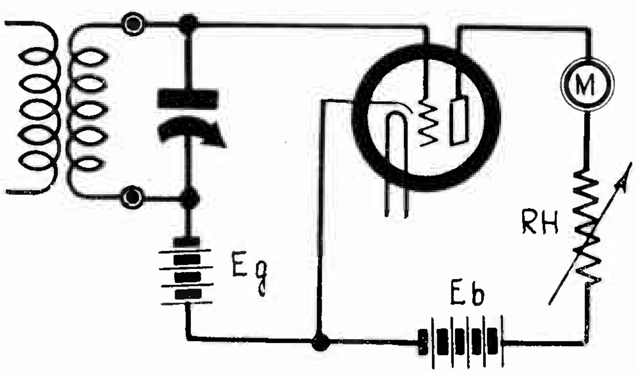



FIG. 1
THE CIRCUIT OF A VACUUM TUBE VOLTMETER THAT MAY BE USED FOR MAKING ADJUSTMENTS OF A CIRCUIT FOR HIGHEST EFFICIENCY. THE TUBE IN QUESTION MAY BE EITHER THE DETECTOR OR THE POWER TUBE.

AMATEUR radio experimenters usually judge the effects of changes in their circuits by ear. That is, if they make any change whatsoever they listen to the effects of *that* change. If the change results in louder response, or better quality, the circuit is left as changed, or it is changed further in the same direction and manner, but if the change results in a weaker sound output, or poorer quality, the circuit is either left in its original condition or a change in it of opposite kind is made. This is the tuning method employed in nearly all instances and it is often used in selecting plate and grid voltages, in adjusting trimming condensers, and in selecting tubes.

This method is all right as long as the changes to be effected are of major proportions. If a change which alters the performance only a little bit is to be made, the ear method of judgment is not sensitive enough because the ear does not possess sufficient resolving power in respect to differences in volume intensity. For example, in many receivers the volume from a particular station appears to be equally strong over several divisions of a tuning dial. Actually, there is one point where it is stronger than at all others, assuming correct and conventional design of the tuner. The object of tuning is to find this point. It cannot be done accurately by ear for the reason just stated.

### Use of Milliammeter

In receivers having grid bias detectors a very keen method of telling which of two adjustments is better is provided by putting a milliammeter in the plate circuit of the detector tube. If the receiver is not of the grid bias type, it is a simple matter to arrange it temporarily so that it works in this way. The circuit arrangement of a grid bias detector with a meter in the plate circuit is shown in Fig. 1, in which M is a milliammeter measuring directly the rectified plate current and indirectly the signal voltage impressed on the grid. The greater the signal voltage impressed on the grid the greater will the deflection on the meter be, assuming that the grid bias has been adjusted to the right value.

In case the detector operates on the grid bias principle the grid battery Eg or an equivalent grid bias resistor is provided and it its not necessary to make any changes in the circuit, except to put the milliammeter in the plate circuit in series with a suitable rheostat Rh to limit the current to a suitable value. The primary of the coupling transformer normally in the plate circuit need not to be taken out, and in some instances it is not necessary to remove a plate coupling resistor that may be in the circuit. However, if the detector tube is followed by a resistance coupling it is well to put Rh in shunt with the coupling resistor.

Eb in the figure indicates the plate battery voltage. Of course, this, too, is provided in the receiver and therefore no special provision need be made.

If the receiver employs the grid leak-condenser method of detection the condenser may be short-circuited and the grid return made to a suitable negative potential. This is most easily provided by a battery Eg.

### How to Use It

It will be recognized that the circuit in Fig. 1 is nothing but a vacuum tube voltmeter. Now if the tube in question is the regular detector in the receiver, that is simply used as a vacuum tube voltmeter. The only difference between this and a conventional vacuum tube voltmeter is that the detector circuit is not calibrated in volts, while a vacuum tube voltmeter is. For the purpose of noting relative effects of changes introduced into a circuit it is not necessary to know what the voltages are, but only to know whether a given change results in a greater or smaller signal voltage on the grid of the detector tube. The greater the deflection on the meter M the higher is the signal voltage on the grid of the tube.

As a test of the effect of the signal voltage on the deflection on the meter M it may be tried on a broadcast station. When the station is not tuned in the deflection on the meter is very small, and it should be adjusted by means of Rh so that it is. Then when the station is tuned in the deflection increases to a certain maximum. As the circuit is detuned by turning the condenser in the same direction the deflection again goes down to a very small value. This experiment may be done while listening to the station. This will give a striking comparison between the volume of sound and the deflection of the meter.

Having established the correspondence between the deflection of the meter and the intensity of the signal voltage on the grid of the detector tube, we are ready to make use of the meter to stablish which of two adjustments is the better. For example, it can be used to find the exact tuning point, which cannot be done by listening alone.

Suppose that the circuit has been tuned in accurately on a given station by this method and it is desired to find what grid bias on the radio frequency tubes will give the greatest response. The bias is simply changed by definite voltage values, say 1.5 volts at a time, and the meter is observed for the greatest deflection. That which gives the greatest deflection is the bias that gives the greatest amplification. This does not necessarily give the final adjustment, however. for there are other factors entering into the choice of bias.

### The Best Screen Voltage

In the same manner the best screen grid voltage can be found by varying the voltage applied and observing which gives the greatest deflection on the meter M. Of course, it is understood that the tuning should not be changed while an observation is in progress, and also that the strength of the signal from the station should not vary. It would not do to tune in on a distant station subject to fading, for entirely wrong conclusions might be reached, if any at all.

The effect of changes in the plate voltage on the amplification can be determined in the same manner, qualitatively.

The effect of shielding on the amplification can also be studied by means of this instrument, although this is a little more complex, because when a shield is removed or installed the circuit involved is detuned. The circuit then would first have to be tuned in accurately with the shield off and the deflection on the meter M noted. Then the shield should be put on and the circuit again tuned in accurately, with the aid of the meter, and the deflection again noted. Comparing the deflections obtained when the shield was on and off gives a relative estimate of the effect of the shielding.

When the receiver is gang-tuned it is necessary to tune the circuit from which the shield is removed separately because otherwise spurious results will be obtained.

Still another application is to the determination of the effect of coupling between the primary and secondary windings in a radio frequency transformer. For example, the first observation may be taken when the primary has a large number of turns. Then the turns may be removed, five at a time or so, and an observation taken at each time. As a rule, there will be a greater deflection for one combination of turns than any other. This experiment should be conducted on a broadcast frequency in the middle of the band, say 950 kilocycles.

### Uncertainty of Signal

There is one disadvantage of using a broadcast signal as a source of voltage when making these tests, and that is its continual variation due to modulation. The time to take an observation is when there is no sound, or when the carrier is unmodulated. This, however, does not occur often nor for any length of time when it does occur. If one had to wait for unmodulated signals it would take a long time to make a series of tests. Therefore it is preferable to provide a local signal, which may be done by setting up a small oscillator and coupling it loosely to the input of the radio receiver, or the apparatus under test. The circuit diagram and its design constants are given in Fig. 2.

While the signal from this oscillator may vary a little, it will remain fairly constant if the filament, grid and plate voltages are kept constant during a run and if the coupling between the oscillator circuit and the receiver is maintained the same throughout. Moreover, it will be unmodulated, which is important.

The method described here for determining the intensity of the

# king Receiver Adjustments

## Ear, Enables Precise Alignment of Gang Condensers

*V. O'Rourke*

signal voltage at the detector is especially suitable for adjusting the trimmer condensers on a gang-controlled receiver. First, the receiver is tuned in as accurately as possible, using the meter as a guide. Then one of the trimmer condensers is adjusted until the deflection on the meter is as high as it can be made by adjusting this condenser. Then the next condenser is adjusted in the same way, and so on until all the trimmers have been adjusted. It will be found that the deflection can be increased greatly by trimming up the circuit in this manner. It should be remembered that the greater the deflection the more sensitive the receiver will be, because the deflection is a direct measure of the intensity of the audio output of the detector.

### Audio Measurements

While the detector in the receiver can be used as vacuum tube voltmeter for measuring the effects of changes in the circuit ahead of that tube, it cannot be used for measuring effects of changes in the audio amplifier, but the method is applicable to the audio amplifier as well, because it is only necessary to convert the power tube to a vacuum tube voltmeter. The simplest way of doing this is to connect the milliammeter, in series with a high variable resistance, in the plate circuit of the output tube and changing the grid bias until practically no plate current flows when no signal is being impressed on the grid to the tube.

When measurements are made on the audio amplifier a broadcast signal cannot be used because the audio component will vary from zero up to rather high values without any consistency. Neither can the local radio frequency oscillator be used because that would not yield any audio signal voltage. However, two radio frequency oscillators such as that shown in Fig. 2 can be used, provided that they are adjusted to slightly different frequencies, to provide an audio signal of constant amplitude. If it is desired to run a performance curve, it may be done, but in this case the radio frequency oscillators as well as the vacuum tube voltmeter should be calibrated.

### Precautions Unneccessary

In adjusting either the detector or the output tube to be a vacuum tube voltmeter precautions are necessary to prevent damage to the meter in the plate circuit. In the first place, the resistance in series with it should be so high at the beginning that no damage can occur even if the grid bias on the tube has not been made greatly negative. Then the bias should be increased until practically no current flows. It is necessary that the bias be so high that the tube is operated near the plate current cut-off point, for only there will the tube function effectively as a rectifier of the signal voltages applied to the grid. A little experimenting will show the bias that will cause the greatest change in the plate current when a given signal voltage is applied, and that is the bias to be sought.

When only small changes in the signal voltage are expected the resistance in series with the milliammeter may be made smaller so that small signal voltage changes will produce large changes in deflection of the meter. If it takes a change of several volts to change the deflection of the meter from its zero setting reading to full scale reading, this method is not much more sensitive than the ear, and therefore such an adjustment of the grid bias and the variable resistance should be avoided when accurate adjustments of the circuit are to be made.

The value of the resistance Rh depends on the tube used as voltmeter on the plate voltage applied, and on the sensitivity of the meter M. Suppose the meter has a range of 0-1 milliampere and the total voltage in the circuit is 180 volts, the resistance in the circuit cannot be less than 180,000 ohms. Of course, the portion of the resistance used will not be so high because the internal resistance of the tube will be high when the proper bias has been found.

In the case of a 227 tube with 180 volts in the plate circuit the proper bias for most effective detection is about 24 volts. In the case of a 245 power tube with 250 volts on the plate the proper bias for detection or voltage rectification is about 70 volts. With these voltages applied to the grids the resistance in series with the meter may be reduced considerably without danger.

### Other Meters Applicable

While it is desirable to use a meter of 0-1 milliampere sensitivity less sensitive meters can also be used. It is only necessary to use a lower resistance in series with it. For example, a 0-5 milliampere instrument can be used successfully. For this meter the maximum value of the resistance might be of the order of 50,000 ohms. It is also possible to use a low range voltmeter in place of the milliammeter because a voltmeter is nothing but a milliammeter with a resistance built in. The external resistance in that case, of course, would be less than when a milliammeter is used. The total resistance of a voltmeter is the product of the ohms per volt and the voltage range of the meter. For example, if the resistance per volt is 2000 ohms and the range of the meter is 0-7.5 volts, the total resistance is 1,500 ohms.

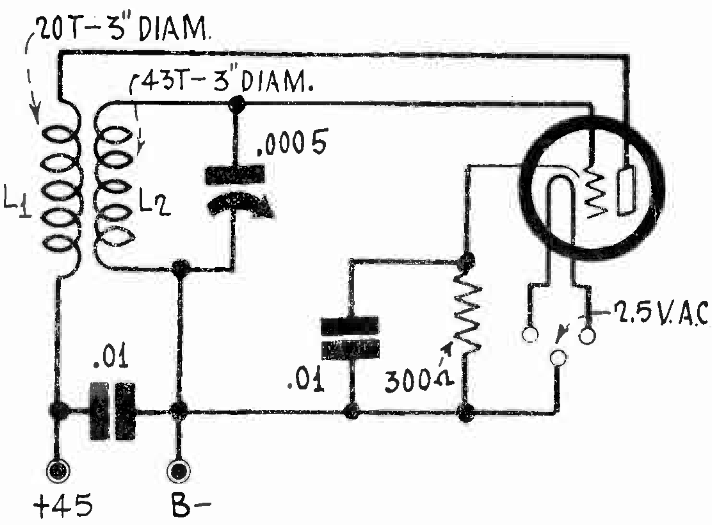



FIG. 2
THE CIRCUIT OF A RADIO FREQUENCY OSCILLATOR THAT MAY BE USED FOR SUPPLYING THE UNMODULATED SIGNAL VOLTAGE NEEDED FOR MAKING MEASUREMENTS WITH THE VACUUM TUBE VOLTMETER.

# *Current Drain Heaviest by Far for Power Tube*

The design of modern sets is such that the current drawn by the detector and voltage amplifier is almost negligible in comparison with the current drawn by the power tube. A 245 tube, for example, takes normally a current of 32 milliamperes. The remaining tubes take an average of 3 milliamperes or less per tube. It would require 10 voltage amplifier tubes at this rate to draw a current equal to that drawn by the power tube. If the power pack operates at 80 milliamperes and the bleeder current is taken as 30 milliamperes, there is enough current for six voltage amplifier tubes, besides the power tube, assuming that each voltage amplifier takes 3 milliamperes.

With the gain in the use of screen grid tubes, high mu tubes, and resistance coupling, the current drawn from the power pack is continually being reduced, while that drawn by the power stage is being increased. The tendency to reduce the number of tubes in the audio amplifier also reduces the requirements on the B supply, at least as far as the voltage regulation goes. It appears now that the time will not be long before there will be a single audio tube on the power supply, the remaining tubes being radio frequency amplifiers.

In the Loftin-White amplifiers there is even a greater difference between the current in the power tube and the tube ahead of it. For example, the power tube takes about 32 milliamperes and the tube ahead not more than about 50 microamperes. This is one of the main differences between a voltage and a power amplifier.

When a 250 tube is used in the Loftin-White the difference is even greater. That tube takes a current of 55 milliamperes whereas the tube ahead of it is often adjusted to take less than 50 microamperes. There is then a ratio of about 1,000 to 1.

It is obviously an advantage from the point of view of economy to arrange a circuit so that only the last tube takes a considerable current, that is, to use some form of resistance coupling. Not only can the B supply be built on more modest proportions, but the tubes, exclusive of the power tube, will last much longer. Indeed they will last almost indefinitely in a resistance coupled amplifier. And then we have the superior quality as a clear gain on top of the economy.

# Sidebands Explained

## Modulation Does Not Change the Frequency of

*By J. E.*

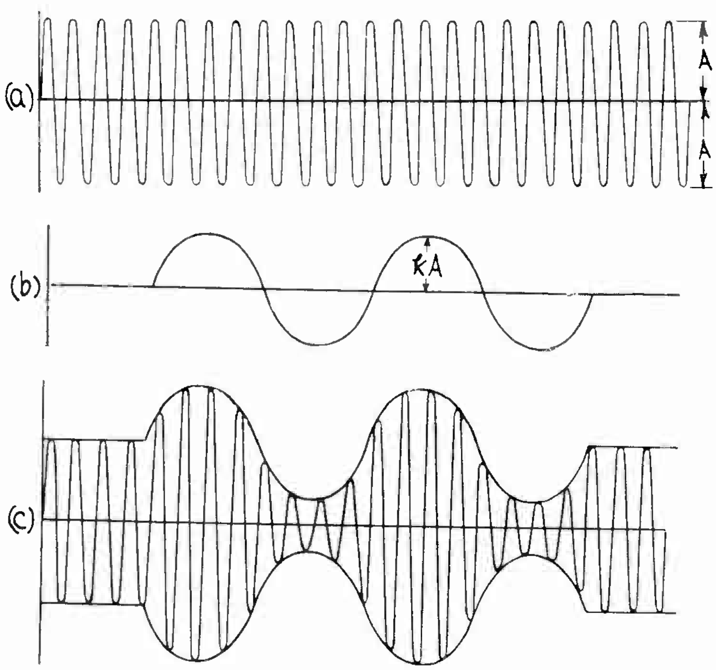



FIG 1
(a) A RADIO FREQUENCY WAVE OF AMPLITUDE A. (b) AN AUDIO FREQUENCY WAVE OF AMPLITUDE kA. (c) A COMPLEX WAVE RESULTING FROM MODULATING (a) WITH (b), THE PERCENTAGE MODULATION BEING k/100. THE SCALE IS SUCH THAT k EQUALS 2/3.

ONE immediate result of the debate on sidebands that appeared in the March 22 issue of RADIO WORLD was a large number of letters proving that the subject is still debatable, debated and misunderstood. Do sidebands really exist? The answer must be that they do not. Yet they do in one sense. Engineers who talk glibly of sidebands know exactly what they mean, and as far as they are concerned they really exist. Yet, they don't. Is there any wonder that the subject should be debatable and misunderstood?

One current misconception of the meaning of sidebands is that the carrier frequency of a modulated signal varies continually within the two sideband limits. For example, if a certain carrier frequency is modulated by audio signals ranging from zero to 10,000 cycles it is thought by some that the carrier frequency continually varies between the limits 10,000 cycles above and 10,000 cycles below the unmodulated carrier frequency. This conception is based entirely on misunderstanding of what is going on. The carrier frequency remains constant all the time, or at least it should in a well-modulated signal. It has no width in the radio spectrum, but has merely a point location. If, for example, it is 1,000 kilocycles when it is unmodulated it is 1,000 kc when it is modulated, and that whether it is modulated with a frequency of 30 per second or 10,000 cycles per second.

### Wobbulation

There is one exception. In the early days of broadcasting the carrier frequency did vary a little as a result of modulation, but the variation did not depend on the frequency of modulation but on the amplitude. Neither did it vary by amounts comparable with 10,000 cycles. The greatest variation was probably not more than 200 cycles in the worst of transmitters. This frequency variation due to modulation was called "wobbulation." In modern transmitters there is no wobbulation. The Federal Radio Commission will not tolerate it and the broadcasters themselves do not desire it. This kind of frequency variation does make the signal "broad" and it is for that reason that it is taboo. We need not consider it further.

We repeat for the sake of avoiding a misunderstanding that the carrier frequency of a broadcast station does not vary during modulation. It is fixed at a certain number of cycles per second.

It is contended by one group that a modulated wave is a radio wave the amplitude of which varies according to the frequency and amplitude of the modulating signal. They are right. It is contended by another group that a modulated wave is equivalent to three waves, the carrier and its two side frequencies, with certain quantitative relationships among the amplitudes. They, too, are right, provided they make certain reservations, which they always do, either explicitly or implicitly. Those who understand the problem do not debate it at all. They admit the equivalence of the two viewpoints and make use of it whenever it is convenient to do so. However, there have been a few instances in which those who did understand the problem have argued against the effectual existence of side frequencies, but they have done so, it seems, because of commercial expediency.

### Meaning of Sidebands

Too frequently the term "sidebands" is used when the meaning is "side frequencies." It is improper to speak of sidebands when a certain radio frequency carrier is modulated by a single audio frequency signal. One should speak of the carrier and its two side frequencies. The complex signal resulting from the modulation, after having been resolved into its three components, does not occupy a band in the frequency spectrum. It occupies three distinct points, for there are three distinct frequencies. If the carrier frequency is 1,000,000 cycles and the modulating frequency is 100,000 cycles, the three distinct frequencies are 1,100,000, 1,000,000, and 900,000 cycles per second. There is no band of frequencies 200,000 cycles wide occupying the spectrum space between 1,100 and 900 kc. If there is to be a band there must be frequencies of every gradation between the limits. The fact is there are only three frequencies, and they occupy definite points in the spectrum.

If there are many modulating frequencies impressed on the same carrier there will be two side frequencies for each modulating frequency. These modulating frequencies may be impressed on the carrier simultaneously or in rapid sequence. If they are modulating simultaneously the several pairs of side frequencies will co-exist, but if they are modulating in sequence only one pair of side frequencies will exist at a time. This is obvious.

### Analogies of Side Frequencies

Does the sideband conception have no place in the scheme? It does in connection with the apparatus used for producing modulation, detection, and tuning. If the modulating frequency is likely to have any value between zero and 10,000 cycles per second, the apparatus must be designed so that it makes no difference in the final results in respect to volume what the value of the modulating frequency happens to be. The equipment must be designed so that it will handle any frequency in a certain band of the spectrum. It is this band that is called the sideband. For example, if the modulating frequency is likely to have any value up to 10,000 cycles and the carrier frequency is 1,000 kc, the equipment must be designed to handle any frequency lying in the band of the spectrum between 990 and 1,010 kc, the two sidebands being the two slices out of the spectrum that lie between 990 and 1,000 kc and 1,000 and 1010 kc. The first of these is the lower sideband and the second the upper side band. The sidebands are the loci of all the side frequencies that may occur as a result of modulation by frequencies lying in a given band of the audio spectrum.

It may help to illustrate the meaning and production of side frequencies by drawing on analogies. Suppose two automobiles are traveling on the same highway, first in the same direction and then in the opposite direction. Let one of them travel at the rate of 5 miles per hour and the other at 75 miles an hour. In this case the lower speed corresponds to the modulating frequency and the higher speed the carrier frequency. We might call one the modulating speed and the other the carrier speed.

When the two cars are moving in the same direction the *relative* speed seems to be 70 miles per hour, that is, the carrier speed minus the modulating speed. Thus 70 miles per hour would be the lower side speed, corresponding to the lower side frequency. If the cars are traveling in opposite directions the *relative* speed appears to be 80 miles per hour. This would be the higher side speed, corresponding to the higher side frequency.

### Extending the Analogy

Are these side speeds real, or are they mere mathematical fictions? To anything stationary they do not exist at all, but in so far as the two cars involved are concerned, they are real. Suppose the two cars should collide. There would be greater damage if they collided when going in opposite directions than when going in the same direction, and the difference would be in the proportion of the relative speeds, 80 to 70. This ratio is not great and consequently the amount of damage would not be greatly different. For a similar reason when the ratio of the two side frequencies in a modulated radio wave is small, the same tuner will bring in

# by Familiar Analogies

## the Carrier— Conflicting Conceptions Reconciled

*Anderson*

both without much relative suppression to either, or it will reject both with nearly the same damage.

Let us extend this analogy by making the ground speeds of the two cars very nearly equal. For example, let the speed of one be 51 miles per hour and that of the other 49 miles per hour. The upper side speed, as we have called it, would then be 100 miles per hour and the lower side speed would be only two miles per hour. If the cars should now collide going in the same direction no damage would result, but should they collide while going in opposite directions there would be great damage. No one would argue against the assertion that the relative speeds are real. If any one should have the temerity to do so, he would change his mind by a moments consideration of the consequences of a collision should he be in one of the cars.

### Zero Beat

We might extend the analogy by assuming that the two cars are traveling at the same speed of 50 miles an hour with respect to the roadway. One of the relative speeds would still be 100 miles per hour but the other would be just zero.

We have similar situations in radio. Suppose the two side frequencies had ratios 50 to 1, the ratio of the two relative car speeds. One tuner could be adjusted to either but not to both at the same time. If it is adjusted to one it would do great damage to the other, or in other words, it would suppress it.

There is also a correspondence between the two cars going at the same speed and radio phenomena. The zero relative speed finds its counterpart in the zero beat and the double relative speed finds its counterpart in the sum frequency. Those who have tried to hold two oscillators at zero beat know the difficulty of doing so. There is much growling indicating that the relative frequency of the oscillators is changing. It is also difficult to hold two cars going at exactly the same speed, and hence to maintain a given distance between them when they are going in the same direction.

### Doppler's Principle

Let us take another illustration of the production of side frequencies due to relative motions, one which is familiar to all students of physics. Suppose a person is riding on a train past a road crossing at which there is a bell. On the approach of the train the bell is heard at a given pitch. At the instant the person on the train passes the bell there is a marked lowering of the pitch. Does the bell ring with one pitch when the train is approaching and with a lower pitch when the train is receding, or is it ringing with the same pitch all the time? Obviously, the pitch of the bell does not change just because a train is passing. The train does not change the make-up of the bell.

Nevertheless, the person riding on the train can hear the pitch change. What makes the frequency of the sound from the bell change? Are the two frequencies heard by the passenger mathematical abstractions or are they real frequencies that affect the ears of the passenger in a normal manner? Or does the ears of the passenger change the instant he passes the bell?

When the train approaches the bell, the frequency heard by the passenger is higher than that emitted by the bell, and when the train recedes, it is lower than the frequency of the bell. The approach frequency is the upper side frequency of that of the bell, and the recession frequency is the lower side frequency. These frequencies are just as real to the passenger as any other sound that he may hear. They exist to the passenger but not to a person standing near the bell. The change in the pitch of the bell as observed by the passenger is known as the Doppler Principle.

The change in the pitch is due to the relative motion of the train and the sound waves from the bell. When the train is approaching it meets the waves, that is, the succession of condensations and rarefactions of the air constituting the sound wave. Consequently the person on the train perceives a greater number of these sequences per second than he would do if he were standing near the bell. When the train is receding, on the other hand, the train moves in the same direction as the sound wave, and the passenger perceives a smaller number of condensations and rarefactions of air per second. The number of such changes in the air pressure on the ear drum determines the pitch, or frequency, of the sound. Hence the pitch is lower on recession than on approach. To the person on the ground near the bell there is no change in pitch provided he himself is not moving toward or away from the bell.

### Returning to Radio

The Doppler effect was observed experimentally and then it was explained mathematically. It is interesting to observe that the mathematical form of the expression for the two side frequencies in the case of the Doppler effect is not unlike the expression for the side frequencies in the radio case.

In Fig. 1 we have a set of curves representing (a) an unmodulated radio frequency wave, (b) an audio frequency wave, and (c) a modulated radio frequency wave resulting from the combination of the curves in (a) and (b). In (c) the wave starts unmodulated, goes through two cycles of modulation, and finally ends up unmodulated. The two curves inclosing the modulated wave are called the envelope of the curve. The envelope is not a part of the curve and should be disregarded. In fact, it was drawn only as a guide for obtaining the proper amplitudes of the modulated wave.

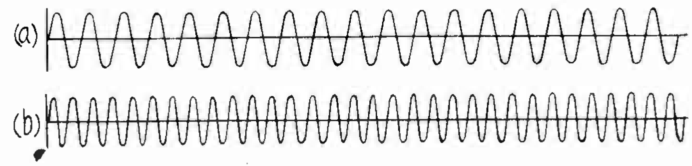


FIG 2

(a) A CURVE REPRESENTING THE LOWER SIDE FREQUENCY CONTAINED IN THE COMPLEX WAVE (c) OF FIG. 1. (b) A CURVE REPRESENTING THE UPPER SIDE QUENCY CONTAINED IN THE COMPLEX WAVE (c) OF AMPLITUDES ARE DRAWN TO SCALE BUT NOT TO FREQUENCY.

### The Question

Now the question is, "Does the modulated wave consist of a radio frequency wave the amplitude of which varies in accordance with the amplitude and frequency of the modulating waves?" Obviously it does. Where, then, do the side frequencies come in? None is shown in the drawing of the modulated wave.

It is here that mathematics come in. The complex wave in (c) can be expressed in mathematical terms as

$$e=A(1+k\cos qt)\sin pt \quad \ldots\ldots\ldots\ldots (1)$$

in which e is the intensity of the complex wave at any instant of time t, A is the amplitude of the carrier wave (a), k is the relative modulation, q is 6.28 times the frequency of the audio wave (b), and p is 6.28 times the frequency of the radio wave (a). When k is zero the carrier wave is unmodulated and when it is unity the wave is 100 per cent. modulated. In (c) the value of k is 2/3 and the wave is 67 per cent. modulated.

The trigonometric terms cosqt and sinpt merely give the wavy form to the curves in (b) and (a) respectively. Their occurrence in the expression for the composite wave show how they enter to produce the complex wave. The factor $(1+k\cos qt)$ is that which causes the amplitude of the wave to change.

It can be shown by a simple trigonometric transformation of the expression in (1) that this expression is identically equal to

$$e=A\sin pt+0.5kA\sin(p-q)t+0.5kA\sin(p+q)t \quad \ldots\ldots\ldots (2)$$

This expression represents three distinct waves similar to that in (a) of Fig. 1. In fact the first term on the right of the equality sign represents that wave without alteration. It is the unmodulated carrier term. The second term represents the lower side frequency, and $p-q$ is 6.28 times the side frequency. The third term represents the upper side frequency, and $p+q$ is 6.28 times that frequency. The amplitudes of the side frequency terms are equal to each other and equal to ½kA. Thus if the per cent. modulation is 67 and the amplitude of the carrier is 60 millivolts per meter, the amplitude of either side frequency wave is 20 millivolts per meter.

### Equivalence of expressions

Since the two expressions in equations (1) and (2) are mathematically equal and physically equivalent it makes no difference which is used in studying modulation phenomena. If certain results are obtained by considering the expression in (1), that is, the variable amplitude conception, the same results must necessarily be obtained by considering the expression in (2), that is, the conception of a carrier wave and two side frequency waves. In various studies the desired results are more easily arrived at by considering equation (2) and for that reason it is used. For example, in studying the effects on the modulation of tuning it is easier to consider the complex wave as composed of three independent waves of slightly different frequencies and computing the suppression of those which are off tune.

Suppose that carrier frequency is quite different from either of the side frequencies, and that a very selective tuner is adjusted to the carrier frequency. It is clear that the two side frequencies are suppressed in a degree depending on the selectivity of the circuit and the relative amount by which the side frequencies differ from the carrier frequency. This is easy to see after the complex wave has been resolved into its components, but it is not at all easy to see it when it is in its complex form.

# Resolved, That RF is G

## AFFIRMATIVE

*By Lewis Winner*

IN view of the facts that only tubes amplify and that a high degree of sensitivity is admittedly desirable it is obvious that it is also desirable to have receivers of many tubes. It is more than desirable, it is necessary. How else can a high degree of sensitivity be obtained when nothing provides it save tubes? Less than a decade ago we did not use tubes in receivers at all. Crystal sets were in vogue, and practically all receivers outside of the large laboratories were of this type. With one of these receivers it was possible to listen to a local broadcast station with a sensitive headset, provided that every precaution had been taken to conserve the extremely feeble signals that were at that time in the air. A loudspeaker was out of the question and very few people thought of the possibility of using one.

After a short time it was found that better results—louder and clearer signals could be received with a tube detector, especially if that tube was made to regenerate, and consequently crystals were rapidly displaced by tube receivers. DX became a new term in the radio fan's vocabulary and lists of distant stations received came into being.

### Tubes Multiply

Before the efficacy of more tubes was realized every means was taken to make the receivers of that day more and more sensitive. Experiments were made with variable grid leaks, variable grid condensers, special detector tubes, variable by-pass condensers in the plate circuit, antennas of every description, grounds, coils, tuning condensers, and different headsets. While a great deal was accomplished in this manner, real DX with good volume was unknown.

And then came the idea of using tubes for amplifying the detected audio frequency signals. First one stage of audio, then two, three, and sometimes four and five. Plenty of volume could be obtained for the headset, and soon it was realized that a loudspeaker could be used to advantage. This change was brought about by using amplifying tubes. It was found desirable to use at least two stages of audio frequency amplification. However, more than two did not work out so well because there was too much amplification for the tubes and the speakers then available. This practical limitation was not against the use of more tubes for amplification, but against the size of the tubes and the capabilities of the speakers.

The need for greater selectivity—greater than could be obtained with one tuner and regenerative detector—arose, and that brought into use another tuner and a radio frequency amplifier. The first radio frequency amplifier tube was not primarily added to increase the selectivity but to prevent radiation from an oscillating receiver. But it was soon realized that both increased selectivity and radiation prevention could be secured by the addition of a radio frequency amplifier. It was not long before no one ever thought of building a receiver which did not have a radio frequency amplifier tube ahead of the detector. Its desirability was self-evident, and nothing has arisen since then to change the situation in the direction of fewer tubes.

### Tubes Continue to Multiply

If one radio frequency amplifier ahead of the detector was desirable, then certainly two of them would still be more desirable. That it was is attested by the phenomenally rapid rise of the Neutrodyne, a circuit containing three tuners, two radio frequency tubes, and a detector. The circuit for the first time made trans-continental reception a reality, and it made unique reception a fact. That is to say, it made it possible to select the desired station and to exclude all stations momentarily undesirable.

Was it the tuners that made trans-continental reception possible? Of course not. It was the two added tubes that did the trick. They amplified the feeble radio impulses from the remote stations and made them as strong as if they had emanated from a local station. The tuners added made the selectivity satisfactory for such high sensitivity as the tubes provided.

When the Neutrodyne was ultimately displaced it was not by any receiver having fewer radio frequency amplifiers, but by receivers having more. Means were found for stabilizing such multi-tube receivers and to make practical use of the immense amplification, and the Neutrodyne itself provided one of the best methods of stabilization.

It is doubtful that a greater number of radio frequency tubes than was provided for in the Neutrodyne had ever been necessary if it had not been for the fact that human laziness had to be served under the euphemism convenience. It was found that greater amplification necessitated greater selectivity, which meant a greater number of tuners. The Neutrodyne had three, all independent. This independence made the highest possible amplification just about all that was needed, provided that any one cared to solve the puzzle of exact tuning.

### Gang Tuning

Laziness demanded unified tuning control. Immediately this was installed in a receiver some of the sensitivity of the Neutrodyne type receiver was lost, and more tubes had to be used in order to make up for it. It was cheaper to add more tubes than to spend the time required to tune three independent resonant circuits. The result was not only greater simplicity of tuning but also greater sensitivity and selectivity. It is now nothing unusual to see a receiver which will consistently receive trans-continental stations with loudspeaker volume and with a single tuning control.

What made this increased sensitivity possible? The tuners? Only indirectly in that it made unique reception possible. Was it the gang tuning? Not at all. That militated only against the reception of the distant stations because of decreased selectivity. Was it the added tubes? Absolutely. It was the increased amplification that the added tube provided. We are forced to the conclusion that many tubes are not only desirable, but that they are necessary under modern reception conditions.

### Best Stabilizer

One of the best means discovered for stabilizing a radio frequency amplifier, and, strange as it may seem, for increasing the selectivity, is to shield the various stages, especially the tuning coils. This, unfortunately, introduces a certain amount of loss in the amplification, but this is more than offset by the gain contributed by one tube. Hence the shielding and the addition of a tube makes the set more selective, more stable, and more sensitive. It is the amplification in the tubes added that makes this refinement possible. Again the facts confute any assertion that many tubes in a receiver are not desirable.

Shielding can be made effective against feed back without at the same time lowering the selectivity and amplification by making the space between the coils and the shielding large. That is, if the shields are of given dimensions it is best to use coils of rather small diameter, or if the coils are fixed in size, to make the shields large. The diameter of the coil inside a circular shield should be about one-third the diameter of the inside dimensions of the shielding. When there are many tuners and many amplifying tubes it is practical to reduce the separation considerably without making any appreciable sacrifices in the desirable features of the circuit. Without plenty of amplification the shielding must be impractically large or no shielding at all can be used. This limits the usefulness of the receiver to local reception, unless the receiver be made so large that it will occupy the major portion of the living room.

### Volume Control Necessary

Many of the objections raised against receivers of many tubes is that the amplification is so great that it cannot be controlled. These objections are valid in many instances, but to raise them is no argument against the use of receiver with a high degree of sensitivity. It is an argument for having a volume control that has sufficient range to limit the amplification to the required amount. Of course, a receiver without a volume control cannot be sensitive, for it would be useless except for the reception of the most distant stations. On all other stations all the tubes, with the possible exception of the first two, would be hopelessly overloaded. If the receiver is to be used for local stations only it would be just as well to use a crystal or a one-tube set.

No matter what receiver of a given degree of sensitivity is used it must have a certain volume control range, and the greater the sensitivity the wider that range must be. Hence a multi-tube receiver capable of trans-continental reception must have a very wide volume control range indeed. The signals, for example, from a station clear across the country may not have a signal strength at the receiver of more than one microvolt per meter. The gain in the receiver must be so great that this weak signal can be built up to loudspeaker volume under the worst conditions. On the other hand, the signal strength from a local station may be as great as 500,000 microvolts per meter. The volume control must be such that this can be surpassed so that the speaker delivers no more sound than it does on the distant station. Therefore, the range of the volume control must be 500,000 to one. It is easy to provide such a range but it is not always done. Note that it is always a simple matter to cut the volume out, but it is only possible by means of tubes to build it up. Again, many tubes are a necessary condition.

# ained Faster than Lost

## NEGATIVE

*By Herbert E. Hayden*

THE need of many tubes in a modern radio receiver is admitted. It is only a question of how many tubes are needed for a given sensitivity. It is possible to build a receiver having 100 tubes, which is no more sensitive than a well-constructed receiver having two or three tubes. It is also possible to build a receiver with five or six tubes which is so sensitive that there never will arise a reasonable need for a more sensitive one. Simple adding tubes to a receiver does not add to the sensitivity. It all depends on how they are added.

Much hoodwinking of the public has been practiced on this question of tubes and sensitivity. It is easy to convince the average radio fan that an eight-tube receiver is more sensitive than a four-tube set, but it is mighty difficult to explain to him why the four-tube set runs rings around the eight-tube circuit, if it does, and it does that quite frequently. The average fan is sold on a certain eight-tube set because he is certain that it will do what no other set will do. But the more-than-average fan sticks to the four-tuber. Now these two fans may be close friends and may exchange notes.

"I got Denver last night, clear as a bell on my new eight-tuber," says the average fan, a New Yorker, one morning when he sees his friend. "That's nothing," replies the more-than-average fan, a commuter from New Jersey, "I get KFI every night on my old four-tuber." Of course, the average fan puts this down as plain boasting and discounts it all the way back to Chicago. But one evening the New Yorker pays his New Jersey friend a visit and is invited to tune in KFI, and he does it. Then he goes home with the determination to lop off four tubes from his eight-tuber. Of course, being an average fan, he does not know which tubes to cut out, nor how to do it. Hence he asks somebody who knows the tricks, and he is told that it is not done that way. He has to start from scratch, although he may get suggestions for making worthwhile improvements in the eight-tube receiver.

### Much Ado About Nothing

What is the trouble with this particular eight-tube set? There is no one trouble in particular. There is only a lot of lost motion in it—much ado about nothing. There is amplification galore but it is not made to do anything. There is a lack of co-ordination among the stages.

There is a close analogy between multi-tube receivers and large-volume business. One receiver may have a large number of tubes with a very small gain per stage. It is like a large-scale business with a very small margin of profit. Another receiver may have only a small number of tubes with a large gain per stage. That is like a small business with a large margin of profit. Some receivers have been put out which had a loss per stage, and many of these were multi-tube receivers. They are like big business ventures in which the sales amount to less than the costs.

One game practiced by certain designers is to put in a tube to amplify the signals to a certain point, then to put in some form of losser to keep that gain from getting out of control, largely for the purpose of adding another tube so that it can have something to do. This is followed by a losser put in to allay the fear that the amplification will become too great. And this losser prepares the stage for another tube. This see-saw game goes on until the total number of tubes in the receiver is at least one more than the number of tubes used in the receiver made by a competitor, or until the receiver presents a truly imposing appearance

### Types of Lossers

There is only one way of gaining amplification in a receiver, and that by taking advantage of the properties of vacuum tubes. But there are countless lossers. To name them all would be to write a book on what not to do to get the best radio receiver. It might seem to some fans that many radio engineers know half a dozen such books by heart, and that they took advantage of everything that the books contained. But this is not fair to the engineers, for in most instances it is really the fans themselves who are to blame. It is really not necessary to read any of these books in order to do all that they say should not be done to build the best receiver.

One of the most effective lossers, as far as sensitivity is concerned, is lack of line-up of the tuned condensers and the tuning coils in gang controlled receivers. If the receiver has only one tuned circuit there is no chance of going wrong on this score. If there are only two tuned circuits on the same control there is only one chance. And if there is any number of tuned circuits there is always one chance less of going wrong. But suppose there are ten tuned circuits? There are nine possibilities of going wrong, and in many instances all nine have been taken advantage of to make the receiver as bad as possible. The proper thing to do is to line all the condensers and the coils up so that all the tuned circuits are in tune with the same frequency at the same dial setting, no matter what the frequency may be. To do that is quite a job, and few there are who can do it.

But even if the tuned circuits are a little out of tune, if the circuit has enough tuners and enough amplifier tubes there will be both sensitivity and selectivity. Plenty of it, in fact, unless the mismatching is very bad.

This fact calls for shielding another effective losser. The only real object of shielding is to introduce losses. It may be said that the object is to stabilize the circuit, but that is only a clever way of avoiding the unpleasant word "loss." Or it may be said that the object of the shielding is to prevent feedback, which is only another way of avoiding saying the same unpleasant word.

Those who are frank enough to admit that shielding is a losser usually wriggle out of the difficulty by saying, in some way or other, that shielding losses are introduced in order that a greater gain may be effected as a result. Their way of looking at it is that shielding loss is a sort of income tax which is only a small fraction of the total gain. Who does not want to pay an income tax, provided that the rate is low?

This is indeed an optimistic view of the matter, but those who hold it usually forget to mention the fact that the rate of taxation is frequently 100 per cent. Who, by the way, has not taken out one tube in a receiver to find that the sensitivity went away up? This signifies, not a 100 per cent. tax, but perhaps 110 per cent. There are many receivers of this kind, and they are usually of the multi-tube, well-shielded type.

Another method of avoiding the gain that the tubes pile up is to couple them very loosely. Very small primaries placed far away from the tuned secondaries are used. This is particularly the case in screen grid tube receivers, which normally require closer coupling than three-element tubes. When the useful load on a tube is made very small, as it is when the coupling is not sufficiently close for the tube, there is much ado in the tube but it does not produce any results. Of course, that is one of the necessary conditions for using a long array of high gain tubes in a receiver.

There are many other methods for preventing amplification in a receiver oversupplied with high gain tubes. One is to put a resistance in the grid leads of all the tubes. It is surprising how effective this is in preventing amplification and in making a multi-tube receiver practical. Still another way is to put high resistance in the plate circuits of the tubes. They serve to put high, useless loads on the tubes, and hence to prevent the full signal output from reaching the next tube. Or in some instances they serve to cut down the effective plate voltage so that the tube does not amplify much, if any at all.

And still another way of accomplishing the same thing is to cut down the screen voltage in screen grid tube receivers. It is easy to set the screen voltage so that even if everything else is as it should be for high amplification, the tube acts only as a signal blocker. Indeed, in most screen grid tube receivers this fact is taken advantage of in controlling the volume, that is, the amplification.

Low resistance shunts across the tuned circuits are also used in some cases to prevent amplification when there are so many tubes in the circuit that it would be impossible to handle it if the full gain were permitted. Likewise shunts are put in the antenna circuit for the same reason and with the same object. Resistances in series with the tuning coils are also resorted to, usually in the guise of small, "efficient" coils. Primaries wound with resistance wire is another method of circumventing high gain. The excuse for doing this is that high resistance primaries put high loads on the tubes and make them more efficient as amplifiers.

This excuse is actually believed by some. But "those in the know" appreciate the fact that high resistance primaries simply put a useless load on the tubes and reduce the amplification. It would be just as well to put high resistances in series with the primaries externally. The effect is exactly the same. Any load on a tube must be useful if it is to add anything to the amplification.

It may help some to appreciate what is being done when lossers of various kinds are put in a circuit by drawing on a common analogy. The gain contributed by the tubes may be likened to the acceleration of a motor car resulting from feeding it more gas, and the loss contributed by the various lossers is like the retardation of the motor car resulting from applying the brakes. Nobody but an automobile novice will step on the brake and the accelerator at the same time. But nearly everybody does the thing in radio sets. Designing radio engineers do it just because they can "get away with it," leaving the impression that the multi-tube receiver is a world-beater in sensitivity. They are not content with a single brake on each tube, but they clutter up every tube with all the brakes that have been found.

# The 6-Cir

## Design In Its Semi-Final Evils It Avoids

*By Herman*

*[Herewith is the fifth of a series of articles detailing the design and experimental work being done on an AC circuit using two three-gang condensers in connection with screen grid tubes. Laboratory tests compelled many changes in the course of the experimental work. However, as the author states in the following article, the design shown this week is semi-final.—Editor.]*

A BAND pass filter pre-selector has been chosen definitely for the circuit I have been experimenting with for five weeks and discussing in these columns for four weeks. Also, one of the sections of the first three-gang condenser is to be used as a series ground condenser for the antenna primary winding alone, to even up the radio frequency amplification.

There will be three stages of screen grid radio frequency amplification, using AC tubes, while a filament transformer will be a part of the chassis assembly, as will a voltage divider, so that we will run no risk of obtaining incorrect voltages, or of depending too confidently on the capacity of filament windings of a power amplifier with which it is suggested this circuit be used.

### 227 Tube Used As Output

The mere fact that a power amplifier is to be used makes it inadvisable to use a 245 tube as output, since the power amplifier will have two stages of audio, and it would have its first stage biased less by far than the output of the preceding circuit. So a 227 tube will be used as output, and the full voltage as obtained from the 180-volt tap of the power amplifier will be applied to the sixth tube's plate. At 180 plate volts, the negative grid bias should be 13.5 volts, for amplification, under which conditions 6 milliamperes will flow. Depending on the resistance of the load to be placed on the final plate circuit, the effective plate voltage, hence the plate current, may be a little less than the stated 6 milliamperes.

It will surprise many to be told that the 227 as an output tube is a good one, outranking the 112 or 112A of battery-set operation, at the rated voltages. At 135 plate volts, with 9 volts negative bias, 7 milliamperes of plate current will flow, and the maximum undistorted output will be 120 milliwatts in the case of the 112A. Now, the 227, at the maximum rated plate voltage of 180 volts, at 13.5 volts negative bias, not only will stand half again as much grid swing before overloading, as compared with the 112A at 135 volts, but has a maximum undistorted power output of 164 milliwatts, an improvement of more than 36 per cent. The 112A has an amplification factor of 8, while the 227 has an amplification factor of 9. The mutual conductance of the 112A is 1,600 micromhos under the stated conditions, and that of the 227 is 1,000 micromhos, but the mutual conductance, or change in plate current for a given change in grid voltage, is not a figure of merit for a tube used for output purposes.

### When Tubes Are Over-Voltaged

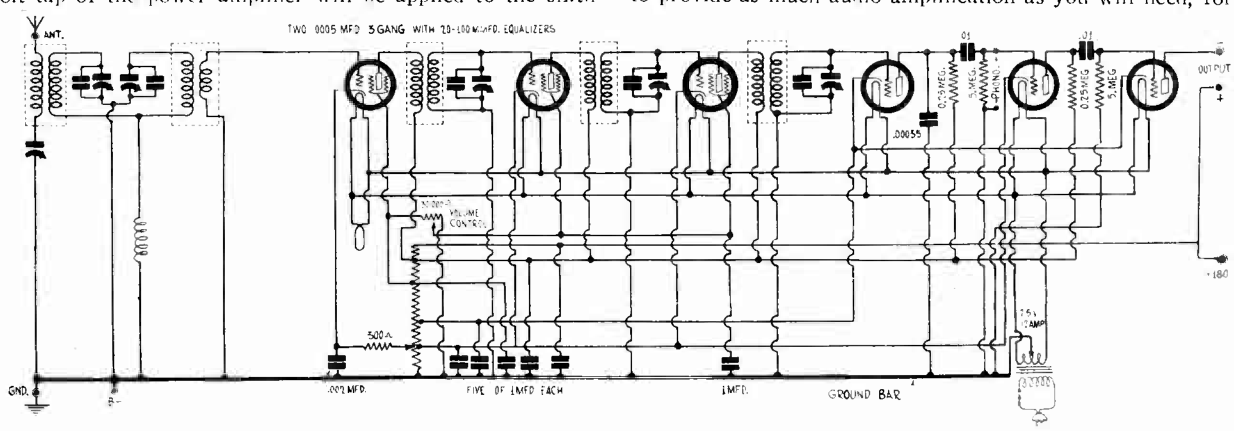
It is true that the 112A, if 180 volts are applied, will exceed the other in all directions except mu, but 180 volts should not be applied to the 112A, as the tube's life would be halved. By ignoring tube life the voltage on the 227 could be lifted to 250, so that with equal life reduction inflicted on both—say, halving the normal life of 1,000 hours—the 227 always would retain the lead. So it is a fact indeed that the 227, when worked at 180 volts with proper bias, is a good output tube, beyond the 112A, hence properly semi-power tube class, although this fact is seldom stated.

It is conceivable that persons who desire only moderate volume will work the present design into a loudspeaker, preferably the magnetic or inductor type, without invoking the aid of a power amplifier. For such persons no extra equipment is needed except a B eliminator that furnishes 180 volts, although the precaution should be taken to choose one of the 60 or 65 milliamperes type, rather than the 35 milliamperes type. The circuit will work on either, but better results are obtainable from the larger capacity eliminator, because the regulation is better, the voltage obtained being therefore nearer the rating, even with the six-tube draw.

### Use Dynamic With Power Amplifier

As for feeding a power amplifier, which is recommended to those who like plenty of volume on distant stations, for this circuit surely will bring in distance, two stages of audio should be used, making four stages, all told. A dynamic speaker is necessary. Four stages are a great deal of audio frequency amplification, but can be utilized with success. When a little station in Wisconsin is brought in at New York with "local volume" on the speaker, it becomes obvious that those who like their DX loud should make proper audio preparations to insure such enjoyment. True, local stations will be too loud, at maximum volume, but the volume control virtually will cut off the signal completely, if desired, so you need use no more volume than you desire. The point is rather to provide as much audio amplification as you will need, for you can always subtract, never add, on these radio machines.

The voltage divider has been arranged a little differently this week, and a boosting resistor of 300 ohms or less is used for maintaining the grid of the first RF tube at a higher bias than obtains on the grids of the rest of the RF tubes or the first audio




DESIGN OF THE SIX-CIRCUIT SCREEN GRID TUNER, WITH BAND PASS FILTER AND 227 OUTPUT.

# Right or

*[The following questions and answers are based on technical information contained in last week's issue. Read the present issue carefully and know the answers to next weeks questions before they are asked.—Editor.]*

### QUESTIONS

One—A good outdoor antenna is essential to get the most distant reception out of any receiver.

Two—A good ground is not essential, since most receivers work just as well without as with one.

Three—If best the results are to be obtained with any broadcast receiver it is necessary to select a set of matched tubes.

Four—Weather conditions do not affect radio reception in the least, contrary to general opinion.

Five—It is possible to predict what the weather conditions will be the following day by observing reception from distant stations in various directions.

Six—All crackles heard in radio receivers are due to static, that is, to electrical discharges between clouds or between clouds and the earth.

Seven—DX reception is practically impossible in the Spring and Summer.

Eight—Weather does not in any way affect the efficiency of a receiver.

Nine—A milliammeter and a voltmeter can be used as a direct reading ohmmeter provided that they are associated properly with resistance and a voltage source.

Ten—The addition of an extra radio frequency amplifier stage in a receiver does not always increase the sensitivity of the receiver.

### ANSWERS

One—Right. There is no better way of insuring distance than using a first class antenna. The signal picked up is directly propor-

# cuit Tuner

## Form Is Outlined—
## Are Listed

*Bernard*

tube. The object of heightening the bias here is not to cope with any enormity of amplitude, for the amplitude is least here, but for avoiding stray detection that results in cross-modulation.

### What It Does Not Do

The receiver, as it is working now, in conjunction with a power amplifier that has one stage of resistance audio and one stage of push-pull audio feeding 245s, does *not* do any of the following:

It does *not* cross-modulate, whereby a station of strong signal strength is tuned out, only to ride through again elsewhere on the dial along with the program of another station to which the receiver now is tuned.

It does *not* produce resonance hum, that is, develop a hum when a station is tuned in, although there would be no hum when no station was tuned in. (Actually, resonance hum is encountered at resonance, whether a station is receivable at that frequency or not, where the vice exists.)

It does *not* get off balance at one end of the tuning spectrum when balanced for the other end. The tuning condensers may be trimmed at the highest receivable frequency, the most exacting place to choose, and yet resonance will prevail at the lowest radio frequency you can tune in, because of the extreme accuracy and ruggedness of the gang condensers used, the equality of the inductances of the coils and the position of the wiring connections. For purposes of inductive equality, if for no other, all the coils are wound with the same number of turns on both primaries and secondaries.

It does *not* oscillate, unless you want it to. That is, the circuit may be built and the potentiometer arm at the low end of the voltage divider may be set so that no oscillation takes place at the highest receivable frequency, even when the volume control is advanced to maximum. This affords a sensitive and selective receiver, but those who want oscillation may adjust the arm of the voltage divider potentiometer so that the circuit will oscillate.

It does *not* overload the detector, since real power detection is used at a bias of around 16 volts, hence the first tube to overload would be the last tube, the 227 output, which is best practice. A reeiver should be as distortionless as its final tube, not as distortionless as its detector, otherwise the detector is permitted to distort ahead of the other, and when the detector distorts you have distortion greatly amplified by the audio channel.

It does *not* fail to tune in the entire frequency spectrum of broadcasting (550 to 1,500 kc.) More than half the receivers in use do fail to cover the frequency band. It does *not* pick up any signals unless antenna is corrected.

### Copper Ground Bar

A single filament winding is used for the secondary, since the unvaried use of heater type tubes makes this possible. The center tap of this secondary is grounded to the copper bar which is used as the ground connection in all instances, except the antenna winding alone, which is intercepted by the series condenser. All ground leads are run directly to this ground bar, and the bar is connected to the ground binding post and to B minus, so that all ground currents will be assured of a low impedance path. Even the bypass condensers are connected to the ground bar. Although the diagram does not show the fact specifically, since it is schematic and not a pictorial diagram, the condenser frame is grounded directly to the bar, and the grid return ends of the coils likewise are treated, and are not interconnected to the condenser lead and the common path to ground for these two made through or over one wire to the bar. The whole object of the ground bar is to avoid any common coupling in the ground lead except in the low impedance bar, for the receiver is rendered more sensitive and more stable by that method, and even the selectivity is increased.

### New Mechanical Layout

The mechanical layout of the receiver has been changed from what was shown in previous issues. The shields formerly were on bottom, attached to a flap built in the subpanel, at right angles to its under side, but now the shields are on top. The available width of the subpanel, for a 7x21 inch front panel, was consumed entirely by the shields, and their size was therefore determined by the distance divided by the number of shields, considering the symmetrical desirability of six shields. Into one of the shields the filament transformer was built, while the five remaining shields housed the identical coils.

Since the shields have been changed, so as to be larger, and since their wall thickness and even their height have been increased, the number of turns for the secondaries is not the same as previously given. The thickness of the walls and the distance between them and the coil inside alter the effective inductance. Hence a coil wound with a given number of turns of wire, used unshielded, will be all right for a given capacity tuning condenser. Put that coil in a certain shield and it will not tune in the highest wavelengths at all. Put on more turns and the circuit will get the highest but may miss the lowest wavelengths. So coils, condensers and shields have to be considered together, and the tables of number of turns, that we have been brought up on since we got interested in radio, do not mean anything in this shielded age.

As the shields are not in final condition, but will be exercised some more, the coil data can not be given exactly and finally, but it is expected that next week not only will these data be published, but also photographs of the final receiver.

### Semi-Final Circuit

So far as the circuit goes that is shown this week, let us regard it as semi-final, so as to leave room for any improvements that can be developed during the sixth week of experimental work. It is confidentially expected that after the disclosures in the May 3d issue next week, the constructional data can be published, which would mean in the May 10th issue.

Not much has been said about what the circuit has done in any of the stages of its development, but rather more of what it has not done.

One fact stressed was that stray pickup was suffered. This enables reception of stations without aerial or ground, which is a bad feature. Such stray reception proves the circuit is sensitive, but it also proves that not all of the pickup derives the benefit of tuning in all of the tuned stages, hence selectivity suffers. For this reason not only will the metal subpanel have a shield bottom piece, to bottle up the wiring inside that acts as an adventitious aerial, but even the hole cut out to pass the drum of the dial will be bottled up, and each of the tubes will have a shield of its own, so that the six sockets will not make a sieve out of the subpanel and thus frustrate other shielding precautions. The tube shields will serve as stoppers over the bakelite wafers on which the sockets are built.

Next week also we hope to be able to give the constants, particularly for the voltage divider and the potentiometer. The divider's resistance values were all worked out and verified experimentally, but then the change was made calling for a higher voltage on the plate of the last tube than on the plates of any of the other tubes. That makes a new set-up necessary, and the whole calculation was upset. The calculation has been made anew, but has not been checked against practical results. As slide rules do slip once in a while, the checkup is perhaps more important than the computation.

The data as finally given will reveal how to wind your own coils, make your own shields, use your present apparatus as far as it covers requirements, and will reveal the performance, including selectivity analysis and sensitivity rating in microvolts per meter.

# Wrong?

tional to the height of the antenna and therefore the higher it is the louder the signals will be.

Two—Wrong. While a receiver may work fairly well without a good ground it will work immeasurably better with one. Not only does it make the antenna a better collector of radio signals but it stabilizes the circuit. It acts as a sort of anchor.

Three—Right. To answer this in the affirmative it is necessary to make some modification. If matching means that tubes having characteristics which make them work most efficiently into the coupling devices in the set, then the statement is right. If it means that they should be selected because they have certain inter-electrode capacities the matching can be done more cheaply with trimmers.

Four—Wrong. The weather has a great deal to do with the strength of signals received from distance stations and the amount of noise that accompanies them.

Five—Right. While the connection between weather conditions and radio reception has not been worked out fully, the connection is well enough understood that it is possible to make predictions.

Six—Wrong. It is true that many of the noises that are heard are caused by atmospheric electricity, possibly most of them are due to the disturbances from the electric power system.

Seven—Wrong. DX reception is usually more consistent during these seasons and if the receiver is sensitive enough satisfactory reception can be obtained.

Eight—Wrong. There are many parts in a receiver which are affected by moisture. For example, the insulation in coils and the sounding board in the loudspeaker are likely to absorb moisture. Absorption usually will make the set less sensitive and selective.

Nine—Right. The method of doing this was explained in an article by William A. Forbes in the April 19th issue of RADIO WORLD.

Ten—Right. Often the addition of another stage of RF amplification results in a worse receiver because of instability.

# Stations in United States and Canada, Effective May 1

*(*) New frequency, effective May 1st. Change to this on list of stations by frequency, published in March 29th issue.*

**CANADA**

| Station | kc |
|---|---|
| CFAC | 690 |
| CFBO | 890 |
| CFCA | 840 |
| CFCF | 1030 |
| CFCH | 600 |
| CFCN | 690 |
| CFCO | 1210 |
| CFCR | 960 |
| CFCT | 630 |
| CFCY | 960 |
| CFJC | 1120 |
| CFLC | 1010 |
| CFNB | 1210 |
| CFQC | 910 |
| CFRB | 960 |
| CFRC | 930 |
| CHCA | 690 |
| CHCK | 960 |
| CHCS | 880 |
| CHCT | 840 |
| CHGS | 1120 |
| CHLS | 730 |
| CHMA | 580 |
| CHML | 880 |
| CHNS | 930 |
| CHRC | 880 |
| CHWC | 960 |
| CHWK | 1210 |
| CHYC | 730 |
| CJBC | 580, 840, 960, 690 |
| CJBR | 960 |
| CJCA | 580 |
| CJCB | 880 |
| CJCJ | 690 |
| CJGC | 910 |
| CJGX | 630 |
| CJHS | 910 |
| CJOC | 1120 |
| CJOR | 1030 |
| CJRM | 600 |
| CJRW | 600 |
| CJRX | 1120 |
| CJSC | 580 |
| CKAC | 730 |
| CKCD | 730 |
| CKCI | 880 |
| CKCK | 960 |
| CKCL | 580 |
| CKCO | 890 |
| CKCR | 1010 |
| CKCV | 880 |
| CKCF | 730 |
| CKGW | 690 |
| CKIC | 930 |
| CKLC | 840 |
| CKMC | 1210 |
| CKMO | 730 |
| CKNC | 580 |
| CKOC | 880 |
| CKOW | 840 |
| CKPC | 1210 |
| CKPR | 930 |
| CKSH | 1010 |
| CKUA | 580 |
| CKWX | 730 |
| CKX | 540 |
| CKY | 780 |
| CNRA | 630 |
| CNRC | 690 |
| CNRD | 840 |
| CNRE | 580 |
| CNRL | 910 |
| CNRM | 730 |
| CNRO | 600 |
| CNRQ | 880 |
| CNRR | 960 |
| CNRS | 910 |
| CNRT | 840 |
| CNRV | 1030 |
| CNRW | 780 |
| CNRX | 690 |

**UNITED STATES**

| Station | kc |
|---|---|
| WAAF | 920 |
| WAAM | 1250 |
| WAAT | 1070 |
| WAAW | 660 |
| WABC | 860 |
| WBOQ | 860 |
| WABI | 1200 |
| WABZ | 1200 |
| WACO | 1240 |
| WADC | 1320 |
| WAGM | 1310 |
| WAIU | 640 |
| WAPI(*) | 1130 |
| WASH | 1270 |
| WBAA | 1400 |

| Station | kc |
|---|---|
| WBAK | 1430 |
| WBAL | 1060 |
| WBAP | 800 |
| WBAX | 1210 |
| WBBC | 1400 |
| WBBL | 1210 |
| WBBM | 770 |
| WJBT | 770 |
| WBBR | 1300 |
| WBBY | 1200 |
| WBBZ | 1200 |
| WBCM | 1410 |
| WBMS | 1450 |
| WBNY | 1350 |
| WBOW | 1310 |
| WCLB | 1500 |
| WCLO | 1200 |
| WCLS | 1310 |
| WCMA | 1400 |
| WCOA | 1340 |
| WCOD | 1200 |
| WCOH | 1210 |
| WCRW | 1210 |
| WCSC | 1310 |
| WCSH | 940 |
| WCSO | 1450 |
| WDAE | 1220 |
| WDAF | 610 |
| WDAG | 1410 |
| WDAH | 1310 |
| WDAY | 940 |
| WDBJ | 930 |
| WDBO | 1120 |
| WDEL | 1120 |
| WDGY(*) | 1170 |
| WDOD | 1280 |
| WDRC | 1330 |
| WDSU | 1250 |
| WDWF | 1210 |
| WLSI | 1210 |
| WDZ | 1070 |
| WEAF | 660 |
| WEAI | 1270 |
| WEAN | 780 |
| WEAO | 570 |
| WBRC | 930 |
| WBRE | 1310 |
| WBSO | 920 |
| WBT(*) | 1040 |
| WBTM | 1370 |
| WBZ | 990 |
| WBZA | 990 |
| WCAC | 600 |
| WCAD | 1220 |
| WCAE | 1220 |
| WCAH | 1430 |
| WCAJ | 590 |
| WCAL | 1250 |
| WCAM | 1280 |
| WCAO | 600 |
| WCAP | 1280 |
| WCAU(*) | 820 |
| WCAX | 1200 |
| WCAZ | 1070 |
| WCBA | 1440 |
| WCBD(*) | 1040 |
| WCBM | 1370 |
| WCBS | 1210 |
| WCCO | 810 |
| WCDA | 1350 |
| WCFL | 970 |
| WCGU | 1400 |
| WCHI | 1490 |
| WCKY | 1490 |
| WEBC | 1290 |
| WEBE | 1210 |
| WEBQ | 1210 |
| WEBR | 1310 |
| WEBW | 560 |
| WEDC | 1210 |
| WEDH | 1420 |
| WEEI | 590 |
| WEHC | 1490 |
| WEHS | 1420 |
| WELK | 1370 |
| WEMC | 590 |
| WENR | 870 |
| WBCN | 870 |
| WEVD | 1300 |
| WEW | 760 |
| WFAA | 800 |
| WFAN | 610 |
| WFBC | 1200 |
| WFBE | 1200 |
| WFBG | 1310 |
| WFBL | 1360 |
| WFBM | 1230 |
| WFBR | 1270 |
| WFDF | 1310 |
| WFDV | 1370 |
| WFDW | 1420 |
| WFI | 560 |

| Station | kc |
|---|---|
| WFIW | 940 |
| WFJC | 1450 |
| WFKD | 1310 |
| WFLA | 620 |
| WSUN | 620 |
| WGAL | 1310 |
| WGBB | 1210 |
| WGBC | 1430 |
| WGBF | 630 |
| WGBI | 880 |
| WGBS | 600 |
| WGCM | 1210 |
| WGCP | 1250 |
| WGES | 1360 |
| WGH | 1310 |
| WGHP | 1240 |
| WGL | 1370 |
| WGN | 720 |
| WLIB | 720 |
| WGR | 550 |
| WGST | 890 |
| WGY | 790 |
| WHA | 940 |
| WHAD | 1120 |
| WHAM(*) | 1160 |
| WHAP | 1300 |
| WHAS(*) | 1020 |
| WHAT | 1310 |
| WHAZ | 1300 |
| WHB | 860 |
| WHBC | 1200 |
| WHBD | 1370 |
| WHBF | 1210 |
| WHBL | 1410 |
| WHBO | 1370 |
| WHBU | 1210 |
| WHBY | 1200 |
| WHDF | 1370 |
| WHDH | 830 |
| WHDI | 1180 |
| WHDI(*) | 1170 |
| WHEC | 1440 |
| WABO | 1440 |
| WHFC | 1420 |
| WHIS | 1420 |
| WHK | 1390 |
| WHN | 1010 |
| WHO | 1000 |
| WHOM | 1450 |
| WHP | 1430 |
| WIAS | 1420 |
| WIBA | 1210 |
| WIBG | 930 |
| WIBM | 1370 |
| WIBO | 560 |
| WIBR | 1420 |
| WIBU | 1310 |
| WIBW | 580 |
| WIBX | 1200 |
| WICC | 1190 |
| WIL | 1200 |
| WILL | 890 |
| WILM | 1420 |
| WIOD | 1300 |
| WMBF | 1300 |
| WIP | 610 |
| WIS | 1010 |
| WISN | 1120 |
| WJAC | 1310 |
| WJAG | 1060 |
| WJAK | 1310 |
| WJAR | 890 |
| WJAS | 1290 |
| WJAX | 900 |
| WJAY | 610 |
| WJAZ | 1490 |
| WJBC | 1200 |
| WJBI | 1210 |
| WJBK | 1370 |
| WJBL | 1200 |
| WJBO | 1420 |
| WJBU | 1210 |
| WJBW | 1200 |
| WJBY | 1210 |
| WJJD(*) | 1090 |
| WJJD | 1130 |
| WJKS | 1360 |
| WJR | 750 |
| WJSV | 1460 |
| WJW | 1210 |
| WJZ | 760 |
| WKAQ | 890 |
| WKAR(*) | 830 |
| WKAV | 1310 |
| WKBB | 1310 |
| WKBC | 1310 |
| WKBF | 1400 |
| WKBH | 1380 |
| WKBI | 1420 |
| WKBN | 570 |
| WKBO | 1450 |

| Station | kc |
|---|---|
| WKBP | 1420 |
| WKBQ | 1350 |
| WKBS | 1310 |
| WKBV | 1500 |
| WKBW | 1480 |
| WKBZ | 1500 |
| WKEN(*) | 1060 |
| WKJC | 1200 |
| WKRC | 550 |
| WKY | 900 |
| WLAC | 1470 |
| WLAP | 1200 |
| WLB | 1250 |
| WGMS | 1250 |
| WLBC | 1310 |
| WLBF | 1420 |
| WLBG | 1200 |
| WLBL | 900 |
| WLBW | 1260 |
| WLBX | 1500 |
| WLBZ | 620 |
| WLCI | 1210 |
| WLEX | 1410 |
| WLEY | 1370 |
| WLIT | 560 |
| WLOE | 1500 |
| WLS | 870 |
| WLTH | 1400 |
| WLVA | 1370 |
| WLW | 700 |
| WLWL | 1100 |
| WMAC | 570 |
| WMAF | 1410 |
| WMAK | 900 |
| WMAL | 630 |
| WMAN | 1210 |
| WMAO | 670 |
| WMAY | 1200 |
| WMAZ | 890 |
| WMBA | 1500 |
| WMBC | 1420 |
| WMBD | 1440 |
| WMBG | 1210 |
| WMBH | 1420 |
| WMBI(*) | 1040 |
| WMBI | 1500 |
| WMBO | 1310 |
| WMBO | 1500 |
| WMBR | 1370 |
| WMC | 780 |
| WMCA | 570 |
| WMES | 1500 |
| WMMN | 890 |
| WMPC | 1500 |
| WMRJ | 1420 |
| WMSG | 1350 |
| WMT | 600 |
| WNAC | 1230 |
| WBIS | 1230 |
| WNAD | 1010 |
| WNAX | 570 |
| WNBF | 1500 |
| WNBH | 1310 |
| WNBJ | 1310 |
| WNBO | 1200 |
| WNBR | 1430 |
| WNBW | 1200 |
| WNBX | 1200 |
| WNBZ | 1290 |
| WNJ | 1450 |
| WNOX | 560 |
| WNRC | 1440 |
| WNYC | 570 |
| WOAI | 1190 |
| WOAN | 600 |
| WOAX | 1280 |
| WOBT | 1310 |
| WOBU | 580 |
| WOC | 1000 |
| WOCL | 1210 |
| WODA | 1250 |
| WODX | 1410 |
| WOI | 640 |
| WOKO | 1440 |
| WOL | 1310 |
| WOMT | 1210 |
| WOOD | 1270 |
| WOPI | 1500 |
| WOQ | 1300 |
| WOR | 710 |
| WORC | 1200 |
| WORD | 1490 |
| WOS | 630 |
| WOV | 1130 |
| WOW | 590 |
| WOWO* | 1180 |
| WPAW | 1210 |
| WPCC | 560 |
| WPCH | 810 |
| WPEN | 1500 |
| WPG | 1100 |

| Station | kc |
|---|---|
| WPOE | 1370 |
| WPSC | 1230 |
| WPTF | 680 |
| WQAM | 560 |
| WQAN | 880 |
| WQAO | 1010 |
| WPAP | 1010 |
| WQBC | 1360 |
| WQDM | 1370 |
| WRAF | 1200 |
| WRAK | 1370 |
| WRAW | 1310 |
| WRAX | 1020 |
| WRBI | 1310 |
| WRBJ | 1370 |
| WRBL | 1200 |
| WRBQ | 1210 |
| WRBT | 1370 |
| WRBU | 1210 |
| WRC | 950 |
| WRDA | 900 |
| WREC | 600 |
| WREN | 1220 |
| WRHM | 1250 |
| WRJN | 1370 |
| WRK | 1310 |
| WRNY | 1010 |
| WRR | 1280 |
| WRUF | 830 |
| WRVA(*) | 1150 |
| WSAI | 1330 |
| WSAJ | 1310 |
| WSAN | 1440 |
| WSAR | 1450 |
| WSAZ | 580 |
| WSB | 740 |
| WSBC | 1210 |
| WSBT | 1230 |
| WSFA | 1410 |
| WSGH | 1400 |
| WSDA | 1400 |
| WSIX | 1210 |
| WSJC | 1310 |
| WSM | 650 |
| WSMB | 1320 |
| WSMK | 1380 |
| WSPA | 1420 |
| WSPD | 1340 |
| WSSH | 1410 |
| WSUI | 880 |
| WSVS | 1370 |
| WSYR | 570 |
| WTAD | 1440 |
| WTAG | 580 |
| WTAM(*) | 1080 |
| WTAQ | 1330 |
| WTAR | 780 |
| WPOR | 780 |
| WTAW | 1120 |
| WTAX | 1210 |
| WTBO | 1420 |
| WTFI | 1450 |
| WTIC | 1060 |
| WTMJ | 620 |
| WTNT | 1470 |
| WTOC | 1260 |
| WWAE | 1200 |
| WWJ | 920 |
| WWL | 850 |
| WWNC | 570 |
| WWRL | 1500 |
| WWVA(*) | 1180 |
| KBTM | 1200 |
| KCRC | 1370 |
| KDB | 1500 |
| KDFN | 1210 |
| KDKA | 980 |
| KDLR | 1210 |
| KDYL | 1290 |
| KECA | 1430 |
| KEJK | 710 |
| KELW | 780 |
| KEX(*) | 1170 |
| KFAB | 770 |
| KFBB | 1280 |
| KFBK | 1310 |
| KFBL | 1370 |
| KFDM | 560 |
| KFDY | 550 |
| KFEL | 920 |
| KFEQ | 680 |
| KFGQ | 1310 |
| KFH | 1300 |
| KFHA | 1200 |
| KFI | 640 |
| KFIF | 1420 |
| KFIO | 1230 |
| KFIU | 1310 |
| KFIZ | 1420 |
| KFJB | 1200 |
| KFJF | 1480 |
| KFJI | 1370 |

| Station | kc |
|---|---|
| KFJM | 1370 |
| KFJR | 1300 |
| KFJY | 1310 |
| KFKA | 880 |
| KFKB | 1050 |
| KFKU | 1220 |
| KFLV | 1410 |
| KFLX | 1370 |
| KFMX | 1250 |
| KFNF | 890 |
| KFOR | 1210 |
| KFOX | 1250 |
| KFPL | 1310 |
| KFPM | 1310 |
| KFPY | 1340 |
| KFQD | 1230 |
| KFQU | 1420 |
| KFQW | 1420 |
| KFRC | 610 |
| KFRU | 630 |
| KFDS | 600 |
| KFSG | 1120 |
| KFUL | 1290 |
| KFUM | 1270 |
| KFUO | 550 |
| KFUP | 1310 |
| KFVD | 1000 |
| KFVS | 1210 |
| KFWB | 950 |
| KFWF | 1200 |
| KFWI | 930 |
| KFWM | 930 |
| KFXD | 1420 |
| KFXF | 920 |
| KFXJ | 1310 |
| KFXM | 1210 |
| KFXR | 1310 |
| KFXY | 1420 |
| KFYO | 1420 |
| KFYR | 550 |
| KGA | 1470 |
| KGAR | 1370 |
| KGB | 1330 |
| KGBU | 900 |
| KBGX | 1310 |
| KGBZ | 930 |
| KGCA | 1270 |
| KGCI | 1370 |
| KGCR | 1210 |
| KGCU | 1200 |
| KGCX | 1310 |
| KGDA | 1370 |
| KGDE | 1200 |
| KGDM | 1100 |
| KGDY | 1200 |
| KGEF | 1300 |
| KGEK | 1200 |
| KGER | 1360 |
| KGEW | 1200 |
| KGEZ | 1310 |
| KGFG | 1370 |
| KGFI | 1500 |
| KGFJ | 1200 |
| KGFK | 1200 |
| KGFL | 1370 |
| KGFW | 1310 |
| KGFX | 580 |
| KGGC | 1420 |
| KGGF | 1010 |
| KGGM | 1230 |
| KGHF | 1320 |
| KGHI | 1200 |
| KGHL | 950 |
| KGIQ | 1320 |
| KGIR | 1360 |
| KGIW | 1420 |
| KGIX | 1420 |
| KGIZ | 1500 |
| KGJF | 890 |
| KGKB | 1500 |
| KGKL | 1370 |
| KGKO | 570 |
| KGKX | 1420 |
| KGKY | 1500 |
| KGMB | 1320 |
| KGMC | 1310 |
| KGMD | 1500 |
| KGMP | 1210 |
| KGO | 790 |
| KGNF | 1430 |
| KGNO | 1210 |
| KGRS | 1410 |
| KGU | 940 |
| KGW | 620 |
| KGY | 1200 |
| KHJ | 900 |
| KHQ | 590 |
| KICK | 1420 |
| KID | 1320 |
| KIDO | 1250 |
| KIT | 1310 |
| KJBS | 1070 |

| Station | kc |
|---|---|
| KJR | 970 |
| KLCN | 1290 |
| KLO | 1370 |
| KLPM | 1420 |
| KLRA | 1390 |
| KLS | 1440 |
| KLX | 880 |
| KLZ | 560 |
| KMA | 930 |
| KMBC | 950 |
| KMED | 1310 |
| KMIC | 1120 |
| KMJ | 1210 |
| KMMJ | 740 |
| KMO | 860 |
| KMOX(*) | 1110 |
| KFQA | 1090 |
| KMTR | 570 |
| KNX | 1050 |
| KOA | 830 |
| KOAC | 550 |
| KOB(*) | 1170 |
| KOCW | 1400 |
| KOH | 1370 |
| KOIL | 1260 |
| KOIN | 940 |
| KOL | 1270 |
| KOMO | 920 |
| KONC | 1370 |
| KOOS | 1370 |
| KORE | 1420 |
| KOY | 1390 |
| KPCB | 1500 |
| KPJM | 1500 |
| KPO | 680 |
| KPOF | 880 |
| KPPC | 1210 |
| KPQ | 1500 |
| KPRC | 920 |
| KPSN | 1360 |
| KPWF | 1490 |
| KQV | 1380 |
| KQW | 1010 |
| KRE | 1370 |
| KREG | 1500 |
| KRGV | 1260 |
| KRLD(*) | 1070 |
| KRMD | 1310 |
| KRSC | 1120 |
| KSAC | 580 |
| KSAT | 1240 |
| KSCJ | 1330 |
| KSD | 550 |
| KSEI | 900 |
| KSL(*) | 1190 |
| KSMR | 1200 |
| KSO | 1380 |
| KSOO(*) | 1100 |
| KSTP | 1460 |
| KTAB | 560 |
| KTAP | 1420 |
| KTAR | 620 |
| KTBI | 1300 |
| KTBR | 1300 |
| KTBS | 1450 |
| KTHS(*) | 1070 |
| KTLC | 1500 |
| KTM | 780 |
| KTNT(*) | 1160 |
| KTRH | 1120 |
| KTSA | 1290 |
| KTSL | 1310 |
| KTSM | 1310 |
| KTUE | 1420 |
| KTW | 1270 |
| KUJ | 1500 |
| KUOA | 1390 |
| KUSD | 890 |
| KUT | 1500 |
| KVEP | 1500 |
| KVI | 760 |
| KVL | 1370 |
| KVOA | 1260 |
| KVOO(*) | 1130 |
| KVOS | 1200 |
| KWCR | 1310 |
| KWEA | 1210 |
| KWG | 1200 |
| KWJJ | 1060 |
| KWK | 1350 |
| KWKC | 1370 |
| KWKH | 850 |
| KWLC | 1270 |
| KWSC | 1220 |
| KWWG | 1260 |
| KXA | 570 |
| KXL | 1420 |
| KXO | 1200 |
| KXRO | 1310 |
| KYA | 1230 |
| KYW(*) | 1140 |
| KFKX | 1020 |

# When to Deduct for the Resistance of the Meter Used in Tests

If a low value is used for each potentiometer, say 1,000 ohms, it is best to turn off the current from the battery whenever a reading is completed and while readjusting for another because there is an appreciable drain from the battery. When values as high as 10,000 ohms are used the current is relatively small.

An inexpensive 0 to 1 milliammeter having an internal resistance of 88 ohms is available for use as current indicator. More expensive meters of the same range having only 27 ohms internal resistance can also be obtained. It should be remembered that, for any given type of meter, the greater the maximum scale reading the lower the internal resistance of the meter. Thus a milliammeter having a range of 0 to 100 milliamperes has a resistance of one ohm and one of the same type having a range of 0 to 1 milliampere, 27 ohms, the resistance increasing with the sensitivity.

Whatever current meter is used, its internal resistance should be ascertained so that it may be subtracted from the measured resistance in case it is necessary. Whether to deduct it or not depends on percentages. The meters used as a rule are accurate to one per cent. and the reading may deviate still more, possibly as high as five per cent. Hence if the internal resistance is less than five per cent. of the measured value of the total resistance it is not worth while to make the deduction.

# FIGHT IS BEGUN TO ELIMINATE CLEAR CHANNELS

Washington.

The primary ailment of broadcasting, according to Commissioner Harold A. Lafount of the Federal Radio Commission, is that there are "entirely too many stations on the limited number of available channels." Cramming of more than 600 stations on the 90 available broadcast channels has resulted in inter-channel interference and heterodyne whistles, he said.

Broadcasting on the whole is not a profitable business and this, he declared, leads to "too much competition in certain localities, resulting in the presenting of mediocre programs with an excessive amount of advertising."

The Commissioner was optimtistic about the future of television, and declared that both television and synchronization of broadcasting stations on the same channel are in sight, and that broadcasting stations will be permitted to use power up to a maximum of 100,000 watts. Regarding television and synchronization, he said that both "are in the experimental stages and will require millions of dollars and some few years to perfect."

**Wants Clear Channels to Stay**

Commissioner Lafount is opposed to the elimination of the 40 cleared channels, saying that the operation of two stations on the same wave at great geographical separation does not work out. Although a station operating on one coast cannot be heard consistently on the other it is capable of interfering with a station operating on the same wave, he said. Hence it is not practical, he contends, to let two stations operate on the same channel, as some persons insist should be done.

Power, he declared, is the only real means of reducing the effect of static, both natural and man-made, and therefore power is necessary to provide the rural and suburban listener with the same clear reception as is available to the city listener, he maintained. For that reason he said, he is a believer in cleared channels and high power for stations. He admitted that a number of small local, low-power stations for local programs is necessary, but asserted that most persons are chiefly interested in the programs broadcast from the stations in the metropolitan centers.

**Robinson's Proposal**

Elimination of all 40 cleared channels set aside for the exclusive use of high power stations will be proposed to the Commission by Commissioner Ira E. Robinson, former chairman. He claims that this is the only practical solution of the radio problem.

"We cannot have so many favored 'big fellows' as now without having too many 'under dogs,'" he said.

"I would devote all cleared channels to regional uses," he declared, "thereby relieving the squeeze which is at present so interfering among the small stations. There is no reason in the world why any one of the channels now cleared can not be used by at least two stations widely separated geographically, thereby releasing one channel for use elsewhere.

"There is only one practical solution to the radio problem in America, and that is through dependable regional stations."

# *Forum*

**Musical Taste and Mentality**

YOU have taken the stand in favor of popular music and jazz and similar diddies that the air is filled with. I wish to come in defense of chamber and symphonic music.

Jazz is intended for and is good enough for those whose souls are in their feet. It appeals only to our primitive instincts, which are simple enough. But even this is a mere invention by those who make jazz an easy-running and well-paying business.

Syncopation beats in music are nothing new. The best classical composers have made use of them when necessary. Those who can feed themselves exclusively on jazz are like cows who thrive on grass only.

It certainly is revolting to see how this pest of organized sound is being fed to the radio listeners. The advertisers who monopolize the air conclude that the prospective patrons are fit for nothing better. They give awkward quartets, silly dialogues in which the man speaks in bass and the woman giggles hilariously at random, and the jungle jazz. The morons send in applause cards. The result is a deplorable condition for those who know better. The old saying still holds good, "Tell me who your friends are and I'll tell you who *you* are." One can judge the mentality of the individual by the type of music he prefers. We want more and better music.

J. KAHN,
2117-83rd St., Brooklyn, N. Y.

* * *

**Can't Find Quiet Set**

MR. STRUDEMAN, in the April 12th issue gives some very good advice when he tells us to "read RADIO WORLD carefully. But in one direction his opportunities for observing are limited. I fully agree with him that AC receivers are noisy, generally, but cannot agree that they are invariably so. Nor can I agree that battery sets are always quiet.

In over five years of trial I have never succeeded in producing a receiver that I considered "quiet" either DC or AC. But that does not prove it can't be done.

For distance and selectivity the old battery receivers are yet to be surpassed. The first set I had was an old-style Radiola second harmonic Super of the semi-portable coffin box type. The first station I ever tuned in from my home in Southwestern Michigan was WEAF at 4 p. m. of a day in June. I challenge any high-gain screen grid modern receiver to beat it. It was also the only set from which I ever heard KGO from the same location. And all on only six 199 tubes working on dry cells.

But there are other considerations. I became thoroughly disgusted with all storage batteries long before radio was popularized and that disgust has never subsided. Anything that will get rid of storage batteries is a joy.

It is common practice to compare radios with automobiles and along this line I might say that my neighbor does everything with his Ford that I do with my Packard—but still I prefer the Packard. And for the same reason my multi-tube AC receiver is a far greater delight than any battery outfit.

Now, I am not going to quarrel with Mr. Strudeman nor any one else but just wanted to chat a little.

The greatest trouble with the radio business today from the viewpoint of the consumer is not from the receivers but from the press agents of those who make and sell them.

A. B. GARDNER,
Box 296, Coconut Grove, Fla.

# TELEPHONE CO. DEMONSTRATES 2-WAY VISION

Two-way television telephony was demonstrated for the first time recently by the officials of the American Telephone and Telegraph Company and the Bell Telephone Laboratories in New York City. In 1927 the same companies demonstrated one-way television telephony when President Hoover's voice and image were observed in New York by a group gathered in the Bell Laboratories. The apparatus used in the present demonstration is a refinement of the apparatus used at that time.

In discussing the system Walter S. Gifford, President of the American Telephone and Telegraph Company, said:

"On account of its present complexity and high cost," he said, "no substantial commercial field is yet in sight for television requiring good images. There is still a large amount of technical work to do which gives promise of decided improvement over the means and methods now available.

**Distance No Barrier**

"While this equipment has for convenience been installed only a few miles apart," he continued, "and while wire circuits in ordinary underground telephone cable have been employed for the transmission channels, it might equally well have been installed hundreds or thousands of miles apart.

"It might employ either wire or radio for the connecting channels, as was shown in the initial demonstration of television by the American Telephone and Telegraph Company in April, 1927. With suitable telephone channels of whatever sort available, the element of distance is not a controlling factor, although in this form of electrical communication, as in all others, greater distance, ordinarily involves somewhat greater complexity and expense for channel facilities.

**Complicated Indeed**

"Despite the fact that the research and development work of the past three years," said Mr. Gifford, "has resulted in a great improvement and simplification of the equipment required for television, it is still necessarily complicated and expensive, requiring expert attention and large units of apparatus. These facts arise out of the inherent technical requirements for satisfactory television transmission. While substantial progress has been made on the technical side, the future commercial possibilities of television are still uncertain. In line with our long established policy of fully exploring and developing every field which gives promise of possible improvement in extension of electrical communication, we expect to continue our television work."

The new apparatus is called the Ikonophone, coined from two Greek words meaning image and sound. The principle of the system is based on a loudspeaking telephone in conjunction with a television apparatus.

**SMOKING STAND SET**

The construction of an AC screen grid receiver to be housed in a smoking stand, intended for the present issue, will be published in "Radio World" next week, May 3rd.

# MB-29

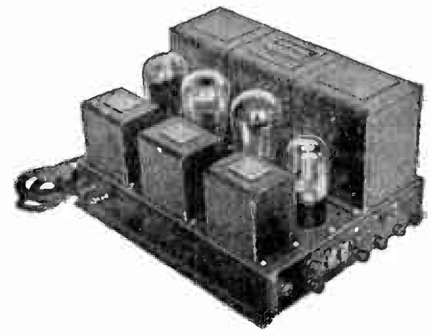
AC TUNER — WRITE FOR WHOLESALE PRICES!

## Push-Pull Amplifier

The National Velvetone Push-Pull Power Amplifier (shown at right) consists of an AC-operated filament-plate supply, with two stage transformer audio amplifier and output transformer built in. Made only for 110-V., 50-60 cycles. Sold only in completely wired form, licensed under RCA patents.

The new Power Amplifier has been developed and built to get the very most out of the MB-29. It is a combination power supply and audio amplifier, using a 280 tube for a rectifier, one stage of transformer audio with a 227 tube and a stage of push pull amplification with two 245s. It furnishes all power for itself and for the MB-29, as well as the audio channel. Order catalog PPPA, list price, completely wired and equipped with phonograph jack, (less tubes) $97.50. Your price.

WRITE FOR WHOLESALE PRICES

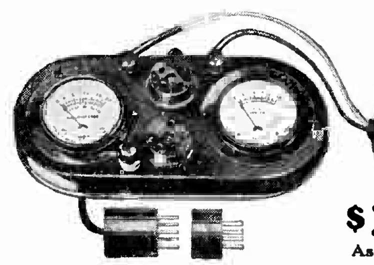


View of National Velvetone Push-Pull Power Amplifier, an expertly made A, B and C supply and audio amplifier, producing marvelous tone quality.

**GUARANTY RADIO GOODS CO.**
143 WEST 45TH STREET NEW YORK CITY

# SEPARATE TESTER COMBINATION

Consists of two-meter assembly in neat black metal case, with an external high resistance meter. The two meters in the case read (a) 0-20, 0-100 milliamperes; (b) 0-10 volts, AC or DC, same meter reads both. The external high resistance meter reads 0-600 volts, AC or DC (same meter reads both). Thus you can test any plate current up to 100 ma., any filament voltage, AC or DC, up to 10 V., and any plate voltage, or line voltage or other AC or DC voltage, up to 600 volts. Five-prong plug, screen grid cable, and 4-prong adapter included. Order Cat. ST-COMB @......$11.00
2-meter assembly, cable plugs, Cat. 215 @ $7.00
0-600 AC-DC meter alone, Cat. M600 @ $4.95

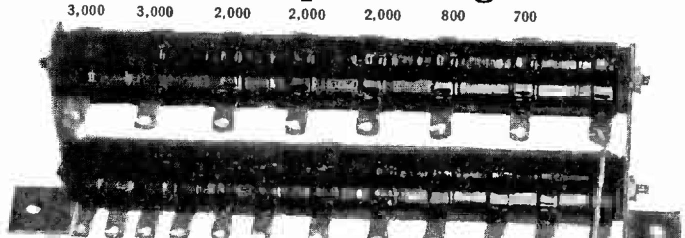


**$11.00**
As Illustrated

**Guaranty Radio Goods Co., 143 West 45th St., N. Y. City**

# New Multi-Tap Voltage Divider

3,000 3,000 2,000 2,000 2,000 800 700



0 50 50 50 100 200 400 450 500 550 600 650

*The resistance values between the twenty taps of the new Multi-Tap Voltage Divider are given above. The total is 17,100 ohms and affords nineteen different voltages.*

*THE Multi-Tap Voltage Divider consists of two rugged, expertly engineered wire-wound, enamelled resistors, mounted in series, one atop the other, with twenty lugs, providing all necessary choice of voltages without the uncertainty of adjustable variable resistance.*

The Multi-Tap Voltage Divider has a total resistance value of 17,100 ohms, of which 3,600 ohms are on the lower bank and 13,500 on the upper bank. Without the zero voltage lug (at lower left) the total number of useful lugs is nineteen. The resistance stated are those between respective lugs and are to be added together to constitute 17,100 ohms total.

The unit is serviceable in all installations where the total current drain does not exceed 100 milliamperes. Extreme care has been exercised in the manufacture of the Multi-Tap Voltage Divider. It is mounted on brackets insulated from the resistance wire that afford horizontal mounting of the unit on baseboards and subpanels.

There long has been a need for obtaining any necessary intermediate voltage, including all biasing voltages, from a Multi-Tap Voltage Divider, but each lug has to be put on individually by hand, and soldered, so that manufacturing difficulties have left the market barren of such a device until now.

The Multi-Tap Voltage Divider is useful in all circuits, including push-pull and singe-sided ones, where the current rating of 100 milliamperes is not seriously exceeded and the maximum voltage is not more than 400 volts. If good ventilation is provided, this rating may be exceeded 20 per cent.

The expertness of design and construction will be appreciated by those whose knowledge teaches them to appreciate parts finely made.

When the Multi-Tap Voltage Divider is placed across the filtered output of a B supply which serves a receiver, the voltages are in proportion to the current flowing through the various resistances. By making connection of grid returns to ground, the lower voltages may be used for negative bias by connecting filament center, or, in 227 and 224 tubes, cathode to a higher voltage.

If push-push is used, the current in the biasing section is almost doubled, so the midtap of the power tubes' filament winding would go to a lug about half way down on the lower bank.

Order Cat. MTVD at $3.95.

Guaranty Radio Goods Co.,
143 W. 45th St., New York City.
(Just East of Broadway.)

Please send C.O.D. one Multi-Tap Voltage Divider. Total resistance, 17,100 ohms; twenty taps.

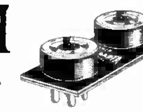
Name ..........................................

Address ..........................................

City ........................... State ............

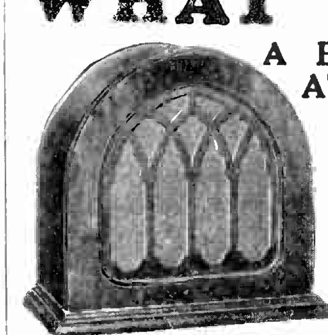
# LYNCH

**TUBADAPTA**
*For Better TONE*



List Price..$2.50
Improves reception and prolongs life of expensive power tubes. Used in last audio stage. Write for descriptive circular and complete catalogue Lynch Guaranteed Radio Products.
LYNCH MFG. CO., Inc., 1775 B'way, N. Y.

# WHAT A BARGAIN AT ONLY $4.89!!



**Ansonia Gothic Speaker, a tremendous bargain at.......$4.89!**

A loudspeaker that gives you real performance, that stands up to a 171 or 171A tube without requiring an output filter, and that works splendidly from output filters in sets using 210, 245 or 250, single or push-pull, in a genuine walnut cabinet, all at less than the price of a good magnetic unit alone! And the magnetic unit in this Ansonia Speaker is of the very best Ansonia type.

The cabinet is of the popular Gothic type, and is a beauty indeed. Why, the cabinet alone cost the manufacturer in thousand lots more than the price now asked for the complete speaker.

Use this speaker on any set, battery-operated or AC, and you'll be delighted.

GUARANTY RADIO GOODS CO.
143 West 45th Street, New York, N. Y.
Just East of Broadway

Please ship C. O. D. one Ansonia Gothic magnetic speaker, in genuine walnut cabinet, @ $4.89 plus post office charges, on 5-day guaranty of quick refund of purchase price if I am not satisfied with speaker for any reason.

Please send me a square model (not Gothic), but same unit in square walnut cabinet @ $4.24.

Name ..........................................

Address ..........................................

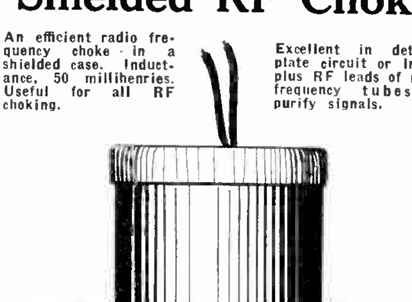
City ............................State .............

**5-day Money-Back Guaranty.**

# Shielded RF Choke

An efficient radio frequency choke in a shielded case. Inductance, 50 millihenries. Useful for all RF choking.

Excellent in detector plate circuit or in B-plus RF leads of radio frequency tubes to purify signals.



**Insulated outleads are provided on this RF choke. Order Cat. RF-CH—50 at 50c.**

**Guaranty Radio Goods Co.**
143 West 45th Street, New York City

**TRIAL SUBSCRIPTION, 8 WEEKS, $1.00. Send $1 and we will send you Radio World for 8 weeks, postpaid. RADIO WORLD, 145 West 45th St., N. Y. City.**

# High Efficiency Tuning Coils

Wound with non-insulated wire plated with genuine silver, on grooved forms, these coils afford high efficiency because of the low resistance that silver has to radio frequencies. The grooves in the moulded bakelite forms insure accurate space winding, thus reducing the distributed capacity, and keep the number of turns and separation constant. Hence the secondary reactances are identical and ideal for gang tuning.

The radio frequency transformer may be perpendicularly or horizontally mounted, and has braced holes for that purpose. It has a center-tapped primary, so that it may be used as antenna coil with half or all the primary in circuit, or as interstage coupler, with all the primary on a screen grid plate circuit, or half the primary for any other type tubes, including pentodes.

The three-circuit tuner has a center-tapped primary, also. This tuner is of the single hole panel mount, but may be mounted on a chassis, if preferred, by using the braced holes.

The secondaries are for .0005 mfd. tuning only. There are no models for .00035 mfd.

These coils are excellent indeed for popular circuits like the Diamond of the Air and tuned radio frenquency.

Diameters of form, 3 inches.
Two-winding coil, order Cat. GRF @ 99c.
Three-winding coil, order Cat. G-3 CT @ $1.49.

GUARANTY RADIO GOODS CO.
145 West 45th St., N. Y. City
(Just East of Broadway)

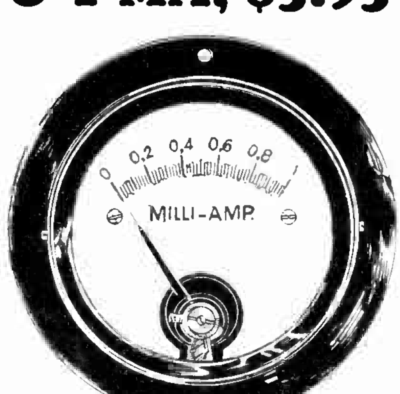
Please mail me C.O.D. at stated prices, plus few cents extra for postage, the following coils on 5-day money-back guaranty:
☐ GRF at 99c. ☐ G3cT at $1.49

Name ..............................................

Address ..............................................

City ...................... State ....................

# 0-1 MA, $5.95




*Here is a 0-1 milliammeter, accurate to plus or minus 1%, clearly legible to two-one hundredths of a milliampere at any reading (20 microamperes). This expertly made precision instrument is offered at the lowest price so far for a 0-1 ma. Order Cat. FO-1 at* $5.95. *C. O. D.*

*Internal resistance 88 ohms.*

**Guaranty Radio Goods Co.
143 West 45th Street,
New York City**

**ARISTOCRAT FLOOR SPEAKER**
**With Molded Wood Horn and Horn Motor built in. Good value. $12.00. Acoustical Engineering Associates, 143 W. 45th St., N. Y. C.**

# *115 Circuit Diagrams*

## of Latest Commercial Receivers and Power Supplies

SCHEMATIC diagrams of the latest factory-made receivers, giving the manufacturer's name and model number on each diagram, are now obtainable for the first time—including the most important screen grid receivers. These diagrams were collated by John F. Rider, author of "Trouble Shooter's Manual." The 115 diagrams, each in black and white on sheets 8½ x 11 inches, constitute a supplement to the diagrams contained in "Trouble Shooter's Manual."

There is no duplication of the diagrams that appear in the "Manual." The 115 diagrams are additional and being up-to-date the diagram presentation started in the "Manual."

## All Owners of "Manual" Need These Diagrams

YOU triple the value of "Trouble Shooter's Manual" by getting these 115 new diagrams of latest receivers and power supplies. Every service man needs all the diagrams he can get. Here is the list of 115 diagrams, known as Catalog SP-No. 1:

Audiola 30B and 7330 Screen Grid
Balkite Model F
Crosley 41A, 42 A.C.
Crosley 609, 610 A.C.
Crosley 20, 21, 22 screen grid
Crosley 30S, 31S, 33S screen grid
Crosley 804 A.C.
Crosley, 40S, 41S, 42S, 82S screen grid
Crosley 60S, 61S, 62S screen grid
Sonora Electric phonograph 7P
Sonora A30, A32
Sonora B31 screen grid
Sonora A36 Sonora A40 Sonora A44
Kennedy royal 80 Kennedy model 10
Kennedy model 20 screen grid
Stewart-Warner 900 A.C.
Stewart-Warner 950 battery screen grid
Stewart-Warner 950 A.C. screen grid
Stewart-Warner 950 D.C. screen grid
Automatic Electric model B screen grid
Radiola 44 screen grid
Radiola 47 screen grid Radiola 66
Majestic 90
Majestic 9P6 power unit
Majestic 9P3 power unit
Stromberg-Carlson 641 screen grid
Stromberg-Carlson 642 screen grid
Stromberg-Carlson 846 screen grid
Edison R1, R2 and C2
Edison R1, R2 and C2 (25 cycles)
Edison R4, R5 and C4
Parts list for Edison R4, R5 and C4
Edison C1
American Bosch 54 D.C. screen grid
Victor R32 and RE45
Grebe SK 4 A.C. screen grid (early model)
Grebe SK 4 A.C. screen grid (late model)
Grebe SK 4 D.C. screen grid
Grebe 428 DeLuxe console
Traveler A.C. power pack
Erla 224 A.C. screen grid
Silver-Marshall 30B screen grid
Silver-Marshall 30C screen grid
Silver-Marshall 30D screen grid
Silver-Marshall 30E screen grid
Eveready 1, 2, and 3 Eveready series 30
Eveready series 40
Eveready series 53 screen grid
Steinite 40, 50 and 102 Steinite 50 power unit
All American Mohawk 96 screen grid (60 cycle)
All American Mohawk 90 (25 cycle)
All American Mohawk 80 (60 cycle)
All American Mohawk 70, 73 and 75
Gulbransen Model C (early model)
Gulbranson Model C (late model)
Bremer-Tully 7-70 and 7-71
Bremer-Tully 81 and 82
Earl 21, 22 Earl 31, 32 Earl 41, 42
Philco 65 screen grid Philco 76 screen grid Philco 87
Philco 95 screen grid
Peerless Electrostatic series, screen grid
Fada 20 and 20Z Fada 22 battery
Fada 25 and 252 screen grid
Fada 25 and 25Z screen grid with M250 and M250Z Electric units
Fada 35 and 35Z screen grid Fada 75 and 77 screen grid
Brunswick 5 NC8 Radio Chassis Schematic
Brunswick 5 NC8 Audio Chassis Schematic
Brunswick 5 NC8 and 3 NC8 Audio Chassis Schematic
Brunswick 5 NC8 cabinet wiring
Brunswick 3 NC8 Radio Chassis Schematic
Brunswick 3 NC8 cabinet wiring
Brunswick S14, S21, S31, S81, S82 screen grid Radio Chassis Schematic
Brunswick S14, S21, S31, S81, S82 screen grid Radio Chassis Actual
Brunswick S14, S21, S81, S82 Audio Chassis Schematic (25 cycle)
Brunswick S14, S21, S81, S82 Audio Chassis Schematic (60 cycle)
Brunswick S14, S21, S81, S82 Audio Chassis Actual (25 cycle)
Brunswick S14, S21, S81, S82 Audio Chassis Actual (60 cycle)
Brunswick S31, Audio Chassis Schematic (60 cycle)
Brunswick S31 Audio Chassis Actual (60 cycle)
Brunswick 3 KR8 cabinet wiring
Brunswick 3 KR8 Radio Chassis
Brunswick 3 KR8 Audio Chassis Schematic
Brunswick 3 KR8 Audio Chassis Actual
Brunswick 5 NO Radio Chassis Schematic
Brunswick 5 NO Socket Power Schematic
Brunswick 5 NO Socket Power Actual
Brunswick 3 KR0 and 3 KR6 Radio Chassis
Brunswick 3 KR0 and 3 KR6 Socket Power
Brunswick 5KR, 5KRO, 2KRO Socket Power
Brunswick 5KR, 5KRO, 3KRO, 2KRO, 5KR6 Socket Power
Brunswick 5KR, 5KRO, 2KRO, 5KR6 Radio Chassis
Amrad Bel-Canto series
Sparton 89, Sparton 89A, Sparton 49
Sparton ensemble
Sparton 931, 301 D.C., Sparton 931 A.C.
Sparton 110 A.C., Sparton 301 A.C.

Here is an opportunity to obtain these hard-to-get wiring diagrams of modern radio receivers. The sheets are punched with three standard holes for loose-leaf binding. Each diagram is on a separate page. As you will see by glancing through the above list, these diagrams include the popular receivers of the day. Electrical constants are indicated on the majority of the diagrams and in many cases the actual chassis layouts are shown with color coding.

These schematics will save you a good deal of time. No more tracing circuits! The diagrams are a necessary part of your working equipment.

We cannot offer individual drawings. Please use coupon below.

Subscribe for RADIO WORLD for six months at the regular price, $3.00, and have these diagrams delivered to you free! No other premium with this $3.00 offer!

**RADIO WORLD, 145 West 45th Street, New York, N. Y.
Just East of Broadway.**

☐ Enclosed find $3.00 for which send me RADIO WORLD for six months (26 issues, one each week for 26 weeks) and as a premium send me postpaid, FREE, Cat. SPK No. 1, consisting of 115 separate diagrams, compiled by John F. Rider, as listed in your advertisement.

☐ Enclosed find $6.00 for which send me RADIO WORLD for one year (52 issues) and as a premium send Rider's "Trouble Shooter's Manual" free.

☐ Enclosed find $9.00. Send me RADIO WORLD for a year and a half (78 issues) and send both of above premiums free.

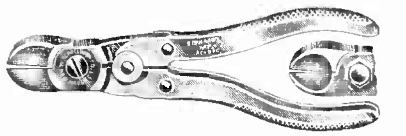
☐ This is a renewal of an existing subscription. (Put cross in square, if true.)

Name ..............................................

Address ..............................................

City .............................................. State ..............................

# Spring Action Diagonal Nipper



A DIAGONAL cutting nipper is the second most useful tool for radio work, next to the soldering iron. Non-friction spring action adds convenience of use, as the handles are sprung back just far enough for a comfortable grip, and the jaws are closed by easy pressure or the handles.

For cutting wire, a constant operation in your work, this tool is most serviceable, as it makes a clean cut, right through fuzzy insulation as well as through metal. The cut is far more incisive than with the common diagonal cutting pliers. With the diagonal nipper you can cut wire not only along its length, but wherever it may be attached, since accessibility is perfect. A cut can be made any place where the diagonal nipper can enter, since the cutting can be done at the tip. Pliers with diagonal cutters can only ply, not cut, at the extremity.

With the diagonal nipper insulation can be bared from wire ends for soldering. Also screws up to 8/32 machine screw used in radio can be nipped off at any point with one firm application of pressure with one hand.

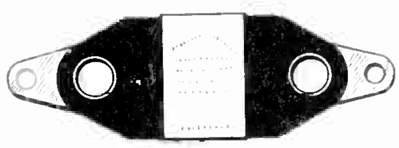
The device is used extensively in radio set factories and by custom set builders and radio experimenters.

Size 5½" long; weight 1⅝ lbs.; material, drop forged steel; finish, nickel plated.

Send $3.00 for 6 months' subscription for Radio World and ask for No. 177 Nipper, free. RADIO WORLD, 145 West 45th Street, New York, N. Y.

☐ Put cross here if renewing subscription.

# FIXED CONDENSERS!



*Fixed Condenser, Shown Actual Size.*

**Dubilier Micon fixed condensers, type 642, removed from receivers, are available at following capacities and prices.**

| | | | |
|---|---|---|---|
| .0001 mfd. | 10c | .006 | 20c |
| .00025 mfd. | 10c | .00025 with clips | 20c |
| .0003 mfd. | 10c | | |
| .00035 mfd. | 15c | | |
| .001 | 17c | | |
| .0015 | 17c | | |
| .002 | 18c | | |

All are guaranteed electrically perfect and money back if not satisfied within five days.

**GUARANTY RADIO GOODS CO.**
143 WEST 45TH STREET

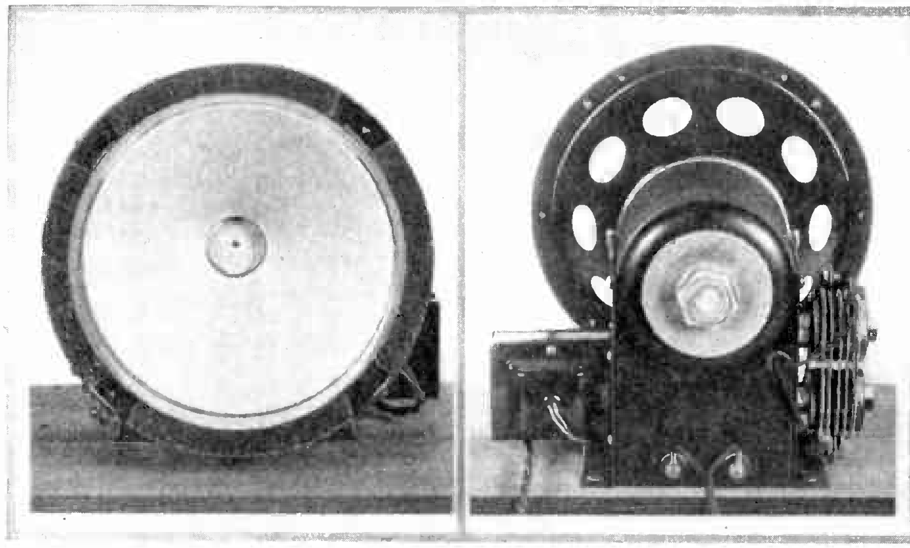
# BROADWAY-HOLLYWOOD

World's most intriguing places. Where famous stage, screen, radio stars live their lives. Intimate stories of their stage and personal doings in

NEW YORK **STAR** National Illustrated Amusement Weekly

Edited by Roland Burke Hennessy. Clever writers cover comedy, tragedy, fascination of professional life. Portraits and unusual pictures of favorites. 10c copy, $5 year (52 issues). SPECIAL: 12 issues $1. STAR. 1562 Broadway, New York.

# Nothing Finer Than This Dynamic in Tone Quality!



## Try This AC Dynamic Erla—No Matter on What Set and You Will Verify These Facts: Tone Unexcelled, sensitivity most remarkable

*TO WORK this speaker, put plug into AC wall socket, lamp socket or convenience outlet of set, connect speaker tips to output posts of set, and tune in.*

**Here are the technical data on the AC dynamic Erla:**

10 feet long power leads with plug
10 feet long speaker leads with one-inch terminal tips
Outside diameter of cone, 9 inches
Depth of speaker, 8 inches
Overall width of speaker, 9.5 inches
Mounting board, detachable, 10¾x12¾x⅞ inches
Burtex cone
Diameter of central magnet pole, 1.5 inches
Flexible spring mounting of tip of cone, and moving coil
Moving coil accurately center-mounted
Depth of magnet structure, 4.5 inches
Outside diameter of magnet structure, 4.5 inches
Built-in full-wave Westinghouse Rectox dry rectifier
Husky output transformer built in; heavy core, shielded
Superior workmanship
Thick felt buffers on front of cone edges
Built-in power transformer for rectifier
Will stand output of 250 tubes in push-pull and work superbly in any tubes, single or push-pull
Tone quality is unsurpassed

**$12.50**

## Our Guaranty!

We have had considerable experience with AC dynamic chasses, and it is our firm conviction this is the best one we have offered so far.

So convinced are we that you will be overjoyed from the reproduction afforded by this Erla chassis that we ask you to buy it at no risk to yourself whatsoever. Order one shipped C.O.D. Try it for five days. If for any reason you desire to return it in that time, do so and we will refund your purchase price and expressage you laid out. This widest guaranty applies only to the Erla chassis.

**Acoustical Engineering Associates**
143 West 45th Street New York, N. Y.

Please ship at once, express C.O.D., one Erla dynamic chassis, 110 volt AC, 50-60 cycles, as advertised, at $12.50, on a five-day guaranty or money-back if not completely satisfied, including cartage money, which applies to the Erla offer only.

Name ..........................................

Address ..........................................

City .................... State ..................

**PLEASE GIVE US TWO WEEKS for changing your address, showing new renewal expiration date, etc. Subscription orders are arriving in such large numbers that it takes two weeks to effectuate the change. RADIO WORLD, 145 West 45th St., N. Y. City.**

**RADIO WORLD'S BOOK SERVICE has been found of great value not only by radio fans, constructors, etc., but also by radio and other technical schools throughout the country. See the radio books advertisement in this issue.**

# Quick Action Classified Ads

## Radio World's Speedy Medium for Enterprise and Sales

**10 cents a word — 10 words minimum — Cash with Order**

AGENTS WANTED—Over 500,000 articles, low wholesale prices, directory with Keystone Post. Agents Mail Order Guide 25c. Morrion, 2305 Gratz, Philadelphia.

**AMAZING NEW LIQUID FLUX for soldering. Superior to anything ever used or money refunded. Large bottle $1. Sample 50c. Furmhold, 109-24 208th Street, Bellaire, N. Y.**

"AUDIO POWER AMPLIFIERS," by J. E Anderson and Herman Bernard, the first and only book on the subject. $3.50. Hennessy Radio Publications Corporation, 145 West 45th St., N. Y City.

BARGAINS in first-class, highest grade merchandise. B-B-L phonograph pick-up, theatre type, suitable for home, with vol. control, $6.57; phono-link pick-up with vol. control and adapter, $3.50; steel cabinet for HB Compact, $3.00; four-gang .00035 mfd. with trimmers built in, $1.95; .00025 mfd. Dubilier grid condenser with clips, 18c. P. Cohen, Room 1214, at 143 West 45th Street, N. Y. City.

YOU NEED Haan's "Radio Trouble Shooting." 328 pages of practical radio information. Price $3.00. Details on request. "Radio Service Magazine." $1.00 yearly. Sample copies ten cents. Radio Service Library, P.O. Box 4422, Crafton, Pittsburgh, Pa.

**ARISTOCRAT FLOOR SPEAKER—With Molded Wood Horn and Horn Motor built in. Great value. $14.00. Acoustical Engineering Associates, 143 W. 45th St., N. Y. C.**

**"EVERYBODY'S AVIATION GUIDE." By Maj. Page. $2 postpaid. Also "Modern Aircraft" by same author. $5. postpaid. Radio World, 145 W. 45th St.. N. Y. City.**

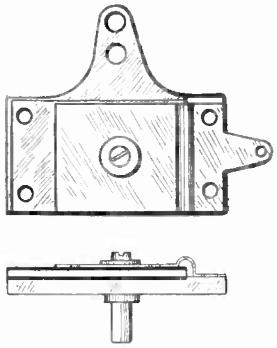
**LACAULT'S BOOK, "Superheterodyne Construction and Operation." and Radio World for 8 weeks for $1. Radio World, 145 W. 45th St., N. Y. City.**

**"MATHEMATICS OF RADIO."—A great help to everybody interested in radio. $2 postpaid. Radio World, 145 W. 45th St., N. Y. City.**

RADIO WORLD, a weekly paper published by Hennessy Radio Publications Corporation, from Publication Office, 145 West 45th Street, New York, N. Y. Vol. XVII, No. 6. Whole No. 422. April 26th, 1930. 15c per copy, $6.00 per year. [Entered as second-class matter, March, 1922, at the Post office at New York, N. Y., under act of March, 1879.] Roland Burke Hennessy, president and treasurer, M. B. Hennessy, vice-president; Herman Bernard, business manager and managing editor; J. E. Anderson, technical editor.

# *Accurate Tuning Condensers and Accessories*

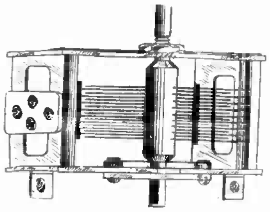
## EQUALIZER



CAT. EQ-100 AT 35c

The most precise and rugged equalizing condenser made, with 20 mmfd. minimum and 100 mmfd. maximum, for equalizing the capacity where gang condensers are used that are not provided with built-in trimmers. Turning the screw alters the position of the moving plate, hence the capacity. Cross-section reveals special threaded brass bushing into which screw turns, hence you can not strip the thread. Useful in all circuits where trimming capacity of 100 mmfd. or less is specified.

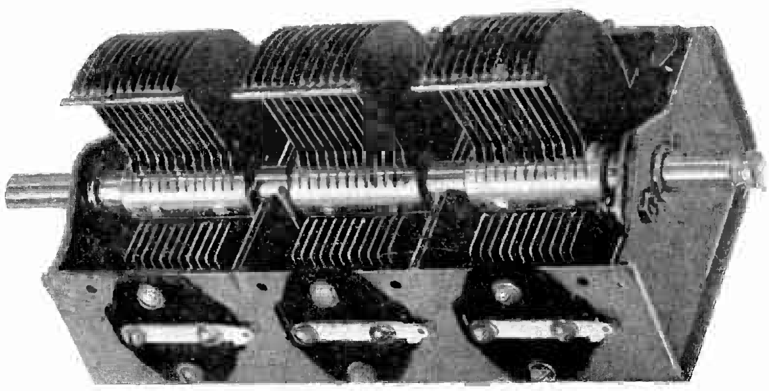
## SINGLE .00035



CAT. KH-3 AT 85c

A single .00035 mfd. condenser with nonremovable shaft, having shaft extension front and back, hence useful for ganging with drum dial or any other dial. Shaft is ¼ inch diameter, and its length may be extended ⅝ inch by use of Cat. XS-4. Brackets built in enable direct subpanel mounting, or may be plied off easily. Front panel mounting is practical by removing two small screws and replacing with two 3/34 screws ¾ inch long. Condenser made by Scovill Mfg. Co.

## THREE-GANG SCOVILL .0005 MFD.



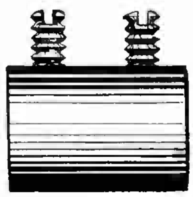
*One of the finest, strongest and best gang condensers ever made is this three-gang unit, each section of full .0005 mfd. capacity, with a modified straight frequency line characteristic. The net weight of this condenser is 3¼ lbs. Cat. SC-3G—5 at $4.80.*

HERE is a three-gang condenser of most superior design and workmanship, with an accuracy of at least 99¾ per cent. at any setting — rugged beyond anything you've ever seen. Solid brass plates perfectly aligned and protected to the fullest extent against any displacement except the rotation for tuning. It has both side and bottom mounting facilities. Shaft is ⅜ inch diameter and extends at front and back, so two of these three-gangs may be used with a single drum dial for single tuning control. For use of this condenser with any dial of ¼" diameter bore, use Cat. XS-8, one for each three-gang. Tension adjusters shown at right, other side of shaft.

### SALIENT FEATURES OF THE CONDENSER

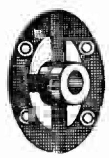
(1)—Three equal sections of .0005 mfd. capacity each.
(2)—Modified straight line frequency shape of plates, so-called midline.
(3)—Sturdy steel frame with rigid steel shields between adjacent sections. These shields minimize electric coupling between sections.
(4)—The frame and the rotor are electrically connected at the two bearings and again with two sturdy springs, thus insuring positive, low resistance contact at all times.
(5)—Both the rotor and the stator plates are accurately spaced and the rotor plates are accurately centered between stator plates.
(6)—Two spring stoppers prevent jarring when the plates are brought into full mesh.
(7)—The rotor turns as desired, the tension being adjustable by set-screw at end.
(8)—The shaft is of steel and is ⅜ inch in diameter.
(9)—Each set of stator plates is mounted with two screws at each side of insulators, which in turn are mounted with two screws to the frame. Thus the stator plates cannot turn sidewise with respect to the rotor plates. This insures permanence of capacity and prevents any possible short circuit.
(10)—Each stator section is provided with two soldering lugs so that connection can be made to either side.
(11)—The thick brass plates and the generous proportions of the frame insure low resistance.
(12)—Provision made for independent attachment of a trimmer to each section.
(13)—The steel frame is sprayed to match the brass plates.
(14)—The condenser, made by America's largest condenser manufacturer, is one of the best and sturdiest ever made, assuredly a precise instrument.

## RIGID AND FLEXIBLE LINKS



CAT. RL-3 AT 12c

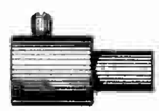
For coupling two ¼ inch diameter shafts, either coil shaft and condenser shaft, or two condenser shafts, a coupling link is used. This may be of the rigid type, all metal, where the linked units are not to be insulated. The rigid link, Cat. RL-3, has two set-screws, one to engage each shaft, and is particularly serviceable where a grounded metal chassis is used, as the returns then need no insulation.



CAT. FL-4 at 30c

Flexible insulated coupler for uniting coil or condenser shafts of ¼ inch diameter. Provides option of insulated circuits

## EXTENSION SHAFTS, TWO SIZES



CAT. XS-4 AT 10c

Here is a handy aid to salvaging condensers and coils that have ¼" diameter shafts not long enough for your purpose. Fits on ¼" shaft and provides ⅝" extension, still at ¼". Hence both the extension shaft and the bore or opening are ¼" diameter.

For condensers with ⅜" diameter shaft, to accommodate to dials that take ¼" shaft, order Cat. XS-8 at 15c.

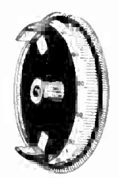
## .00035 TWO-GANG

A two-gang condenser, like the single type, KHS-3, but consisting of two sections on one frame, is Cat. KHD-3, also made by Scovill. The same mounting facilities are provided. There is a shield between the respective sections. The tuning characteristic is modified straight frequency line. Order Cat. KHD-3 at $1.70.

## DRUM DIAL

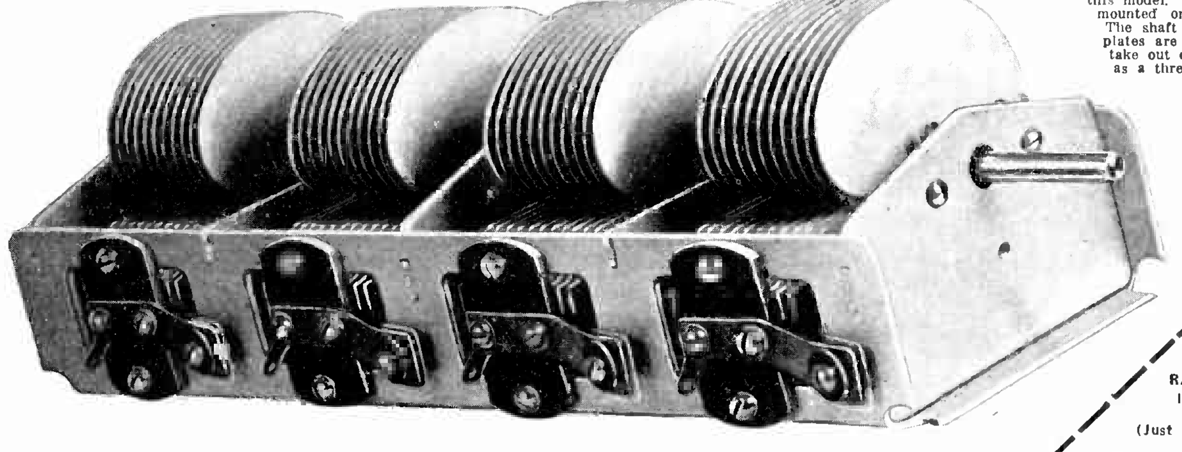
CAT DD-0-100 @ $1.50

A suitable drum dial of direct drive type is obtainable for ¼" shafts or ⅜" shafts, and with 0-100 scales. An escutcheon, is furnished with each dial.



## FOUR-GANG .00035 MFD. WITH TRIMMERS BUILT IN

Trimming condensers are built into this model. The condenser may be mounted on bottom or on side. The shaft is removable, also the plates are removable, so you can take out one section and operate as a three-gang.



Four-gang .00035 mfd. with trimmers built in. Shaft and rotor blades removable. Steel frame and shaft, aluminum plates. Adjustable tension at rear. Overall length, 11 inches. Weight, 3½ lbs. Cat. SPL-4G-3 @ $3.95.

A four-gang condenser of good, sturdy construction and reliable performance fits into the most popular tuning requirement of the day. It serves its purpose well with the most popular screen grid designs, which call for four tuned stages, including the detector input.

Ordinarily a good condenser of this type costs, at the best discount you can contrive to get, about twice as much as is charged for the one illustrated and even then the trimming condensers are not included. The question then arises, has quality been sacrificed to meet a price? As a reply, read the twenty-six points of advantage. The first consideration was to build quality into the condenser. The accuracy is 99¼%.

## SHORT WAVES

Tuning condensers for short waves, especially suitable for mixer circuits and short-wave adapters. These condensers are .00015 mfd. (150 microfarads) in capacity. They are suitable for use with any plug-in coils. Order Cat. SW-S-150 @ $1.50. To provide regeneration from plate to grid return, for circuits calling for this, use .00025 mfd. Order Cat. SW-S-250 @ $1.50.

GUARANTY RADIO GOODS CO.,
143 West 45th St.,
N. Y. City
(Just East of Broadway.)

Enclosed find $.......... for which ship designated parts:

.................................

Street Address.......................

City................ State................

the following merchandise as advertised:

☐ Cat. XS-4 @ 10c
☐ Cat. KH-3 @ 85c
☐ Cat. XS-8 @ 15c
☐ Cat. KHD-3 @ $1.70
☐ Cat. RL-3 @ 12c
☐ Cat. DD-0-100 @ $1.50
☐ Cat. EQ-100 @ 35c
☐ Cat. SC-3 G-5 @ $4.80
☐ Cat. SPL-4 G-3 @ $3.95
☐ Cat. FL-4 @ 30c
☐ Cat. SW-S-150
☐ Cat. SW-S-250

ALL PRICES ARE NET