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Power Equipment for Safeguarding Telephone Service

By H. H. Lowry

In the huge ships, which carry us from shore to shore on our journeys for business or pleasure, there are hidden deep in the holds monster power-plants, intricate in design, the energy of which insures their voyages. The passenger, enjoying the luxury of decks and dining rooms, seldom knows what is going on beneath the surface for his comfort and safety. So in our visit to a telephone exchange we are impressed with the large switchboard of the manual office, with the efficient operators or with the complexity of the machine-switching equipment and its almost human mechanisms. These are the apparent means, human and mechanical, which enable us to reach out in our own locality or to a distant city and complete by telephone the contacts which are necessary to our modern industrial and social life. And as in the ship, not apparent from a casual inspection of the office, there is a power plant furnishing the energy which propels our voices; and upon its reliability depends the structure on which our telephone life is built.

By habit we accept such conveniences and only realize what they mean to us when something happens to cut them short. Fire recently destroyed the telephone exchange in a western city of 9,000 inhabitants, and for a time left it without telephone service. Its Mayor, among other comments relating to the specific losses to the community, had this to say: "When fire destroyed the telephone plant in our community we were buried in the customs of communication that existed forty-five years ago. Business activities were paralyzed . . . . Methods of merchandising had to be rearranged. Social life was disrupted. . . . . Those persons who sigh for the good old days can sigh alone so far as we are concerned. If they had a taste of our experience they would shout hurrahs because they are alive today to enjoy the conveniences and the blessings of the twentieth century, just as we shouted when the telephones began ringing again. . . . . No one knows the value of telephone service until it is taken away. . . . . What the loss of telephone service means to home life, to industrial and commercial activities of a community, no one can realize until he has experienced it."

Entirely aside from the supply of energy at proper voltages and with proper tones and flashes to indicate the progress of a call, the systems engineer concerned with power equipment must consider the reliability of the service. He must place those safeguards around his design which will insure continuity of power supply under practically all conditions which may be encountered in service.

One outstanding example of the engineer's contribution to this continuity of service is the duplex motor which drives the mechanism on our panel machine-switching frames. The fundamental idea of the panel system is the employment of an electrically controlled and power-driven switch, which establishes the connection as dialed by the subscriber. In the earlier offices in Newark large motors, placed at strategic points in the offices, were connected to the individual frames by shafting radiating out from the motor like the shafting of an old-time machine shop. Difficulties with this shafting led to the development of an individual drive for each frame, derived from a small motor operating from the outside source of power.

Outside power is subject to many interruptions, from the simplest of blowing a fuse at some point in the distribution system to a major interruption affecting the power source itself. Stopping the motors even for the few minutes necessary to replace a main fuse would hold up all the connections in that office for those minutes. So an elaborate mechanism, consisting of motor-generator sets, contactors and control relays, was designed and so arranged that should the power supply to the small motor for the frame fail for any reason this auxiliary power-plant, operating from a huge storage battery, would immediately start and furnish power to the motors. This system was complicated and subject to trouble, but it led our engineers to conceive the idea of a new type of motor which would be capable of operating from two sources of power. Within the motor there was to be a device which automatically, when the outside source of power failed, changed over to the storage-battery source. This change over is so quick that seldom is there any interruption to the call which may at that moment be in progress on the frame. It operates as well on a general failure of power as on a failure in the leads to a particular frame. An alarm

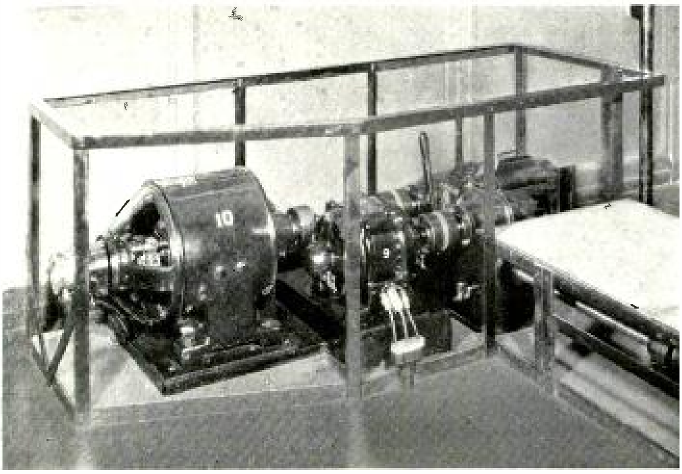


Fig. 1—Common-drive motor in an early Newark Office

is included to notify the maintenance man that the motor is operating on the emergency source of power.

Machine-switching mechanisms must also be protected from power disturbances such as voltage fluctuations, which would affect the speed at which the switch operates and prevent it from functioning. An ingenious relay-mechanism has been worked out which in effect makes a continuous test of the power supply; and if for any reason it varies to voltages which would interfere with the machine-switching mechanism the device changes the duplex motor to the reliable battery supply until the reliability of the primary source can be assured.

A further application of the duplex-motor idea to the ringing machine has insured the same continuity in ringing supply. Every telephone subscriber is familiar with the tinkling bell which indicates someone's desire to talk with him. Sometimes it is the staccato authoritative note, repeated over and over until the subscriber answers, which the engineer knows as machine ringing, or it may be the gentle jingle sufficient to summon us, but under the control of the operator's fingers as she presses the ringing key. In any event, all service stops when for any reason the ringing energy fails. To avoid this two motors, one working from the outside source, the other from the main battery, are placed on the same shaft with the ringing machine and a relay-

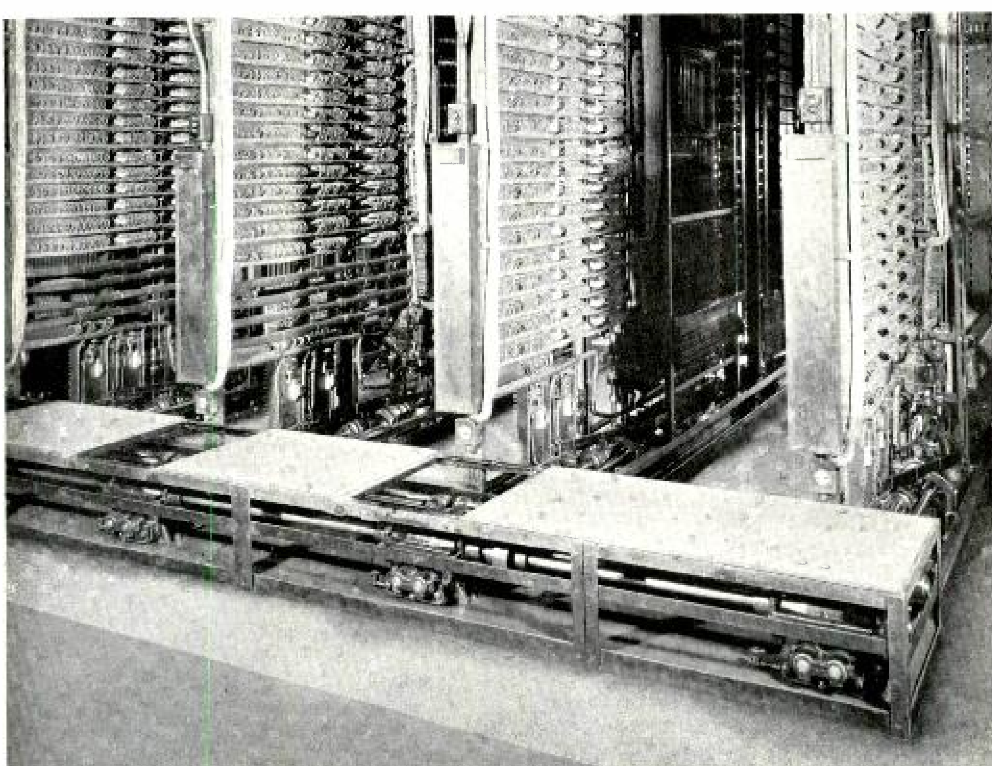


Fig. 2—Common-drive shafting in early Newark Office

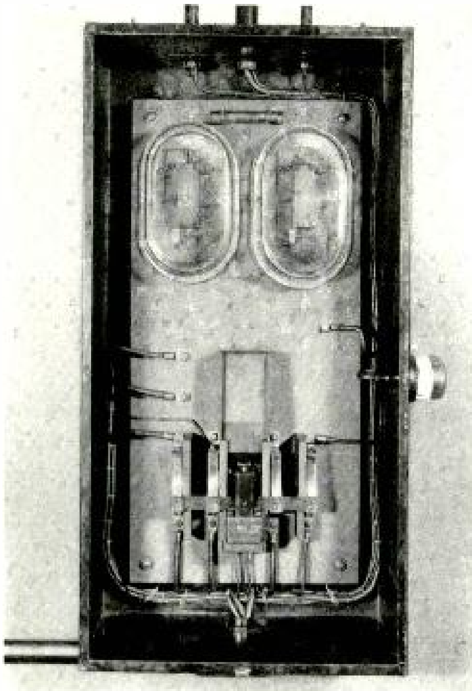


Fig. 3—A master switch making a continuous test of the power supply

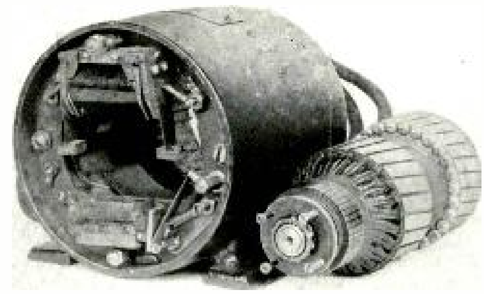


Fig. 4—The 1/16 h.p. duplex motor showing control relay and the double armature

operated mechanism. The latter insures that the machine is kept in continuous operation should the outside power-service fail. Such duplex motors also drive the interrupters which furnish the various flashing signals and tones for piloting a call through the system. Of these tones there are: the dial tone, which tells the subscriber the mechanism is ready for him to dial his call, and the busy back, which notifies him that the calling line is in use. The failure of any of these tones would interfere with, if not entirely block, the progress of a call.

Last, but not least, in insuring continuity of service is the large main source of energy which provides all the current, both that to be modulated by the voice, and that to operate relays and switches along the paths over which the voice travels. Minutely small for the individual call, with the tremendous multiplier of several unit-offices, it becomes a gigantic current—thousands of amperes. To furnish it motor-generator sets are used in varying sizes up to the largest, which can furnish 1500 amperes to charge correspondingly huge storage batteries.

The storage battery acts as a reservoir of energy to take care of fluctuations in load, just as the water systems of our cities store up water in huge tanks or reservoirs to care for fluctuations and emergencies. The largest size of storage battery provides in our larger offices a reservoir for approximately three hours of the busy day-load. While it would be possible to provide additional batteries, it has not been found economical. In smaller offices batteries of available sizes will carry the office for an entire day, or even longer.

If the public-service power-plants could be relied upon nothing more would be necessary; but we know from experience that floods come and fires descend, and tides recede to an extent that make it necessary to provide in many telephone offices an independent source of power. These must be reliable and ready for operation at any time, and able to carry their offices for a long period if necessary. In many of the larger cities the power companies have a number of generating stations. There we can bring into the telephone building through independent feeders power from two or more power-stations; and an independent unit is not required.

It would seem where three large power-stations were available that there would never arise a condition short of a general catastrophe which would shut down all three. And yet recently in one large city a combination of wind, ice and low tide affected three separate stations some distance apart for an hour, because the supply of cooling-water for the condensers failed until the turbo-generators had to be shut down. This same dependence of large power-stations on cooling water, compelling them to locate along sizable streams, has shut down plants on a number of occasions when unusual floods put out their fires and left them helpless for extended periods. On one notable occasion the flood reached the telephone building and put out of commission the emergency plant in the basement. Not to be outdone by the elements, however, a resourceful telephone man made use of the ubiquitous Ford. Jacking up its rear wheels, he belted it to the power generators, which were untouched by the flood, and flivvered away to give service to the subscriber in the usual Bell System

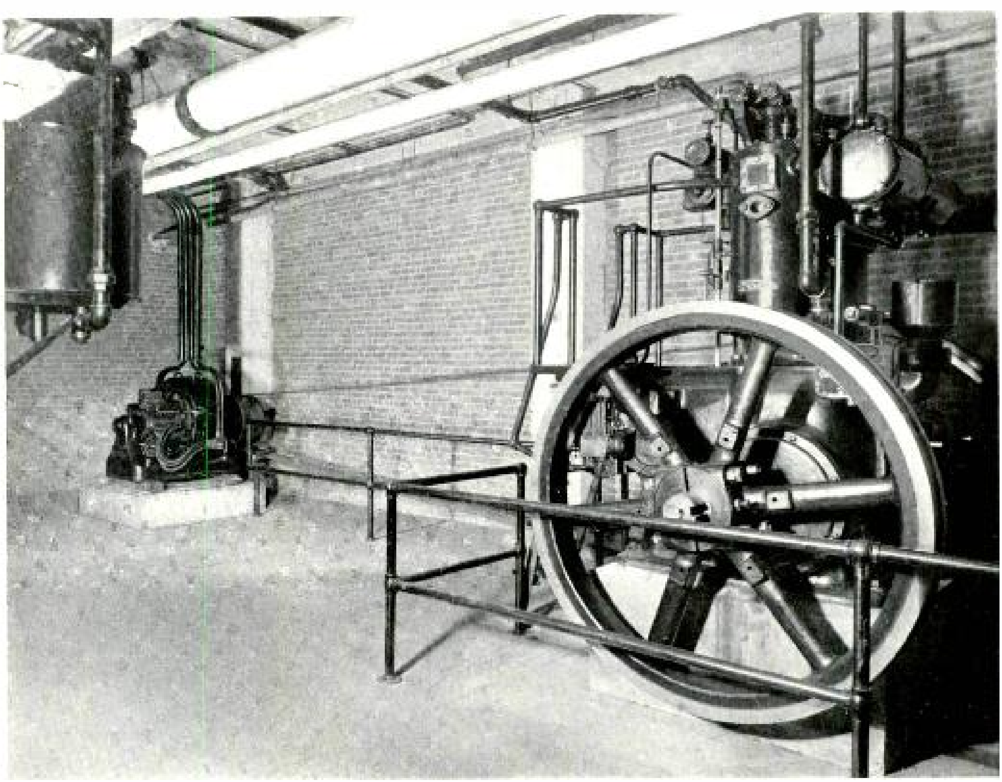


Fig. 5—The two-cylinder gas engine belted to a charging generator. Note the space required for this installation

manner. Wind and sleet storms, particularly in our suburban communities, wrecking high-tension lines, have resulted in other failures of the outside power-supply.

This necessity for an independent source of power has led to the development of gas-engine-driven generators ranging in size from small sets, similar to those used for farm lighting, to a 325 h.p. multi-cylinder engine driving an alternating-current generator. In some instances the engines drive direct-current generators for charging the batteries. In the larger offices it is the usual practice to drive alternating-current generators and furnish power the equivalent in every way of the outside service so that the emergency plant can be made to carry the entire building load exactly as if the regular power service was available. This makes it possible to continue elevator service, lights, ventilating fans and all the auxiliary services of the building, as well as the motor-generator sets, ringing machines and other services purely telephonic in character.

Most of these engines operate on gas piped from regular mains of the local gas-company. Attachments are available so that a failure of the gas supply enables operation to be continued with gasoline. The development of these gas-engine-driven sets has been an epic story of problems entirely outside his usual work which

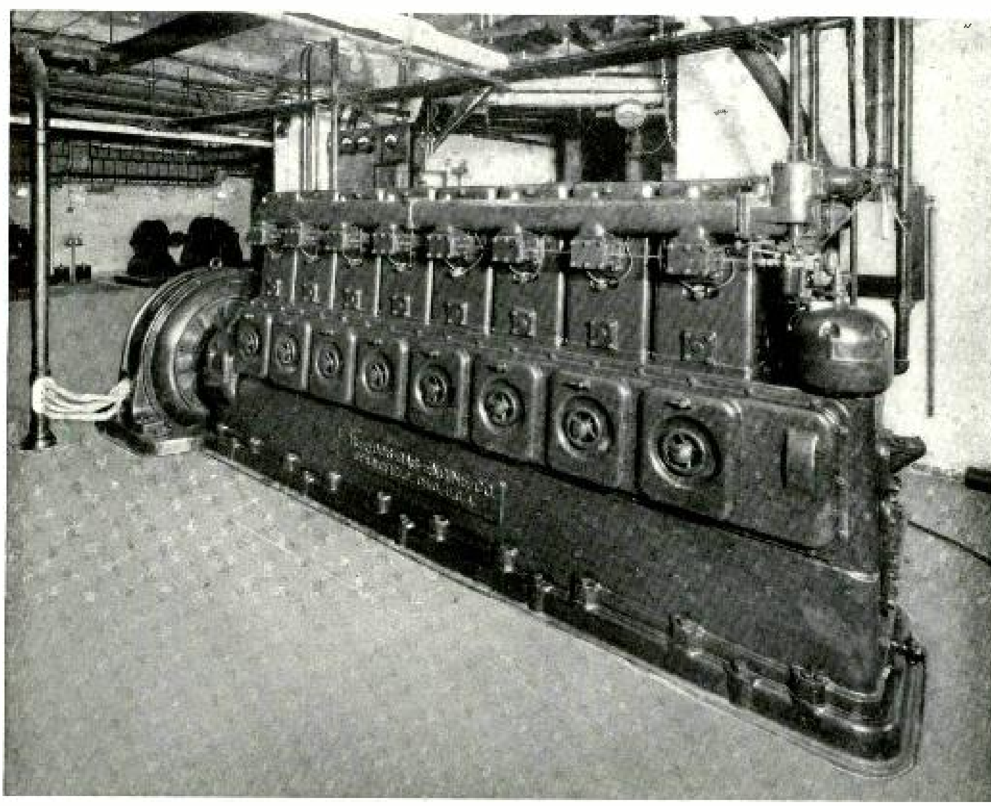


Fig. 6—200 h.p. engine directly connected to an alternating-current generator. Photograph taken from the intake side

have been met by the telephone engineer. Our earlier single-unit manual offices did not require engines of over 50 h.p.; and simple slow-speed single-cylinder engines of commercial design belted to the generator gave satisfactory service. With the advent of machine-switching and multi-unit offices larger engines became necessary. Two-, three- and four-cylinder engines of comparatively slow speed were developed, in cooperation with gas-engine manufacturers, in sizes from 50 to 325 h.p. For the higher-speed charging generators it was necessary to drive by belt from the engine. The height of the engines also was so great that special clearance was necessary in the basement of a telephone building to permit the removal in maintenance work of cylinder heads and pistons.

These limitations led to the investigation of engines of higher speeds, a number of which are in service and under test throughout the country. These are all direct connected, and are similar in design to the straight-line automobile and motor-boat engines of present-day usage. As in automobile practice an electric motor using a Bendix drive is employed to start them. Vibration has given trouble, and has led to the use of cushioned foundations for the largest sizes and of a specially designed spring-base for the smaller engines.

One of the major problems to be overcome is the variation of the gas supply in the various cities of the country. Natural gas with its high thermal content differs greatly from the low-thermal-content water-gas used in the less fortunately located cities. Altitude also has its effect, and must be allowed for in cities of the mountain sections.

There is another aspect to the use of gas engines. Our telephone buildings are located in congested sections and a loud exhaust from an engine would be objectionable to our neighbors. This has led to the development of special exhaust-silencers, worked out with the assistance of the Maxim Silencer engineers; and our neighbors are content with their nearness to our gas engines.

These investigations have led to the development of direct-connected sets rating from 25 to 200 h.p. and having four, six, or eight cylinders. Emergency plants requiring as much as 800 h.p. have been planned by using a number of such sets. Some interesting tests have been carried on for such cases in an endeavor to synchronize gas-engines, similar to steam-plant practice to permit running the alternating-current generators in parallel.

Auditory Masking

By Clarence E. Lane

"THERE is so much noise I cannot tell what you are saying," is a reply familiar to us all, both in telephone conversation and in direct speech. Our auditor may have heard our speech, but could not understand because of the noise, or the latter may have been so loud that the sound of the voice was completely "drowned out" or "masked." We are so accustomed to this that we rarely stop to inquire as to its reason. From experiments in our Laboratories it has been determined how and under what conditions one sound interferes with the perception of another.

If two pins prick the hand simultaneously and are far enough apart so that they stimulate separate nerve endings, they will be recognized distinctly as two; but if they are so close together that the same nerve endings are stimulated they will be recognized as only one. In general if two different stimuli excite different nerve endings of the same sense organ, the stimuli are recognized independently; but if they excite the same nerve endings there is interference.

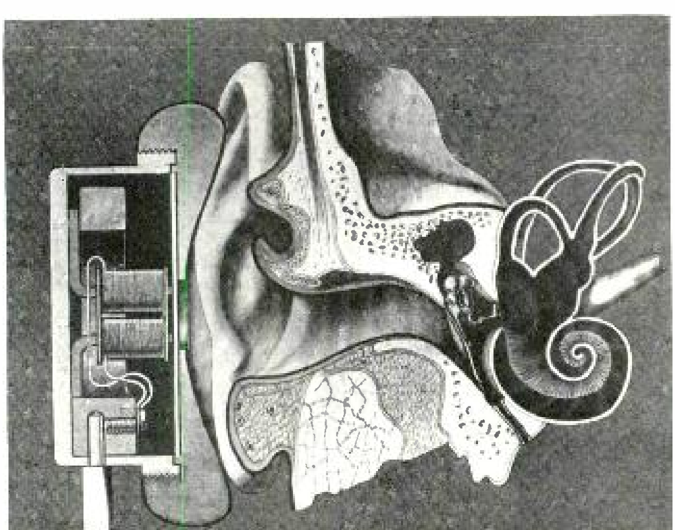
In experiments on auditory masking it has been found that if a noise is introduced into one ear only and the auditor listens to speech with the opposite ear, there is no interference, and he can hear as well as though the noise were not present. This is because the noise stimulates a set of nerve endings entirely different from those receiving the speech sounds. In experiments in which two pure tones were simultaneously introduced into the same ear, it was found that at low intensities (energy not over 10,000 times that required for minimum audibility) one tone never interferes with the hearing of another unless the pitches, or frequencies, of the two tones are within about one-half octave of each other. On the other hand, if they are of nearly the same pitch one need be only a little louder than the other to mask it completely.

The manner in which the inner ear responds to sounds of different frequencies explains these results. There is in the inner ear a thin membrane called the basilar membrane, which is about one and one-quarter inches long and one-sixteenth to one-eighth of an inch wide. Along it the nerves of hearing are distributed quite uniformly. These nerves are stimulated when the membrane moves in response to sound waves. If the sound is a pure tone, and not too loud, there is a rather limited region or spot on this membrane which moves with appreciable amplitude; the rest of the membrane moves scarcely at all. A tone of different pitch will cause a maximum movement at a different point. The nearer the two frequencies the closer together are the positions of the maxima on the membrane. If the frequencies are so close together that the portion of the membrane which responds with maximum motion to one tone moves also with considerable amplitude for the other, there will be interference. If at the position of the maximum due to the weaker tone the membrane has less motion for this tone than for its neighboring louder tone, then the first tone will not be heard at all. In such a case the tones interfere because they stimulate the same nerve endings.

Experiments also showed that a pure tone of loud volume, if of low pitch, will mask any other tone of higher pitch, just as it does those of nearly the same pitch. On the other hand, a high tone, no matter how loud it may be, will never mask a tone of appreciably lower pitch. For example, if the tone of middle "C" on the piano reaches the ear with ten million times the energy necessary for it just to be heard, it will completely mask a tone three octaves higher, even if this high-pitched tone also contains ten million times its minimum audible energy. On the other hand, again, this high tone even at this loudness will not prevent one from hearing the lower tone, even when the lower tone by itself would be just barely audible. The reason a loud low-frequency tone will mask any tone of higher frequency is because in its transmission through the middle ear a large number of harmonics or overtones are introduced. Some of these overtones will be close in frequency to the high-pitched tone, and consequently produce motion of the basilar membrane at the point where the high note produces maximum motion.

Experiments show that complex sounds are always quite effective in masking frequencies higher than their fundamentals, but never mask frequencies much lower. The reason for this is obvious from what has been said, because the complex sound contains a large number of frequencies higher than that of its fundamental.

Speech is very complex, consisting of a large number of frequencies ranging for the most part from 100 to 3000 cycles. If speech is to be understood the frequencies from about 500 to 2500 cycles should be properly perceived. A complex sound, therefore, like the noise in the subway which contains frequencies over this entire range, will mask some of the component frequencies of the speech, and so interfere materially with the understanding of it; or a pure low note will interfere by causing harmonics in the ear itself, arising from strong agitation of the basilar membrane.



In this cross section view of the ear, the basilar membrane is seen in the spiral chamber at the right.

A Universal Laboratory Transmission-Measuring Set

By S. J. Zammataro

WHAT constitutes a transmission measuring set, and why our new design for laboratory and factory use is called a "universal" set, may well be explained before the set itself is described. That it is "adapted or adaptable to all uses, size, etc.," as Webster would say, is apparent to one who reads the first page of its specification as reproduced in the accompanying illustration.

Translating and abstracting the "abstract" of that specification one might say that the set is adapted to the measurement of the efficiency of practically all apparatus for the electrical transmission of audio-frequencies.

Particularly, it is useful for testing vacuum-tube amplifiers of various kinds, such as serve in loud-speaking telephone sets, speech-input equipment, public-address systems, repeaters, audiphones and stethophones. Also the set measures what happens to the transmission of current through apparatus like filters and various other types of networks for discriminatingly attenuating some audio-frequencies in favor of others.

The general method of testing transmission apparatus involves comparing what happens to currents passing through the apparatus under test as compared with equal currents which pass through some other apparatus of known characteristics. A current of a desired value and frequency is supplied to the input terminals of the equipment under test and the resulting current from its output terminals is then caused to manifest its magnitude by some suitable current-indicating device. Next, a current of the same type and value as was applied to the input terminals, is supplied to the terminals of an adjustable artificial line of known characteristics. The output current from this line affects the same indicating instrument. The amount of line through which the current flows is now adjusted until the indicating device gives the same reading as before. It is obvious then that the equipment under test produces the same effect on the current as the known adjustable line. Its effect is usually expressed in terms of so-called "transmission units," abbreviated as TU.

While this is the principle of operation, it is evident that various readjustments are required, as for example, in the testing of amplifiers which introduce a "gain" in transmission because the output currents are larger than the input currents. In such a case the adjustable line is connected in series with the amplifier so as to off-set some of the amplifier "gain" by the "loss" which the line introduces. The loss thus introduced is adjusted so as exactly to off-set the gain; and the number of transmission units of the loss becomes the measure of the gain of the amplifier.

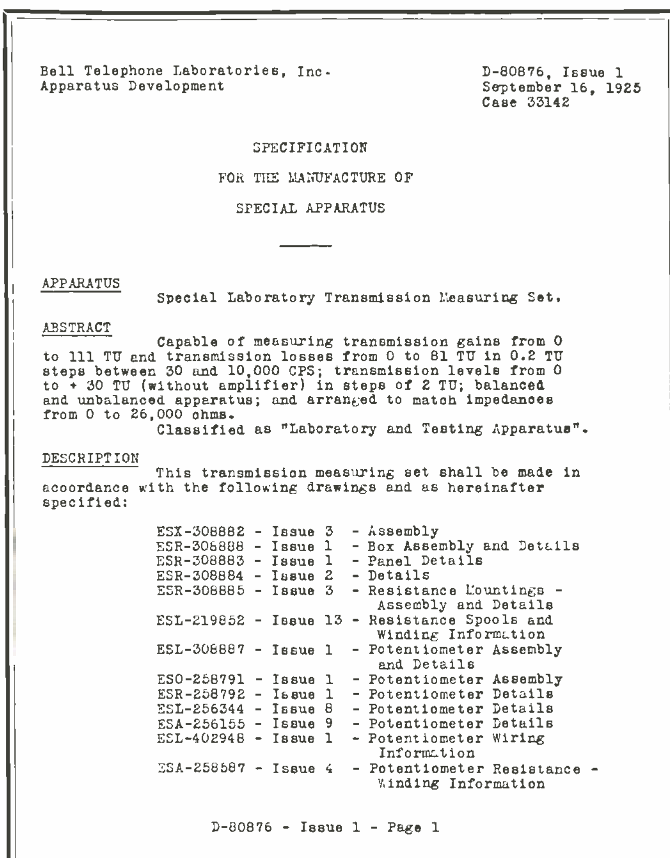
Transmission-measuring equipment, therefore, consists of a source of current, an adjustable artificial line, and a current-indicating instrument.

Switches are provided so that the current may flow successively through two different paths in reaching the current-measuring instrument. In one path may be connected the apparatus under test; in the other path is an adjustable artificial line. Additional switches serve to connect the artificial line in series with the device under test in case it is an amplifier.

Such is the general scheme of making transmission tests, but much more is involved as the "abstract" of the specification implies. For example, there is the matter of properly matching the impedances. It would be misleading and unfair to test a piece of transmission apparatus under conditions other than those for which it was intended. If it is designed to work between circuits having certain characteristic impedances it must in testing be terminated by similar impedances. The lines leading from the alternating-current source to the input of the apparatus under test and from the output of the apparatus to the current-measuring instrument must, therefore, be adjustable to duplicate the terminal conditions which would be normal for the apparatus.

Another factor to be considered in simulating the normal terminations of the apparatus under measurement is the matter of the electrical relation of the apparatus to "ground." Telephone transmission-circuits consist essentially of pairs of conductors which are electrically symmetrical with respect to ground, and hence called "balanced" circuits; or they may be "unbalanced," in which case one of the conductors is the ground. For this reason the transmission-measuring set is designed to provide line terminations which are adjustable in their relation to ground, and hence are suitable for both types of circuits.

In laboratory tests and in shop-inspection tests of transmission apparatus it has been the practice in most cases in the past to set up specially


Bell Telephone Laboratories, Inc.
Apparatus Development

D-80876, Issue 1
September 16, 1925
Case 33142

SPECIFICATION

FOR THE MANUFACTURE OF

SPECIAL APPARATUS

APPARATUS

Special Laboratory Transmission Measuring Set.

ABSTRACT

Capable of measuring transmission gains from 0 to 111 TU and transmission losses from 0 to 81 TU in 0.2 TU steps between 30 and 10,000 CPS; transmission levels from 0 to + 30 TU (without amplifier) in steps of 2 TU; balanced and unbalanced apperatus; and arranged to match impedances from 0 to 26,000 ohms.

Classified as "Laboratory and Testing Apparatus".

DESCRIPTION

This transmission measuring set shall be made in accordance with the following drawings and as hereinafter specified:

ESX-308882 - Issue 3 - Assembly
ESR-308888 - Issue 1 - Box Assembly and Details
ESR-308883 - Issue 1 - Panel Details
ESR-308884 - Issue 2 - Details
ESR-308885 - Issue 3 - Resistance Mountings - Assembly and Details
ESL-219852 - Issue 13 - Resistance Spools and Winding Information
ESL-308887 - Issue 1 - Potentiometer Assembly and Details
ESO-258791 - Issue 1 - Potentiometer Assembly
ESR-258792 - Issue 1 - Potentiometer Details
ESL-256344 - Issue 8 - Potentiometer Details
ESA-256155 - Issue 9 - Potentiometer Details
ESL-402948 - Issue 1 - Potentiometer Wiring Information
ESA-258587 - Issue 4 - Potentiometer Resistance - Winding Information

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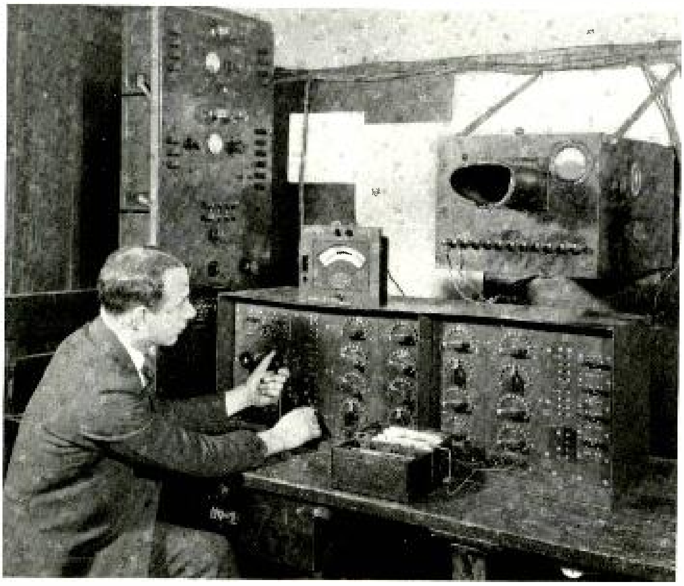
First page of manufacturing specification on the laboratory transmission-measuring set designed testing-circuits fitting the needs of the type of apparatus under test, or to modify, for the particular type, one of the existing standard measuring-sets. Until recently no set had been developed which had the range and flexibility required for general service in testing. The present set, which is shown in the accompanying pictures, was the outcome of the desire of our general testing laboratory to equip itself with a single set of sufficient range, flexibility, and accuracy, to permit measurements of practically all types of audio-frequency transmission apparatus with a minimum amount of preparation in setting up for the test.

While the general design of this set follows well established principles previously employed, its details have been refined and elaborated to meet the closer requirements for testing our present audio-frequency apparatus. It is equipped with a gain-loss key, which rearranges its circuits so as to indicate either gain or loss, depending upon the character of the apparatus under test. In the gain position of this key the adjustable artificial lines neutralize or balance the gain in the apparatus under test. In the loss position the adjustable lines and the apparatus under test are arranged to form respectively two branches, in each of which the measuring current may be successively attenuated.

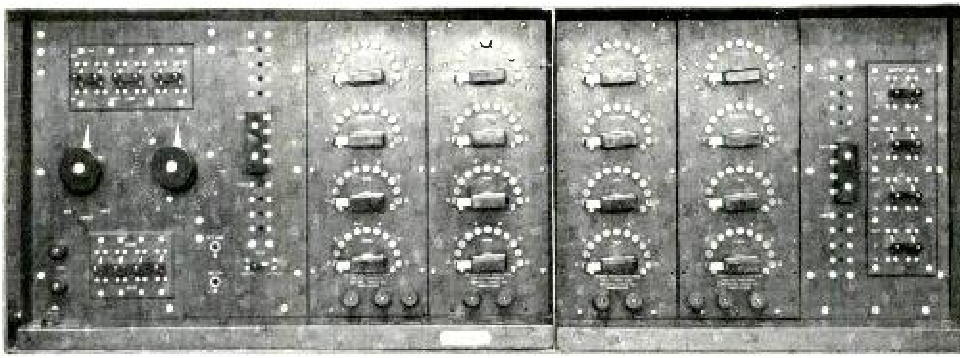
The indicating device consists of a thermocouple and a meiro-ammeter. The latter is not contained in the set, but is connected by plugging into the proper jack. A quick-acting key transfers the indicating device from the end of the branch of the measuring circuit to the end of the other branch, so as to permit reading of the input and output currents of the apparatus under test. Adjustable lines on the output side serve to fix the energy level at which the transmission measurements are made.

This is, of course, important in measuring the gain of amplifiers as it is essential to keep the energy level of the measuring current below the so-called over-load point of any of the tubes in the amplifier.

In the case of amplifiers which operate at very low-levels such as those employing "N" tubes, the testing current must be very small to prevent overloading. As such values of current can not be detected by the thermocouple and meter, it is necesary to amplify the testing current



The author using the transmission-measuring set in the laboratory



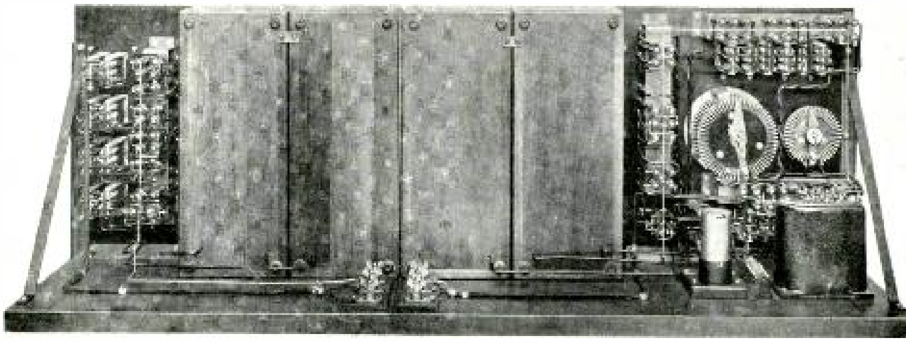
Front view of the set

before it reaches the indicating device. Provision is made, therefore, to insert a vacuum-tube amplifier between the output lines and the thermocouple so that a satisfactory indication may be obtained on the meter. This means of increasing the sensitivity of the indicating device is also required when transmission loss measurements are made because of the limited amount of current from the oscillator and because of the higher attenuations usual in networks.

By making transmission measurements with the output lines adjusted to different values, corresponding to different levels of current through the apparatus, the effect of energy level on transmission efficiency may be noted. This arrangement serves particularly in determining the maximum energy a given amplifier can handle without distortion. The vacuum-tube amplifier mentioned above permits the extension of the range to lower energy levels.

The range of impedance values for terminating apparatus under test is obtained by the use of three fixed lines in connection with decade resistance boxes in both the input and output of the apparatus. The resistance boxes are arranged for connection either in series or in shunt with the fixed lines to match impedances up to 26,000 ohms; and this range may be extended readily by connecting external resistances.

The design of the measuring circuit is of the "balanced" type in which the two "side" conductors are symmetrical with respect to a third conductor. The latter wire is grounded, and is known as the grounded "neutral" of the circuit. To permit measurement of both "balanced" and "unbalanced" apparatus, the indicating device is connected across only half of the measuring circuit: that is, between the neutral wire and one of the "side" conductors. It is balanced on the other half of the circuit by an equivalent resistance. Balanced apparatus, when under measurement, is connected across the whole circuit, so that the two side conductors are connected to the corresponding balanced conductors of the apparatus. To measure unbalanced apparatus, provision is made to connect it to that half of the measuring circuit which contains the indicating device, with



Rear view of the set

the grounded side of the apparatus connected correspondingly to the grounded neutral of the set.

A three-winding transformer is employed to furnish the testing current from the oscillator to the measuring circuit. Its primary is designed to match the oscillator output so as to receive the maximum energy. The secondary windings are equal, or balanced, and serve respectively to apply equal potentials across the input and output branches of the testing circuit. A potentiometer across the primary of the transformer regulates the testing current. The artificial lines and networks are formed by specially wound resistance units which are non-reactive throughout a wide range of frequencies. The special design of the transformer and careful arrangement of the lines makes possible transmission measurements with an accuracy of 0.1 TU in the frequency range from 30 to 10,000 cycles.

The appearance of our laboratory transmission-measuring set is shown by the accompanying photographs. The set is non-portable, and is housed in a metal box forty inches by fourteen inches by twelve inches. A metal partition forms a shield between the two compartments holding the input and output apparatus, respectively. For inspection the boards on which the apparatus is mounted slide out of the box.

The actual operation is simple and rapid. After connecting the apparatus to the proper terminals the input and output impedances are next matched and then the energy level is set by connecting in the output lines. Measurement now begins with the test key in the input position and the current from the oscillator is adjusted by the input potentiometer to indicate a suitable reading on the meter. In the next step the key is thrown to the output position and the input line is adjusted until the meter indication is the same as before. The lines thus introduced indicate the efficiency in transmission units.

New Telegraph Equipment

By D. C. Meyer

THIS story of recent developments in telegraph equipment starts with the conditions pictured in Figure 1. Those familiar with a Long Lines test-board room will at once recognize at the left of the picture the telegraph panels and in the immediate foreground the long mahogany tables which carry the telegraph repeater-equipment.

Telegraph messages may be sent over telephone wires while the latter are being used for telephone purposes, by using so-called "composite" equipment. But how composite equipment works, although its operation is simple, is another story; and for the present it is sufficient to say that it separates telephone from telegraph messages. Practically all long open-wire telephone lines are furnished with such equipment and carry telegraph messages on a leased wire basis. Each wire of such a toll line may be made to serve for telegraphic communication, and by means of so-called duplex equipment it can transmit telegraph messages simultaneously in both directions.

For telegraph purposes connections are made to the telephone toll-lines through the composite equipment and through the telegraph terminal equipment with which this article is concerned. From this equipment a pair of wires extends to the brokerage, banking, or newspaper office which has leased the service. For example, suppose broker's office "A" in New York has a wire connection with broker's office "B" in Chicago. From the "A" office telephone wires connect

Fig. 1—Long-lines telegraph repeater test-board room showing the old-style apparatus

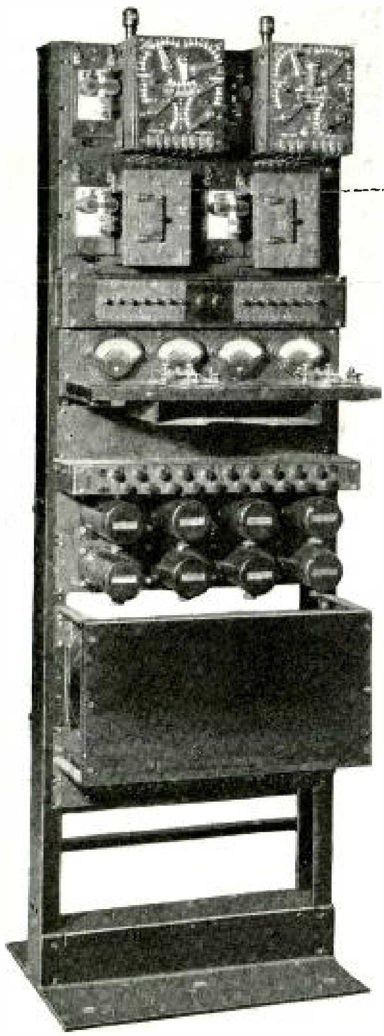


Fig. 2—Telegraph terminal equipment

with telegraph terminal equipment like that shown in Figure 1. At the "A" office are a telegraph sounder and a key. From these instruments, in the case of so-called "full duplex" operation, there may be transmitted simultaneously incoming and outgoing telegraph messages. Under the usual conditions of "half duplex" the subscriber may transmit or receive, but he may not do both simultaneously.

Between the New York and Chicago terminals of the long lines a single wire of a composited telephone line serves for this telegraphic communication; and at the Chicago end there is a similar connection to broker's office "B." This single wire serves because of the duplex feature of the terminal equipment.

Two methods may be employed: one, the so-called "polar duplex," of which the equipment is that of Figure 1; and the other, the "differential duplex," which has been successfully used on metallic telegraph circuits in cables and in the new equipment is applied to open-wire circuits. It has been described in a recent technical paper from the Laboratories *, and as to its fundamental principles in an earlier article in the RECORD on the "Artificial Line." ** Current controlled by the sending key divides between the equal windings of a double-wound relay and flowing in opposite directions through them does not operate it. The current through one winding continues out along the single wire of the open-wire toll line and that through the other winding enters the artificial line which simulates and balances for such transmission the actual wire. On the other hand the current incoming from the distant terminal, and controlled by its sending key, passes through the relay in such a manner as to operate it; and this operation, supplying current to the sounder, makes evident the incoming signal.

If, as is usually the case, the distant terminal is so far that the telegraph

*"*Metallic Telegraph System,*" *by John H. Bell, R. B. Shanck, and D. E. Branson. Electrical Communication, April,* 1925.

***Volume* 1, *pp.* 51-52.

current would be too greatly attenuated, repeating equipment is inserted at intermediate test-boards. This repeater is essentially a combination of certain features of terminal equipment, so arranged as to receive and to start off again in its proper direction each telegraphic signal. Introduction of such equipment also permits the connection at intermediate points of other offices of the leased wire subscriber as, for example, a branch house in Pittsburgh or other houses en route, or to be reached by connections from other intermediate points.

At the terminals and at intermediate repeating stations the leased wire service is supervised, and is cared for by telegraph attendants of the Long Lines Department. The conditions of the circuits, times of operation, and specific services for the subscribers are recorded in log books, one for each leased wire. These are the white pads on top of the apparatus of each of the bays in Figure 1. The white cards standing beside the apparatus give the routings and other necessary information as to the type of service.

These older styles of mahogany tables with their telegraph equipment were awkward in size and, of course, required shipping in knocked-down condition. Their assembly and the mounting of apparatus had to be done locally on a more uneconomical basis than would be met in quantity assembly methods at the factory. The new equipment, which is shown by the photographs of Figure 2 for the terminal equipment, and Figure 3 for intermediate repeater telegraph equipment, is of the rack type. For each set of equipment there is a low channel-iron rack, a little over five feet high. Such construction is favored because its units may be carried in stock and shipped completely wired and equipped. The height is low so that the supervisor may see across the top to supervise the telegraph attendants.

The apparatus which requires manual operation, such as keys and rheostats, is mounted at heights conve-

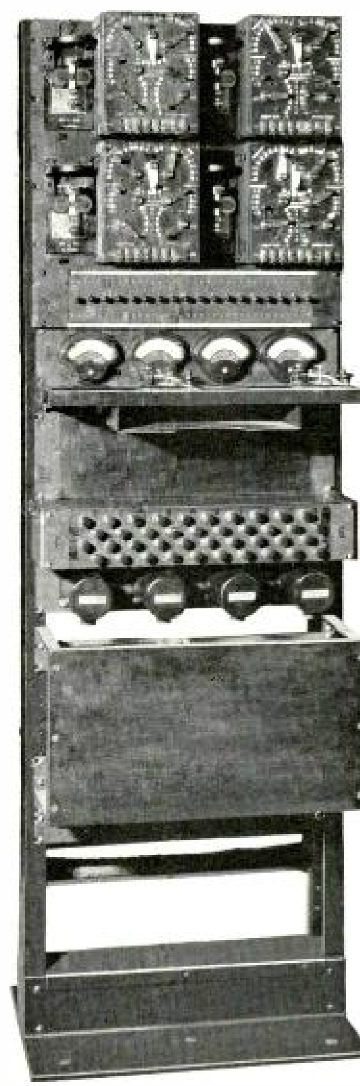


Fig. 3—Intermediate repeater equipment

nient for handling. The meters are near the top for convenience in reading. The sounders* are mounted between rheostats so that the latter form the sounding boxes for concentrating the signals. The shelf at forty inches from the floor provides writing space and a mounting for telegraph keys. Log books when not in use may be placed in the compartments immediately below the shelves. The telegraph relays are of the jack-mounted type, and can be readily removed for adjustment. These relays are also provided with a new mechanical device so that bias adjustments are made by turning a knurled knob.

The new equipment is capable of handling messages much faster than the old system, and is much easier to maintain. Its design is also economical of floor space, as can be understood by comparing the table shown in the foreground of Figure 1. Such a table is arranged for twelve of the old-type sets. For through service this table can be replaced by three of the units shown in Figure 3. For terminating service six units like that of Figure 2 are required. These smaller units of equipment are also an economy: under the old plan it was often necessary to install a large table to provide for ultimate needs, even though only two or four sets were necessary at the time of installation.

** A sounder and a key are part of the equipment and permit the telegraph attendant to monitor the service and when necessary to communicate with the subscriber's operators.*

Putting Sound to Work For Industry

Some results obtained in the solution of industrial problems through fundamental research were demonstrated by H. Clyde Snook at the annual meeting of the Division of Engineering and Industrial Research, National Research Council. Our Laboratories' researches, in the physics of sound, have resulted in developments which produced the Orthophonic phonograph, methods of detecting the destructive work of borers in telephone poles, instruments for prospecting for oil, the electrical stethoscope, and methods of noise analysis in automobiles. Mr. Snook's talk showed the possibility of wide application of this basic research to different industries.

The activities of the National Research Council, to which this demonstration was an important contribution, are of peculiar interest to Bell Telephone Laboratories. Frank B. Jewett is chairman, and Edward B. Craft vice-chairman, of the Division of Engineering and Industrial Research.

The Technical Reprint Series

By John C. Latham

In 1919, it was decided regularly to obtain a number of reprints of the important articles which our Bell System engineers were publishing in various technical journals for distribution within the Laboratories. Each advance in the art which such papers recorded became immediately a source of ideas for further advances. Particular reprints thus became part of the necessary equipment of particular laboratories. With the distribution of these reprints, a demand was created which has grown until today it causes the distribution of our technical reprints not only within our Laboratories and the Bell System generally but, as the knowledge of their existence has slowly spread, to colleges and scientists and engineers throughout the world.

The demand which has required expansion in the circulation of these reprints may be due to a number of factors among which, besides the paramount one of the scientific value of the contributions themselves, is the fact that they form a continuous series of articles covering most of the subjects of interest in communication engineering. They appear in individual pamphlets of convenient size, and are rendered easily accessible by means of a complete index. Whatever the cause, the few hundred copies originally published have grown to thousands. Of these, practically twenty per cent are distributed in the Laboratories, approximately forty per cent go to the American Telephone and Telegraph Company, Western Electric Company, and other associated and related companies of the Bell System. About twenty-five per cent go to the libraries and faculties of colleges and universities and the rest to public libraries and individual scientists. They have even reached the point of being adopted by a number of colleges as text-books for courses in electrical engineering and physics.

In the course of their expansion in numbers and circulation, the reprints have also changed in physical form. The greatest change, of course, was that from the heterogeneous collection of bindings and page sizes supplied by different technical magazines to a uniform binding and page size. The accomplishment of uniform page size of articles printed in journals of such varying dimensions appears to be a source of considerable mystification to persons outside the Company. In fact, we have received a number of letters inquiring how it was possible to accomplish it without entirely resetting the original type. As a matter of fact, this uniformity was simply a matter of measurement. Our reprint page-size (six inches by nine inches) is practically the only size which can be used to reprint articles from the "single column" magazines in which many articles by engineers of the Bell System are originally published, while retaining a comfortable margin and column arrangement. Articles published in "double column" magazines are rearranged into single columns. The only other changes necessary are a rearrangement of the type pages sufficiently to cause each article to begin at the top of a right-hand page, the renumbering of the pages, and the elimination of the "running head" of the original magazine which usually occurs at the top of each page.

With the distribution of the reprint index which is now in press, it is expected that the reference value of our series of technical reprints will be increased. This new index differs in a number of particulars from that issued in 1925. More than fifty new titles have been added, as well as information as to the original source of each article. In order to make the series easier of reference, a small group of reprints originally numbered as the "C" series has been renumbered into the present "B" series. The arrangement of the index by authors and by number is shown in the illustration.

Numerical Index

Author Index

Abstracts from the technical reprint index showing arrangement by numbers and by authors

Lubrication and Wear

By Howard L. Coyne

LUBRICATION as a problem for designers of telephone equipment became important with the development of machine-switching systems. In the manual telephone plant there is practically nothing which one would call a machine. In its keys, jacks and plugs, switchhook mechanisms, and the like, there are parts which roll or slide against each other, but their protection by lubrication is either not essential or not difficult as compared to machine equipment.

In machine-switching apparatus there may be bearings against which other parts must turn millions of times, or even rotate continuously. Neither the bearing nor the rotating part can be allowed to wear away more than some few thousandths of an inch without shortening the useful life of the machine. Compared to power machinery, the various parts of machine-switching equipment are light, and do not bear heavily upon each other; but even with such moderate loads to be withstood the designer often must use the best steel to minimize the wear. Steel, however, rusts or corrodes unless protected, and corrosion accelerates wear. Hence both wear and corrosion must be retarded by a suitable lubricant.

In manual apparatus wear due to corrosion was not so serious because in most cases the loads and duties of bearing surfaces permitted the use of non-ferrous metals which corrode, but not so destructively as does steel.

Bearing surfaces may be kept apart and wear reduced if there is a film of lubricant between them and, of course, if their surfaces contain no sharp points and if there are no particles of grit suspended in the film. A lubricant is usually a "slippery" material: an oil, a grease, or a wax. It has the important characteristic that up to a certain point it offers comparatively low resistance to deformation. In fact, at ordinary temperatures lubricants tend by their own weight to flatten out into thin films. When a film is formed the true lubricant offers comparatively great resistance to being flattened further and resistance even to penetration — although it may, of course, be penetrated by sharp points or edges under considerable pressure. If the cause is removed, the lubricant, provided the supply is adequate, will almost immediately close the film again.

The important characteristics of a lubricant are usually expressed by its viscosity. This is a measure of its internal friction, and hence of its resistance to deformation. A viscid substance is one which flows like molasses in January, as if there were great friction between successive layers of molecules. In our laboratory measurements we express viscosity according to an arbitrary standard and use for its determination an "Engler" viscosimeter. The latter measures the viscosity of a lubricant relative to that of water at a given temperature. For example, 10 (Engler 70°F) means ten times more viscous than water at

70° Fahrenheit. Viscosity is a criterion for the usefulness of a lubricant because the wear of moving metal parts when separated by a film of clean lubricant and the effective friction between the parts are very intimately dependent upon the viscosity.

Lubricants are divided into three classes, according to their origins: namely, mineral, animal, and vegetable. Porpoise-jaw oil illustrates one class. It was used for years for watch mechanisms, but mineral oils are now supplanting it. For telephone purposes, contrary to first thought, it would not be satisfactory because of its tendency to gum. Jewelers have said that when the oil is used in clocks, especially those with glass cases, it gums quite readily as compared to what it does in watches. It would seem, therefore, that its character is changed by sunlight and the practical absence of light inside watches explains the mystery of its successful use. Of the vegetable oils, linseed, for example, would never be considered a lubricant because, as every one knows, it dries quickly into a sticky, hard, varnish-like gum. Castor oil on the other hand is non-drying, and serves for some purposes as a lubricant. Incidentally all vegetable lubricants are avoided in telephone apparatus on account of their relatively unstable chemical composition. Because of this, they oxidize and become sticky and gum more quickly than do mineral products.

Not all mineral lubricants, however, are suitable for telephone apparatus. For example, graphite, because it is a conductor of electricity, would not be used in the neighborhood of contact points. It may be used, however, in combination with metals or phenolic resins to form oilless bearings which are used where loads are small and speeds are low.

Greases, owing to the fact that they contain saponifiable material, are rarely used. A high-grade cup grease commonly used for automobiles has been used for the past two or three years successfully for the cams in an interrupter, and for the bearings in some switches. Greases of this character would have wider application if operating conditions were not such as to bring about the breaking down of their soapy substance, with the resultant formation of acids which corrode bearings, forming in some cases so-called "iron soaps."

In investigating oils or greases one of the first things to be determined is the saponification value. Potassium hydroxide is added; the number of grams of this caustic required to saponify 1000 grams of the lubricant is a measure of the amount of animal or vegetable material present, and hence of its potential corrosive power. In one of the mineral lubricating oils which we use, the saponification value is limited to 0.9, that means, that the oil must be at least 99.5 per cent pure mineral product.

The acid value of a lubricant is another important matter, as the proportion of free acid must be limited because of its corrosive action on the bearings.

Waxes have a lubricating value applicable only in special cases. They have been used successfully where the load is light, the operation is intermittent, the collection of dust on oily surfaces would be exceedingly objectionable, and where relubrication is unnecessary, difficult, or impossible. Ceresin, a natural paraffin, is used on the rollers of certain keys; and spermaceti wax in composition with vaseline is used on the armature and rotor bearings of a selector.

In choosing a lubricant we can be guided to a limited extent by its chemical behavior, and by its reaction to changes in temperature and humidity. Viscosity is practically the only measurable physical characteristic which is of much use in an *a priori* consideration. The speed and load of the machine, the temperature of its surroundings, the kind of metals, the kind of housing, the kind of adjacent apparatus, and the maintenance to be expected help us to choose the approximate viscosity and broadly to classify materials into those which appear to have promise or to have no application. Results of tests of promising materials in the actual apparatus constitute the final criterion in the choice of a lubricant for field trial; while it is only after that trial that we can be sure, in first choice successes far exceed the disappointments.

In field operation definite procedures for the maintenance of bearings are usually necessary. Relubrication must be done periodically, and for its aid odd instruments are sometimes required. In some equipment, for instance, a special type of surgical syringe is employed to permit the delivery of a specified volume of lubricant to a bearing which is inaccessible to any other instrument.

The best lubricating practice would frequently be to flood a bearing with a mineral oil of suitable viscosity. Flooding has the important advantage of washing away the products of wear before they can do any damage by acting as an abrasive. With only a small quantity of lubricant the dirt and grit may mix with the oil to form an abrasive paste, with the net result that the bearing is being "lubricated" with an excellent grinding compound. In telephone apparatus, unfortunately, flooding is seldom possible because of the small size of the parts, lack of space for bearing housings, and the nature of the adjacent apparatus. Both the electrical contacts and the friction drives would cease to function if even a small quantity of oil reached them. No known housing for an oil-flooded bearing is able to prevent some leakage of oil. Oil flooding, therefore, cannot be relied upon, and the resulting deficiencies in lubrication must usually be made up by increased maintenance.

The general study of lubricants and of methods for lubrication is one of increasing importance with the new advancements in the telephone art. For some time it has been carried on by the General Development Laboratory in conjunction with the Research Department. Telephone systems are changing from those involving lamps, plugs, and jacks intermittently operated by hand into a system of continuously operated machinery. In the future it is probable that satisfactory operation of an increasingly large proportion of our telephone apparatus will depend in part upon the right choice of an oil, a grease, or a wax.

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

1578634

Whereas CHARLES BORGMANN, of Great Neck, New York, assignor to BELL TELEPHONE LABORATORIES, INCORPORATED, of New York, N. Y., a corporation of New York,

PRESENTED TO THE Commissioner of Patents A PETITION PRAYING FOR THE GRANT OF LETTERS PATENT FOR AN ALLEGED NEW AND USEFUL IMPROVEMENT IN

CLAMPING AND SUPPORTING DEVICES,

A DESCRIPTION OF WHICH INVENTION IS CONTAINED IN THE SPECIFICATION OF WHICH A COPY IS HEREUNTO ANNEXED AND MADE A PART HEREOF, AND COMPLIED WITH THE VARIOUS REQUIREMENTS OF LAW IN SUCH CASES MADE AND PROVIDED, AND

Whereas UPON DUE EXAMINATION MADE THE SAID CLAIMANT is ADJUDGED TO BE JUSTLY ENTITLED TO A PATENT UNDER THE LAW.

NOW THEREFORE THESE Letters Patent ARE TO GRANT UNTO THE SAID Bell Telephone Laboratories, Incorporated, its successors OR ASSIGNS

FOR THE TERM OF SEVENTEEN YEARS FROM THE DATE OF THIS GRANT

THE EXCLUSIVE RIGHT TO MAKE, USE AND VEND THE SAID INVENTION THROUGHOUT THE UNITED STATES AND THE TERRITORIES THEREOF.

In testimony whereof *I have hereunto set my hand and caused the seal of the* Patent Office *to be affixed at the City of Washington this* thirtieth *day of* March, *in the year of our Lord one thousand nine hundred and* twenty-six, *and of the Independence of the United States of America the one hundred and* fiftieth.

Attest: G. P. Tucker
Law Examiner.

Thomas E. Robertson
Commissioner of Patents.

The first patent issued to Bell Telephone Laboratories. Since January 1, 1925, patents for members of our Laboratories have been applied for in the name of Bell Telephone Laboratories, but up to March first those issuing have been on applications filed by the Western Electric Company.

The Development of Apparatus

By J. J. Lyng
Apparatus Development Engineer

By definition it is comparatively easy to separate the duties and responsibilities of the Apparatus groups from those of the Research and the Systems groups. In actual practice, a sharp line of demarcation is neither possible nor necessary. A considerable amount of work in our Laboratories is of such character that it is difficult to decide to which group should fall the responsibility for its execution. Each case of this character is considered and decided on its own merits by discussion between representatives of the departments.

With the addition of some "etceteras," the responsibilities of the Apparatus Development Department are as follows:

To bring to commercial completion certain of the studies of the Research Group;

To develop apparatus required in exchange systems which are resulting from the work of the Systems Development Engineers;

To develop apparatus required by the Bell System apart from that arising from the work of the Systems Development Engineers;

To develop the apparatus required for certain new fields of service;

To study continuously fields, both within and without the Bell System, covered by our apparatus to insure that advances in the art are made as promptly as possible;

To investigate apparatus designs with the view of cost reductions, either in manufacture, maintenance, repair, or through improved service; these cost studies may involve changes in design of current apparatus or radically new designs;

To keep a constant lookout for raw or finished materials which may permit reduction of the cost or the improvement of the quality of our apparatus;

To examine apparatus similar to our own, made by other manufacturers, and to compare with our designs both as to performance and as to cost;

To furnish information and service to the Manufacturing, Installation and Sales Departments of the Western Electric and to the Department of Development and Research of the American Telephone and Telegraph Company on many and various questions arising through the manufacture, sale, installation and use of the apparatus developed by the Laboratories;

To supervise the installation of broadcasting, public-address and power-line-carrier equipment (this includes the engineering of the layout, the design and manufacture of special apparatus, and the training of personnel to operate the plants after installation);

To maintain close contact with the Manufacturing Department, so that by new designs we may be ready to take advantage of advances in the manufacturing art;

To develop methods of testing materials and apparatus (this embraces both mechanical tests, such as impact resistance, hardness, fatigue limits, and electrical tests covering a wide range of frequencies and voltages);

To design and maintain standards for the precise measurement of fundamental electrical quantities, such as inductance, capacitance and frequency.

In our apparatus engineering the term "design" includes not only the form and make-up of the apparatus, but all the features and characteristics which are necessary to give continuous service over a period long enough, taking into account initial cost and cost of maintenance, to provide a proper investment return. A knowledge of operating conditions is therefore essential to an intelligent conception of the design requirements. Knowledge of such matters, also, as the calibre of the operating personnel and the accessibility for maintenance purposes of telephone-plant equipment is vitally important.

Apparatus development requires knowledge of the physical, electrical and magnetic properties of materials, and a knowledge of how these properties may be affected by temperature and other atmospheric conditions. For example, changes in temperature with the presence of humidity and dust are serious factors in the operation of telephone exchanges which must be borne in mind in the design of apparatus. The combination of dust and moisture is perhaps the worst enemy, but a close second is that of moisture and corrosive gases.

Such matters as strength and resistance to fatigue, or embrittlement, require careful study in the selection of materials. Wherever two or more apparatus parts which are in contact have a relative motion, erosion presents its problems; and so does friction, which in addition to provision against excessive erosion may demand means for decreasing its resistance to movement, or for furnishing the proper resistance to movement. Corrosion, which may result in an alteration of surface undetectable except by a most careful examination, must also be guarded against. In certain contact-making devices, for example, protective finishes are prohibited or are impracticable; and corrosion must be avoided either by the selection of suitable materials or the recommendation of proper maintenance processes. Similar consideration must be given to the frictional or "load" characteristics of certain types of apparatus to insure control within desired limits.

Since certain of our apparatus functions by reason of the electrical and magnetic properties of its materials, these properties (limitations as well as capabilities) must be taken into consideration. In the selection of materials for magnetic properties, for instance, we must bear in mind that a material, which is excellent, may be suitable for certain apparatus, but not for all apparatus. Thus, for some equipment iron of a quality even superior to any now available would be justified; but for other equipment such excellent iron would actually produce inferior apparatus. In the matter of magnetic requirements, therefore, we must be sure not only that the material is good enough, but also that it is not *too good*.

Such is a general outline of the scope of the problems of the development of communication apparatus. Much of the information which has been indicated as essential to that work must, of course, be obtained from sources outside of the Apparatus Development Organization. But there has been included in this survey a fairly comprehensive picture of the fields into which our developmental investigation must go in order to indicate the care and precision which is essential to our satisfactory design of communication apparatus.

These operations of ours, we look upon as part of those vitally essential to the maintenance of an enormous commercial mechanism which is engaged in designing, producing, and selling apparatus and in giving service to the public. To the end that our part shall properly mesh in the general plan, we keep in mind that the raw materials which we specify must be those available at prices and under supply conditions which are commercially satisfactory. To this end, also, we aim to design apparatus so that there may always be employed the most economical manufacturing methods which are consistent with the apparatus requirements of service. In design we endeavor to include further such features, consistent with service requirements, as will help to promote sales. Each piece of apparatus, we aim to design so that it will serve with satisfaction to its user and with credit to its supplier. To this end we enlist every source of information—purchasing, manufacturing, sales, installing, operating or engineering—which will insure the most economical result.

The Apparatus Development Department

By Paul B. Findley, *Managing Editor*

IDEAS, intellectual developments, are the main product of our Laboratories as was pointed out in the April issue of the Record. Of the Systems Development Department, which was then under description, the output appears in the correct and economical assembly of completed systems with their maze-like complexity of pathways for electric currents.

For the Apparatus Development Department, the organization of which the present article outlines, the product of ideas takes the form of subscribers' sets, amplifiers, testing instruments, insulation, relays, loading coils. Their design utilizes the latest advances both in scientific research and in manufacturing methods so that they will function correctly and be economical to make and use. To produce and coordinate these ideas the nearly seven hundred men and women of the Department are organized into six groups under engineers who report to John J. Lyng, Apparatus Development Engineer.

At the head of one of these groups is Omer M. Glunt, who received his early experience in Western Electric's student apprentice course following graduation in 1906 by Ohio State University. After two years in the Manufacturing Department at Hawthorne and several months of installation work he went into engineering, first at Hawthorne and in 1911 at West Street. During the War the group he directs developed many wire communication devices, particularly portable telephone sets for various purposes, and submarine detection equipment. Returning to the design of apparatus for central offices

Omer M. Glunt

his responsibilities grew with addition of many new lines of development. One of these, radio, is headed by N. H. Slaughter. Here are designed radio transmitters* for broadcasting, Army and Navy, and for point-to-point telephony over impassable country. One group develops the associated radio receivers, and another conducts field investigations and supervises all installations of radio broadcasting equipment.* Certain products beyond the immediate field of telephony are engineered by G. E. Mather's group; they are talking movies; picture transmission; electrical phonograph recording; power line carrier telephone; train dispatching and power-station control systems; printing telegraph; and installation of public-address systems. Another group designs motors and generators whose requirements as to speed and frequency put them outside the class of commercial machines. Long indeed would be the list of the projects handled by A. F. Gilson's group; they include the design and layout of panels for repeaters, carrier equipment, public address systems, speech input and switching equipment for radio broadcasting; telephone systems for fire control in the Navy; audiometers and audiphones; precision apparatus for transmission measurements, such as oscillators and artificial lines, transmitters and receivers for all purposes; audio-amplifiers and loud speakers; coin collectors; maintenance tools for cleaning and adjusting central office equipment.

Some of the advances embodied in apparatus under Mr. Glunt made an initial appearance under the auspices of the Research Department. In their final commercial form, they represent contributions from engineers of both Departments, each with his own specialized knowledge broadened through comprehension of the point of view of his associates. Research concerns itself with inquiry into the facts of nature and seeks to establish fundamental principles, while development engineering is the application of such

*"*Water Cooling in Radio Broadcasting*," BELL LABORATORIES RECORD, *February*, 1926; "*A One-Kilowatt Radio Transmitter*" *in the April issue*.

*"*Installing Radio Broadcasting Equipment*," *in the February*, 1926, *issue*.

principles to the creation of practical apparatus for commercial use. In a typical case as an investigation advances beyond the pure-science phase the Research men try out its application with laboratory apparatus in forms which facilitate experimental adjustments and measurements. Sometimes apparatus is studied under field conditions to gather additional data. Whenever a future of commercial utilization can be visualized the project becomes one of development. To it the Research men contribute their knowledge of the scientific principles, while the Apparatus Development men work out the practical problems. Among these are new designs, adaptation of standard parts, studies of life and operation, of costs and economic relationships, the proper balance between lightness, ruggedness, accessibility; and simplification where possible. For this work an engineer needs to understand the underlying researches, to know the prior art and to be familiar with the personnel at Hawthorne and the plant facilities available. To this is added an intelligent attention to details—nothing slighted, nothing overdone — that gives a "style" to our apparatus design so characteristic that Western Electric equipment usually can be recognized instantly.

Another of the Department's major groups specializes in the development of apparatus for machine switching. Its head is John N. Reynolds, who like Mr. Glunt passed through Western Electric's apprentice course, after graduation from Purdue in 1904. His first permanent assignment was to the circuit laboratory, where he contributed to the design of the earliest panel-type machine-switching apparatus; this phase of the historic trial installations in Newark was put in his charge. Except for the years from 1920 to 1922, when he was a member of the System's Development Department, Mr. Reynolds' work has been in design of apparatus; among his contributions is the method of brush-selection. At the recent transfer of W. T. Booth to head a study of cost-reduction, Mr. Reynolds was put in charge of the design of apparatus for machine-switching, reporting to Mr. Lyng.

Of the groups reporting to Mr. Reynolds, that of O. F. Forsberg is concerned with new panel apparatus and cost studies; that of G. W. Folkner with modifications of existing panel apparatus; that of M. P. Chaplin with step-by-step apparatus. A fourth group, reporting to D. H. Gleason, tests in its laboratory the apparatus designed by the other sections.*

John N. Reynolds

* *Some of the equipment of this laboratory is described on pages 48-50 of the* RECORD *for October, 1925.*

A wide range of investigations is made by the General Development Laboratory, which renders a variety of services to the Laboratories as a whole. William Fondiller, its head, holds degrees from City College and Columbia. He entered Western Electric in 1909, in what was then called the Physical Laboratory. His particular interest has been in coils for loading, for filters and for transformers; he was a joint inventor of the high-stability loading which was in 1914 an essential element of the Transcontinental line. He also directed the development work which led to the commercial use of iron-dust cores in loading and other coils.

William Fondiller

Of Mr. Fondiller's staff, W. J. Shackelton supervises design of loading coils and cases, and of condensers; and the study and application of magnetic materials. He is also responsible for inspection and calibration of all measuring instruments and testing sets; measurement services to other laboratories; and development of circuits which are used in making precise measurements with alternating currents.

All sorts of electromagnetic apparatus are designed by engineers of D. D. Miller's group. Mention may be made of relays for telephone and telegraph circuits, involving power from 5 microwatts up to several watts and frequencies from zero to 1000 cycles. Electrolytic condensers, message registers, ringers and resistances are also designed in this group. Coils and transformers for every purpose—from a choke coil weighing a ton to a radio-frequency transformer — come from W. L. Casper's engineers. In this group are designed electric wave filters—of late years widely used in wire and radio communication for sharp discrimination between currents of different frequencies.

Switchboard cords and cables; indicating and ballast lamps; thermocouples; batteries—these are some of the diversified activities of E. B. Wheeler's groups. Incidental to extensive studies of insulating qualities of textiles under varying degrees of moisture,* Mr. Wheeler has developed a humidity laboratory of general service for such tests on all sorts of apparatus. A humidity recorder, one of the products of these studies, is an important contribution to the art.

These four groups in the General Development Laboratory have been principally concerned with design; groups headed by P. Norton and H. N. VanDeusen perform primarily analysis and testing. To them is turned over for review apparatus designed elsewhere in the Department. From the scrutiny of their engineers often grow suggestions for changes which

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*"*Textiles for Insulation in Telephone Equipment*," by *Howard H. Glenn* in the RECORD for *April*, 1926.

are taken into account by the design engineers before the apparatus is put into production. They also study the properties of all new materials that appear on the market with a view to their application in the Bell System. In addition Mr. Norton is the point of contact of the Laboratories with the Board of Fire Underwriters, and secures their comments and approval on apparatus from a fire-protection standpoint. He also advises our engineers, on request, as to the Underwriters' requirements. Some of Mr. VanDeusen's engineers have made a special study of all forms of insulation, and of the properties of various alloys. In particular they have contributed to the practical application of contact metals developed by the Research Department.

Gustavus A. Anderegg

Development of cable for the outside plant is in charge of Gustavus A. Anderegg. Reporting to him are W. C. Redding, who with his group acts in an advisory capacity to the sales departments of Western Electric and Graybar, and as a point of contact for the American Telephone and Telegraph Company and the Laboratories in dealing with the Hawthorne cable development group. Some activities of the latter group, which is in charge of L. S. Ford, are described on another page of this issue of the RECORD. W. A. Mougey is stationed in Europe to guide associated cable manufacturers in making toll cables under Bell System patents. Mr. Anderegg himself has spent most of the last few years in England in connection with the permalloy loading of submarine telegraph cables. He entered the Laboratories in 1908, after being graduated from Oberlin and Harvard, and having several years' teaching at both institutions. In 1910 he went to Hawthorne to take charge of developments of duplex telephone

William T. Booth

cables, remaining there until 1918. Returning to the Laboratories, he headed for a time the Transmission Branch and later the Physical Laboratory; and in 1920 was given technical supervision of the manufacture and laying of the Key West-Havana cables. Following this came permalloy cable with which he is still identified.

An extensive study of telephone apparatus, with a view to further reductions in cost, is headed by William T. Booth; in this work he is assisted by F. H. Hibbard. Mr. Booth entered Western Electric in 1899 as a switchboard wireman. The following year he left us to go into telephone manufacturing and development elsewhere, returning in 1908. For three years ending in 1914 he was an apparatus engineer on the staff of the European Chief Engineer. Returning to West Street he was put in charge of detailed apparatus design on government contracts, including radio apparatus for airplanes. Later he was put in charge of machine-switching apparatus design, and very recently was transferred to head up important studies on cost-reduction.

General services to the Department are rendered by four groups reporting to Roy R. Ireland.* A variety of activities are supervised by W. A. Bischoff, among which may be mentioned the compilation and distribution of cards for some 560 apparatus catalogues in this country and overseas, and the files of apparatus drawings and specifications. Preparation of specifications and writing of technical bulletins is handled by H. W. Heimbach; departmental costs by E. C. Edwards; and a drafting force of some eighty people by W. D. Smith.

This in brief is the organization which carries on under Mr. Lyng's leadership a varied and important group of activities. Its investigative function involves a study of materials, design, manufacture and use of every form of communication apparatus and the development of new, and the modification of present apparatus to serve the needs of the Bell System.

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* *A biographical sketch and a portrait of Mr. Ireland appeared on page 172 of the* RECORD *for December.*

Talking Motion Pictures Developed

Announcement has been made by the Western Electric Company that it has licensed under its patents the manufacture of talking moving pictures. This development marks a distinct addition to the technique available to the motion picture art, and is a culmination based on the electrical and acoustic researches and apparatus developments of our Bell Telephone Laboratories. In it is combined for the first time complete and practicable means for recording events and faithfully reproducing them audibly as well as visibly for an audience in a theatre.

Essential features of the system are methods for electrical recording and reproduction and means for synchronizing the acoustic and optical apparatus. In later issues of the Record the story of this development will be told, and the details of apparatus and systems described.

Printing Telegraph Connections With Hawthorne

By D. R. McCormack

Designing communication equipment for the use and service of others, Bell Telephone Laboratories never hesitates to employ such equipment for its own economy and convenience. Telephone dictation, which was described in the Record of November, 1925, is only one of several illustrations.

An illustration reaching farther back into the past is our printing-telegraph service between West Street and Hawthorne. In 1915 one of the systems which was then under development in the Laboratories was installed for such communication. One of the accompanying pictures shows this equipment and in the background may be seen some of the laboratory apparatus with which the development engineers made constant studies of the service and its condition. The system operated under conditions of field trial and was carefully supervised by the engineers concerned with its development. Occasionally, therefore, there were interruptions in its service which gave valuable experience as to conditions of long-line traffic to the engineers, and during such periods the operators were usually employed on test work in the printer laboratory. Very quickly, however, the apparatus was perfected and dependable long-distance transmission was secured.

Veronica Monahan, head of the group operating the private-wire printer terminal equipment

By July, 1918, when the so-called "1-B Full Duplex Printer" was installed, the printer system was handling over three hundred thousand words each month at a speed of about thirty-five words a minute.

The condition of the equipment in the Printing Telegraph Department of the Service Group in 1924 is indicated by the third of the accompanying pictures. The equipment is the latest No. 10-A type of full duplex printer. Its installation is very compact, with the sending and transmitting mechanisms both on one small table. Two complete equipments are installed, one for reserve and for operation while the other is being serviced.

To transmit, an operator types on a key-board the message which is to be sent. As each key is struck a combination of small holes is punched through a paper tape. This tape then passes immediately through the sending mechanism and automatically results in transmitting to Hawthorne the sequence of telegraphic impulses determined by the successive groups of holes.

The system is full duplex; and at the same time as an outgoing message is being typed and transmitted an incoming message is being received. The impulses transmitted from the Hawthorne terminal are automatically decoded by the receiving mechanism and operate relays to make the proper type-faces strike on the paper of the recording machine. The typing of the incoming message produces a page somewhat similar to that of an ordinary typewriter but using capitals throughout and done in copying ink so that duplicates are readily obtained by means of the familiar hectograph process.

At present this apparatus is transmitting messages by the system of carrier-current telegraphy over a circuit in the new New York-Chicago cable, which was described on page 70 in the RECORD, October, 1925. Both sending and receiving are carried on at a speed of about sixty words per minute; during the last month for which records are available, approximately seven hundred thousand words were transmitted practically without interruption. This printer system handles nearly all the correspondence with Hawthorne which needs to be expedited, except the rush transmission of large amounts of material in the form of reports and specifications which are usually sent by Twentieth Century or night airplane-mail.

One type of service rendered by the department in charge of this prin-

Printer equipment at West Street as it was in 1915

Printer equipment as it is today

ter is known as "Telephone-Telegram," where the delivery of the message to the addressee is by telephone from the operator at the receiving end. Advice as to the hour at which the telegram was delivered over the telephone is immediately returned to the sender. This service, which is probably unique in industrial organizations, has proved invaluable in cases where engineering or technical advice must be immediately exchanged between the Manufacturing Department and the Laboratories.

All of these operations of the Printing Telegraph Department are under the supervision of Veronica Monahan and require the services of four expert operators and several messengers. At present, service to the Western Electric Company at 195 Broadway and at Kearny is given by this Laboratories organization.

But the printer equipment is not limited in its service to purely business matters, for on one Saturday afternoon at least, each year, it transmits the moves in the annual chess contest between the Hawthorne Club team and that of our own Bell Laboratories Club. How successfully it accomplished this transmission is indicated in the Club Notes of this issue, which report the latest victory of our Laboratories team and its permanent possession of the trophy.

Cable Development Outpost at Hawthorne

By Roy C. Jones

In the first issue of the Record, under the heading "Our Far-Flung Outposts," brief mention was made of the Lead-Covered-Cable Division at Hawthorne. Unlike other units of the Apparatus Development Branch, it is unable, because of the nature of the equipment with which it is concerned, to work with model-shop samples. It must use the factory itself as its model shop; and that is one of the chief reasons for its outpost location at Hawthorne.

In that same issue of the Record there was a brief allusion to the "researches on cable which led to the installation of loaded duplex cable on the route from Boston to Washington." For this project it was necessary to develop a cable suitable for loaded phantom circuits. This cable was an important advance in economical, reliable long-distance telephony.

Development work was started intensively during 1910 and that same year the first section of the Boston-Washington toll cable was manufactured. The development required a resident group at Hawthorne, where it was possible to manufacture with the shop equipment large numbers of experimental cables. Later this group undertook general cable-development work. Today it consists of about twenty engineers who are concerned with problems of developing new types of cable and instituting improvements and economies in existing types. It also has the responsibility of preparing all design information on lead-covered cable.

This article will describe briefly some activities of this unit of our Laboratories, particularly those applying to that side of the engineering work most closely associated with the commercial output.

As in the case of other equipment, when a particular type of cable has been developed to the point of standardization, its detailed requirements are covered in regular "M" specification form and a code number is assigned for identification purposes and for ordering.

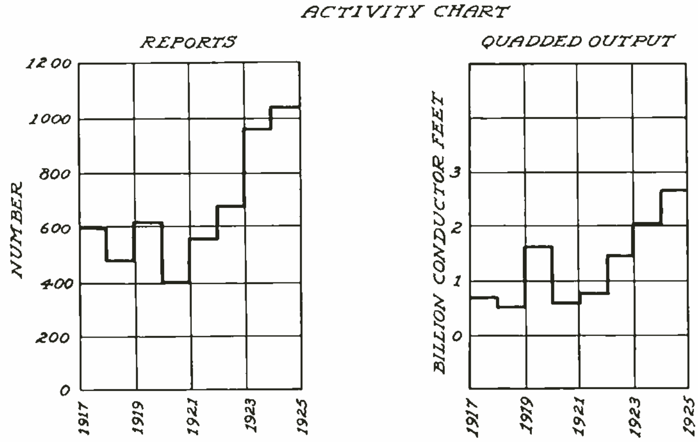


Fig. 1—Chart showing number of reports made and cable output supervised during the last eight years

These cables comprise by far the greater part of the Western Electric output and the orders for them require no review by the Laboratories.

There are, however, a very large number of special cables required. In this class are our many types of composite quadded-cables, the make-up and requirements of which are continually changing. Unlike other special apparatus, these cables are not ordered by "D" specification number, nor by special code-number, but by customer's specifications. All such orders are referred to the cable-development engineers for checking and for assignment of manufacturing information. In the case of special cable for the companies of the Bell System, the results of all the more important electrical tests are furnished to them; and these reports are prepared and sent out by this group. Figure 1 shows graphically the Department's activity during the past eight years. One graph gives the annual output by the Hawthorne Works of quadded cable in billions of conductor feet. The other graphs show the growth in number of reports prepared by the engineers of our cable outpost.

Long toll-cable must be so designed that mutual capacities of each section of cable between successive loading points, a distance of approximately 6,000 feet, shall be 0.062 m.f. per mile of cable. It is further very important that the variations from this value be kept as small

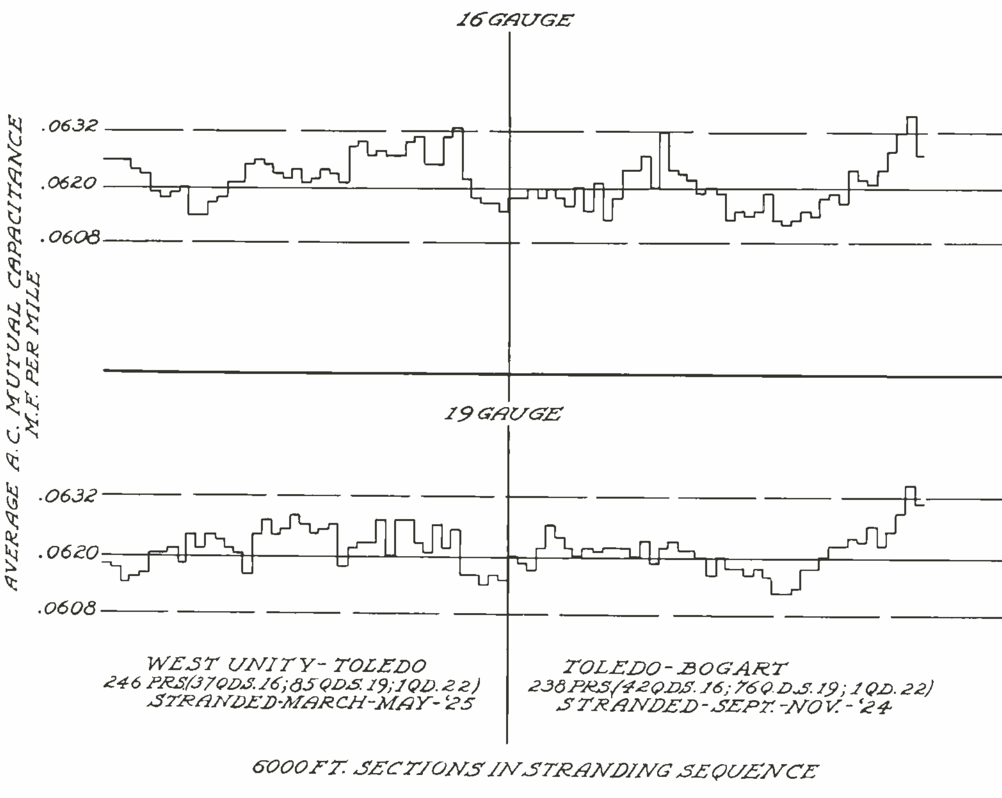


Fig. 2—Variations in average capacitance of No. 16 gauge and No. 19 gauge pairs respectively of the reels of cable used for loading sections of the New York-Chicago cable

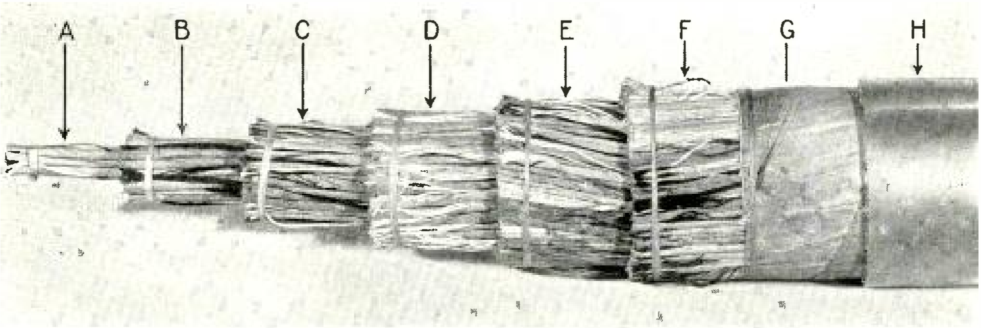


Fig. 3—The composition of the cable between Portsmouth, N. H., and Portland, Me. (A) 2 quads No. 16 white cotton; (B) 8 quads No. 16 black cotton; (C) 13 quads No. 16 white cotton; (D) 19 quads No. 16 white cotton and 1 quad No. 22; (E) 9 quads No. 19 white cotton, 10 quads No. 19 red, 10 quads No. 19 green, 6 pairs No. 16; (F) 21 quads No. 19 white cotton, 10 quads No. 19 red, 10 No. 19 green; (G) 2 wrappings of paper; (H) sheath 2⅝" in diameter

as possible. It becomes necessary, therefore, to follow the manufacturing output closely in order that changes in design may be introduced during the manufacturing processes when needed to reduce this variation. The graph of Figure 2 shows the variations in average capacitance of the No. 16 gauge and No. 19 gauge pairs, respectively, of the reels of cable which were used for loading sections in the New York-Chicago toll-cable on both sides of Toledo.

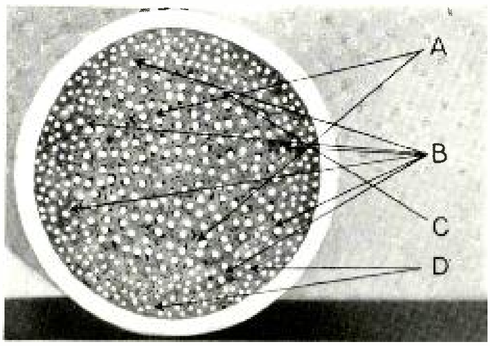


Fig. 4—Cross-section of cable shown in Fig. 3. (A) 42 quads No. 16; (B) 6 No. 16 broadcasting pairs; (C) 1 No. 22 quad; (D) 70 No. 19 quads

A necessary activity of the cable development engineers is the preparation of designs for cost-estimating purposes. In connection with the supply business, now being conducted by the Graybar Electric Company, requests are received for quotation on a variety of miscellaneous jobs. This, of course, involves the preparation of sufficient design information to permit figuring the prices for each specified cable. Orders are, of course, received for only a portion of these requests; as many times, for example, these are for estimating purposes only in connection with engineering problems. Another rather special phase of such cost estimation is that due to evaluation studies of existing cable plant. For the purpose of determining approximately the present reproduction value of cables requests are routed to cable engineers for cost estimates. A recent request involved two hundred and eighty-five items of special cable, including both land and submarine cable.

One of our most interesting special cables, requiring considerable detailed engineering, is our modern long-distance quadded cable. The first cables of this type used No. 10 and No. 13 American Wire Gauge wire, but improvements in telephone repeaters and associated apparatus have made it possible to reduce the size of wire and thereby increase the number of circuits in a given size of cable. For the principal toll-line projects of today the sizes of wire in general use are No. 16 and No. 19.

In the design of such quadded cable it is common practice to place the No. 16 gauge quads in the central portion of the cable, surrounding these quads by others of No. 19 gauge. The No. 16 guage quads are used for two-wire operation, and the No. 19 gauge quads, in general, for four-wire operation, although No. 19 gauge is also used in certain cases for two-wire operation.

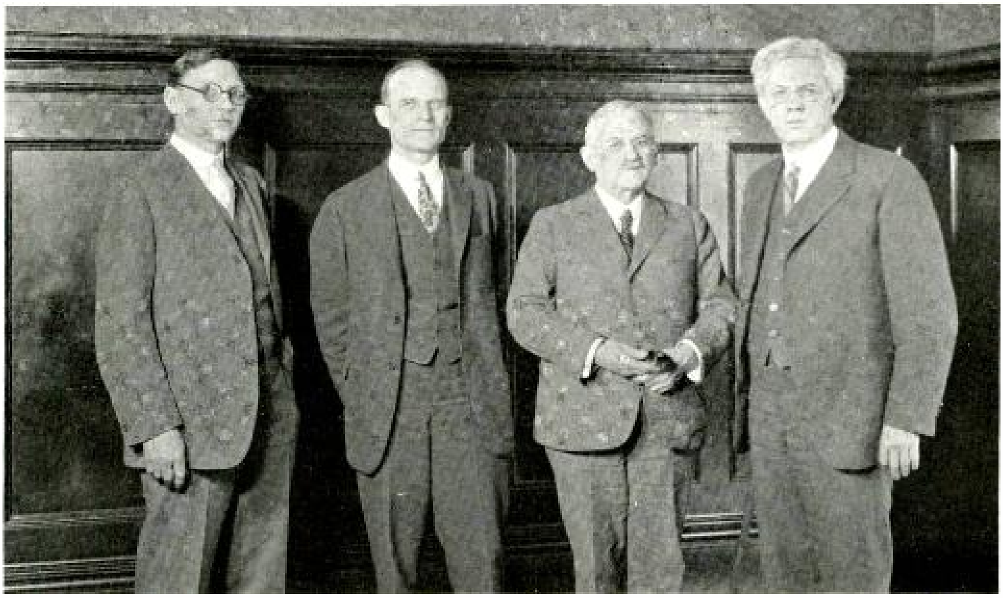
In the manufacture of the quads themselves, cotton is used to bind each pair before twisting with distinguishing colors. White indicates quads for two-wire service, and usually the No. 16 gauge quads have white cotton over the pairs. However, it is sometimes advisable to use different types of loading on some of these circuits, and when extra-light loading is employed, the quads to be so used are designated by black cotton and segregated in a layer. In the No .19 gauge four-wire circuits, certain quads are used for transmission in one direction and others for transmission in the opposite direction. These groups are distinguished by red and green cotton, and are kept apart, common practice being to segregate the red-bound quads in one position of a given layer and the green-bound quads on the other side of the layer.

In the more recent designs of toll cables, circuits for broadcasting service are included. This is usually accomplished by substituting four or six pairs of No. 16 gauge for the same number of No. 19 gauge quads in one layer. These are non-quadded pairs, and are distributed around the layer

The members of the Lead-Covered-Cable Division at Hawthorne in which they are placed, so that they are never adjacent. These are high-grade circuits permitting the same quality of transmission as the quadded pairs.

Views of one of our modern quadded toll cables are shown in an accompanying illustration. The locations of several types of circuits are indicated.

In connection with the installation of quadded cables, telephone engineers have developed certain measuring instruments and a technique of splicing which reduces the possibilities of objectionable capacitance unbalances between circuits in a continuous length of cable. The length of approximately 6,000 feet between successive locations of loading coils is made up by splicing the contents of several reels of cable at points approximately one-quarter, one-half and three-quarters the distance between loading points. These splices are made in accordance with measurements so as to connect together those conductors on the opposite side of the splicing point which would result in minimum unbalance. The remaining splices in the loading section were formerly made without measurements, that is, more or less at random within certain geometrical limits imposed by the various layers of the cable. A recent development in the method of stranding the circuits in the different layers of the cable, so as to provide a definitely pre-arranged sequence, permits a splicing diagram to be prepared which can be furnished to the splicer so that he will know just what quads are to be joined, in order to reduce the possibility of high unbalance between the phantom circuits. This practice has been termed "planned random splicing."



A recent visitor to our Laboratories was Otto P. Amend, past president of the Chemical Club and president of Eimer and Amend, the well-known chemical and scientific instrument supply house. Dr. Amend, who is a musical connoisseur as well as a distinguished chemist, was much impressed by the quality of our latest developments in loud speakers. In the picture, from left to right, are D. G. Blattner, R. R. Williams, Dr. Amend, and J. B. Speed

News Notes

The April issue of The Bell System Technical Journal includes an article on "Development and Application of Loading for Telephone Circuits" by Thomas Shaw and William Fondiller; "A Static Recorder" by Harold T. Friis; "Directive Diagrams of Antenna Arrays" by Ronald M. Foster; "Correction of Data for Errors of Averages Obtained from Small Samples" by W. A. Shewhart; "The Alkali Metal Photoelectric Cell" by Herbert E. Ives; and "Electric Circuit Theory and the Operational Calculus" by John R. Carson.

John W. Horton described the electrical transmission of pictures, at the April fifteenth meeting of the Columbia University Physics Colloquium. On the following day, the members of the Colloquium visited the Laboratories.

The Employee Service Department is being of assistance to those members of the Laboratories who are veterans of the World War in the reinstatement and conversion of their war-risk insurance. The privilege of conversion expires July second of this year. Clyde Drake and J. S. Edwards of the Employee Service Department, located in Section 1-C, have secured information of importance in connection with methods of conversion and may be consulted by the veterans who are interested.

The Essex County Medical Society, at the Academy of Medicine of Northern New Jersey, was shown by H. Clyde Snook a number of the recent developments of the Laboratories which are of particular interest to the medical profession. Mr. Snook explained and demonstrated the multiple electrical stethoscope, phonograph records of heart sounds, the audiometer, and the cathode-ray oscillograph.

As a supplement to the course in radio telephony and telegraphy given to the graduating class of the United States Naval Academy at Annapolis, Edward L. Nelson described to the students the recent development of the art, with particular attention to the employment of sidebands and filters. In his demonstration Mr. Nelson used some of the filters and a carrier-current system of multiplex telegraphy.

Three lectures on magnetostriction and allied phenomena were given during April by Louis W. McKeehan, before the Franklin Institute of Philadelphia. The first lecture, under the heading "Magnetostriction in Iron, Nickel and Cobalt" treated the classical experiments on change in dimensions with change in magnetization, and change in magnetization with forcible change in dimensions; later experiments in pure metals; the theories of continuous media and of manœuvre; and experiments on single crystals of iron. The second lecture, "Magnetostriction in Alloys and Compounds" covered experiments on magnetite, permalloy, and various alloys of nickel and iron; theory of atomic magnetostriction; and change in electrical resistance with magnetization and with mechanical stress.

The third, "Magnetostriction in Non-uniform Bodies," described experiments on bodies chemically non-uniform, the preparation and behavior of bodies physically non-uniform; internal strains; annealing and quenching; cold-work; and crystal orientation and its effect on magnetization.

JOSEPH P. MAXFIELD has contributed an article on the phonograph to the new edition of the Encyclopedia Britannica.

DURING MARCH, H. F. Kortheuer, W. C. Miller and R. M. Moody of the Inspection Department were in Hawthorne in connection with regular Survey Conference work.

P. B. Almquist has been transferred to San Francisco where he is assisting R. J. Nossaman in Field Inspection Engineering work in the Pacific Territory.

"RESEARCH in the Bell Telephone Laboratories" was the subject of a talk by Sergius P. Grace given recently before the Rotary Club of Oil City, Pennsylvania.

C. H. Amadon examines a sample boring from a cedar pole to determine the thickness of its sap wood

AT THE ANNUAL CONVENTION of the American Medical Association in Dallas, Texas, Harvey Fletcher and Dr. E. P. Fowler, of New York, discussed the problem of the detection and treatment of the three million deaf children in the public schools of America.

RESEARCH WORK of the Bell Telephone Laboratories, particularly in relation to speech, hearing and audio-frequency amplification, was the sub-

The group in charge of our P. B. X. operators. Standing: Mary Cassidy, Hattie Payntar; seated: Adele Robert, Anna M. Menig, chief operator, Pearl Goodreds ject of talks given by Paul B. Findley before the Engineers' Club of Hartford, and the Lions' Club of New Haven.

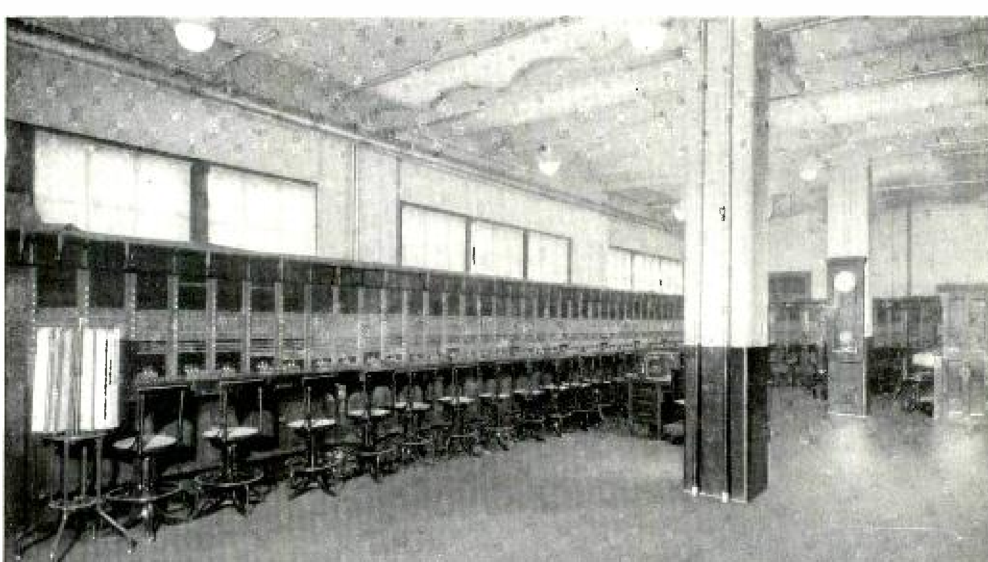
FRANCIS F. LUCAS delivered lectures on recent advances in metallography and the ultra-violet microscope before meetings of the American Society for Steel Treating in Pittsburgh and Cleveland; and two special lectures on photomicrography at the Case School of Applied Science.

FRANK B. JEWETT was one of the speakers at a joint meeting of the Metropolitan Sections, A. I. E. E., A. S. M. E., A. S. C. E., and A. I. M. E. "Qualifying Engineers for High Executive Positions" was the topic under discussion.

ON MONDAY EVENING, April 19, the Colloquium held its hundredth meeting. K. K. Darrow was elected president, C. J. Davidson vice-president, and A. T. Reeve secretary for the year 1925-1926. The speaker of the evening was Mr. Darrow; his subject was ionization.

C. H. AMADON, of the Inspection Engineering Department, recently spent several days in Yarmouth, Me., consulting with the American Forestry Products Company on cedar poles and their preservation.

A NEW PRIVATE BRANCH EXCHANGE telephone switchboard was put into service in the Laboratories on the morning of April 5th. The accompanying photograph shows a general view of the board, which is installed in Room 1024, on the south side of the court in 10-A. It is the result of about two years' negotiation, planning, and construction on the part of our own engineers and the New York Telephone Company and the Western Electric Company, and represents the most modern practice in manual P. B. X. construction. Present equipment consists of thirty-three positions serving sixteen hundred extension lines; in the layout future growth has been provided for to the extent of fifty positions serving twenty-eight hundred lines.



New private branch exchange switchboard recently put into service in the Laboratories

Club Notes

West Street's most successful basketball season was brought to a close March 24th, in the Jersey City Y. M. C. A., when our "All-Star Team," in a fast and thrilling game, defeated the champion ball-tossers of the Western Electric West Side Shops. The West Siders were beaten in the second period after a hard battle.

The big fireworks were let loose in the beginning of the second half, when in a five-minute burst of speed the Western Electric boys brought the score from 14-7 to 14-13. But that was the best they could do. Steinmetz, of the Laboratories, dropped four field goals in rapid succession from the center of the court, and the West Side rooters sank back into their seats. The score at the end was 39-22 in favor of our Club team.

In the last five minutes Coach Waldron took out his "varsity" team and put five substitutes on the floor. These men did well, not only preventing the West Siders from scoring, but adding five points to our own total.

By defeating the Junior Assistants in the final game of the Club Interdepartment League, the Commercial Department's basketball team won the championship trophy donated by A. G. Spalding & Bros. An individual prize—a Parker pen—was given to each member of the team.

Commercial's victory came after a

Our Basketball team which defeated the Western Electric West Side Shops. Standing: W. Steinmetz, G. DeAngelis, C. F. Hiscock, J. Rupp, W. Trottere; seated: T. J. O'Neil, T. V. Curley, C. Gittenberger, C. Maurer, A. T. Hansen

Players who won the annual Hawthorne-New York telegraph chess match: D. G. Grimley, F. A. Voos, R. L. Dempsey, H. A. Whitehorn, D. A. Quarles, G. H. Heydt, C. F. Sacia, H. D. Cahill, H. M. Stoller, H. T. Reeve

hard season's struggle. Equipment finished the season just one game behind the leaders. The final standing:

Team	*Won*	*Lost*	*Pct.*
Commercial	13	1	.928
Equipment	12	2	.857
Research	8	6	.571
Toll & Circuit	7	7	.500
App. Development	5	9	.357
Jr. Assistant	5	9	.357
Tube Shop	5	9	.357
Patent-Inspection	1	13	.071

FOR THE FOURTH TIME in a series of seven annual chess matches over the printing telegraph wires, ten players, representing the engineers of the Bell Telephone Laboratories, triumphed over the team of the Hawthorne Club, at Chicago. The score was 5½ to 3½, with one game unfinished. This game will be adjudicated, although the decision will not affect the result of the match.

By defeating Hawthorne, the Laboratories' team brought back to New York the Championship Cup, which we lost in 1925. Of seven matches played thus far, New York has won four, drawn two, and lost only one.

New York

1. D. G. Grimley	0
2. F. A. Voos	—
3. R. L. Dempsey	0
4. H. A. Whitehorn	1
5. H. T. Reeve	½
6. C. F. Sacia	1
7. H. M. Stoller	1
8. H. D. Cahill	1
9. D. A. Quarles	½
10. G. H. Heydt	½
Total	5½

Chicago

1. J. Shallcross	1
2. J. M. Stahr	—
3. J. M. Juran	1
4. M. J. E. Golay	0
5. C. Rasmussen	½
6. F. Asplund	0
7. B. A. Eliason	0
8. J. Grosvenor	0
9. P. Newman	½
10. H. Brander	½
Total	3½

Margaret Brisbane, snapped during a hike on J. B. Speed's estate near Grassy Sprain Reservoir

IF SUMMER COMES, there will be good weather for outdoor horseback riding. Club members have two riding parks at their disposal: Van Cortlandt Park, available on Saturdays, with A. D. Soper in charge; and the Unity Riding Academy in Brooklyn. Van Cortlandt lessons are two dollars for two hours. The charge at Unity Academy is $1.25 an hour, which includes instruction, contrary to the announcement published in the RECORD last month.

It is rumored that our riders have been instructed to such a state of proficiency that they are ready to steer their chargers fearlessly out into the open spaces. Should a horse suddenly decide to go off on a little jaunt of his own, the rider will simply sit tight, and think of the things he has learned in the indoor ring.

There are plenty of facilities for more riders. Anyone who has not yet learned to ride less stirrups and without "pulling leather" is urged to join the class. Miss Gilmartin will be glad to give information as to hours of instruction and other details.

FOR ALL THOSE who prefer the good firm ground to the heights of a horse's back, there is hiking. The hikers have been going out all winter; but now, with the country at its springtime best, the parties will be much larger. The schedule for May: Saturday, May 1, Orange Reservation, New Jersey; Sunday, May 9, Endurance Hike on Bronx River Parkway; Saturday, May 15, Hunter Island, Pelham Bay; Thursday, May 20, campfire supper at Edgewater; Sunday, May 23, Irvington to Tuckahoe, Westchester County.

Evelyn and Margaret Brisbane and W. C. Buckland, in Central Park

Nothing has been planned for Memorial Day week-end. The endurance hike will be straight walking—no climbing—with distance the object, and time a secondary consideration. There will be time out for lunch, as there is for the Saturday campfire supper—except that there will be no campfire.

THE GOLF CAGES on the roof of Section "G" have been popular with those of our men who want to practice their shots before the greens are ready. The cages are also intended for the use of the women who are ambitious to improve their game. The Club secretary has a supply of clubs which he will be glad to loan.

EVERY CLUB MEMBER should have a pin. The price is a dollar sixty-five.

THE POLICY of the Club, as has been stated frequently, is to promote any activity in which a sufficient number of members are interested. To look after the interests of our women, there has been formed a General Committee on Women's Activities. The first meeting was held on March 29; the members of the committee are: Marian G. Mason, Helen Cruger, Phyllis Barton, Marian G. Gilmartin, Ervin E. Hence, Mary Murtagh and Margaret Horne. Miss Horne was appointed Director of Publicity.

Any member of the committee will be glad to explain the Club's activities and to introduce to new members those now participating.

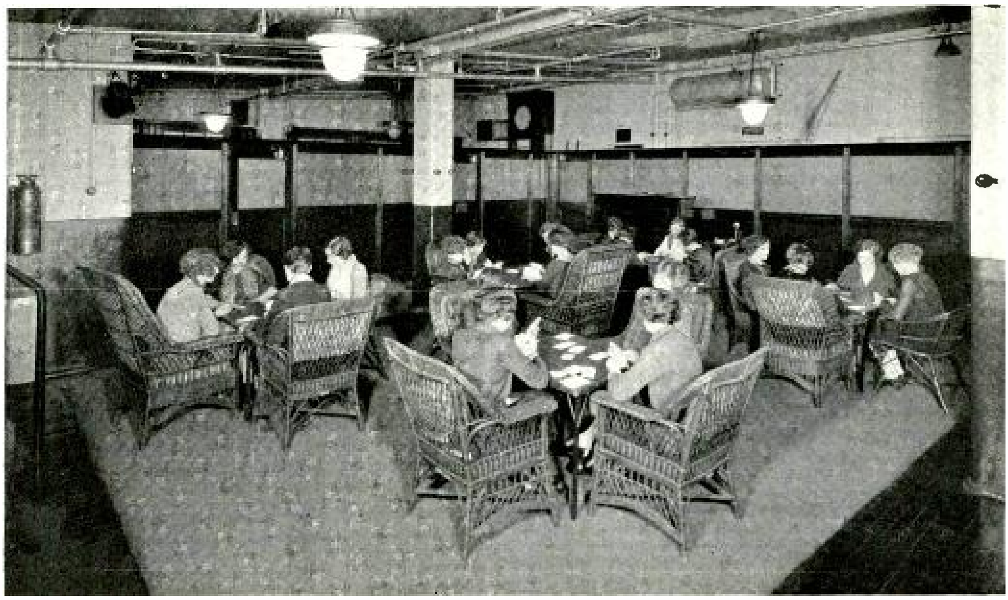
WOMEN'S SWIMMING CLASSES have been started with real enthusiasm. Prospective swimmers enough to more than fill the Carroll Club pool were signed up within a day after the notice of the classes was sent out. Arrangements have been made for a second course on Friday evenings, so that no one who wants to perfect the swan dive and Australian crawl before summer need be disappointed.

The instruction covers a period of eight weeks; both courses—Tuesday and Friday—are given at the Carroll Club, Twenty-ninth Street and Madison Avenue, under the instruction of Miss Steel, Assistant Physical Director of Houston House.

THE CLUB HANDICAP GOLF TOURNAMENT will be held this year at the

G. J. Kreer: also taken on Mr. Speed's estate

Salisbury Country Club, Salisbury Plains, Garden City, Long Island. The qualifying round will be played on Saturday, June fifth, and the finals on Saturday, June twelfth. Both rounds will be eighteen holes of medal play, starting at one-thirty. Entries should be filed with the Club secretary not later than May twenty-ninth. An entry fee of two dollars will be charged.



A card party in the women's rest room

Prizes will be given for the best net and gross scores in the qualifying round and a number of prizes and a trophy for the best net scores in the finals. In order that all players may finish before dark, the committee is obliged to limit the qualifying round to eighty players.

THE INTERDEPARTMENT Baseball League is composed this year of six teams: Research, Tube Shop, Commercial and Shop, Equipment, Toll and Circuit, and Apparatus Development, Patent and Inspection. The season opens May 15th; two games will be played every Saturday, at Erasmus Hall Field.

A LIVELY SOCIAL SEASON ended with the Club's Spring Dance at the Hotel Pennsylvania on April thirteenth. Seven hundred members and friends of the Club danced until the wee, small hours of the morning to the coaxing music of Ben Bernie's orchestra. About ten-thirty, the Club's Symphony Orchestra, under the leadership of G. R. Groves, gave a short concert. This was followed by three songs by F. M. Costello, formerly director of the Glee Club.