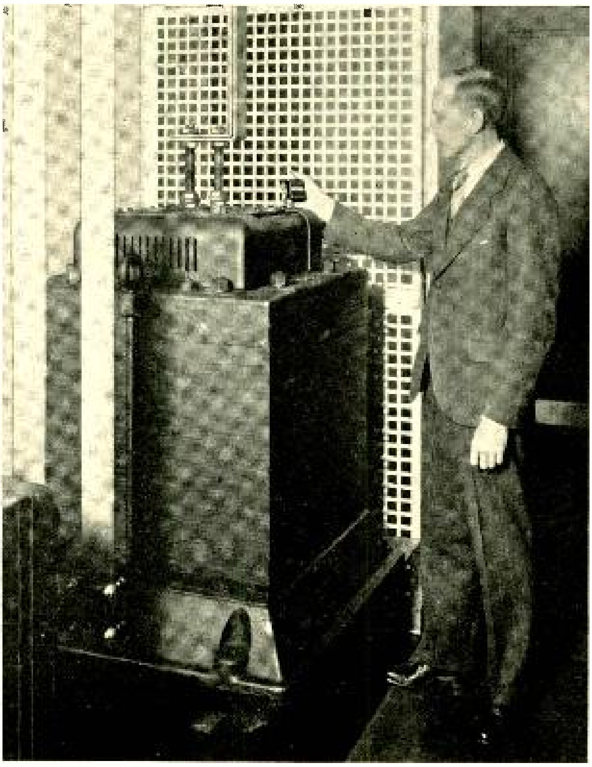
# *Bell Laboratories Record*



*A 1000-ampere choke coil and for comparison a small coil typical of carrier circuits*

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# Viscosity in Solids

By R. L. WEGEL
*Acoustical Research*

WHEN a solid is in a state of strain, energy is stored in its elastic deformation. When a bar is stretched slightly and then suddenly released, it vibrates and the vibrations gradually subside. A part of the energy which was thus originally stored is transformed into heat which increases the temperature of the bar. The remainder is stored in the material in the form of molecular strains incident to a permanent deformation. The rate at which energy is dissipated in heat, as well as the amount of energy which remains stored, varies with the kind of solid and the extent of the initial strain. In the design of many types of vibrating apparatus the damping effect of this dissipation must be quantitatively taken into account, and thus a determination of the nature of internal constants of materials is of importance.

The distortion of a piece of solid matter is generally accompanied by two kinds of energy losses: thermodynamic losses due to changes of volume, and losses due to shearing between layers of the material.

With these shearing losses, loosely called viscous losses, this article is concerned, since they are by far the larger part of the total. There are at least two properties of a solid, viscosity and plasticity, that are concerned with shear and that may be responsible for the internal transformations of mechanical energy of vibration into heat. The viscosity of a solid is its ability to transform mechanical energy of vibration into heat without the establishment of a permanent set, while plasticity is its ability to make this transformation by virtue of the establishment of a permanent set. Plasticity is thus a counterpart in the solid of what is usually called "viscosity" in a

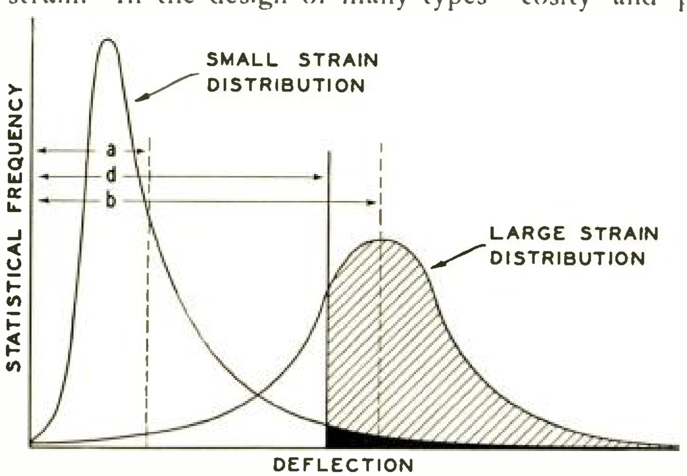



*Fig. 1—When a solid is strained, its component atoms may show different deflections whose average is the overall strain. Ratios of shaded areas to total areas under curves show proportions of atoms deflected more than their distance apart, and thus permanently set.* a *is the average deflection for a small strain;* b, *the average deflection for a large strain;* d, *the distance between particles*

fluid. No property of fluids has been named to which the viscosity of solids is the counterpart.

Ascribing the behavior to "properties" in this way, however, does not explain the mechanism of the behavior. A real explanation is far capable of a motion which is restricted only by collisions with other molecules. In solids the atoms vibrate about relatively fixed positions. Envisaged in these terms the phenomenon to be explained is that of the transfer of the energy from the gross

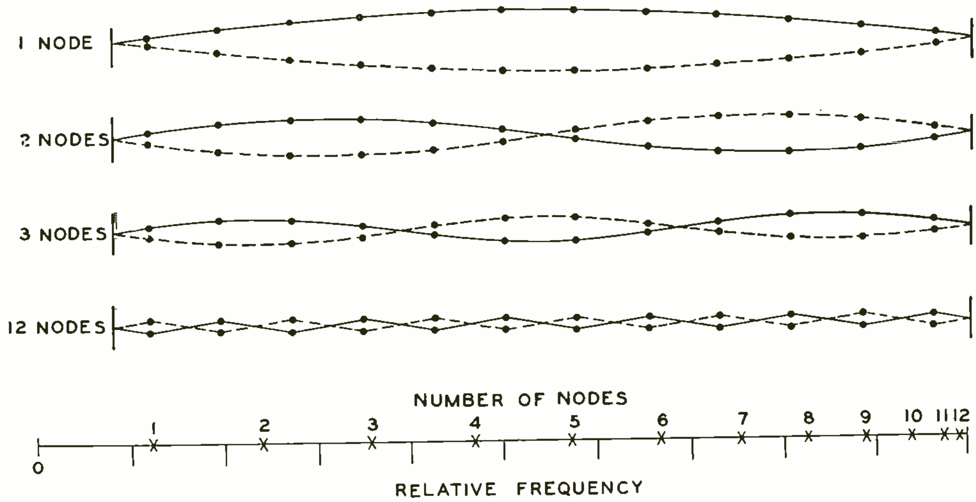



*Fig. 2—Configurations of first, second, third, and highest normal modes, and relative frequencies of all normal modes, of vibration of a string of twelve beads. The two end-points of the string together constitute one node*

more difficult. Several theories have been devised to provide this sort of explanation of the transformation of vibrational energy into heat, but no one of them is yet generally accepted, nor indeed theoretically completed. Three are especially valuable in illuminating the behavior of solids and clarifying the distinction between viscous and plastic dissipation.

It is generally agreed that heat is a rapid motion of certain ultimate characteristic particles, the atoms, of the heated matter. Heat content depends on the energies of these moving particles—on their masses and velocities—and in any one substance increases with increase in the velocities of these particles. In gases the ultimate particles to be considered are more strictly molecules and these are or acoustic vibration of a bar, for example, to the refined vibration of the atoms.

One of the first-proposed mechanisms, an extension of a theory of electrical conduction in solids, makes use of those electrons which are bound most loosely in the solid. When a gas is locally heated and the molecules in the heated region are thus set in more rapid motion, it is easy to see that the increase in their velocity will be communicated through the gas by their collisions and that the heat will thus be conducted throughout the entire volume of the gas. It is less easy to find a similar explanation for solids, but by ascribing to the loosely bound electrons in solids the kinetic properties of a gas, heat conduction in solids is made analogous to heat conduction in gases. Thence it is a simple explanation to regard the electron gas as alternately compressed and expanded in parts of the solid during vibration and to regard the solid as immersed in this electron gas and absorbing energy from it after the manner of any solid enveloped in a gas which is alternately compressed and expanded.

There is at least one obvious direction in which further development of this theory is necessary. In the conduction of electricity through solids it is supposed that the loosely bound electrons act as current bearing agents. On this supposition, non-conductors are those substances in which no electrons are loosely bound. Experiment shows, however, that non-conductors dissipate energy through viscosity as effectively as do the conductors. Much theoretical work is now in progress toward the solution of such apparent contradictions.

A second theory makes use of impacts between the particles of the material themselves. It supposes that when a solid is strained, the material is microscopically so deformed that atoms or small groups of atoms are moved permanently into different relative positions. In the course of this motion impacts occur between adjacent atoms or aggregates. These impacts serve the same purpose as the impacts of gaseous particles, exciting thermal vibrations at the expense of initial strain. Those atoms which have been displaced and do not return after the vibration has subsided are responsible for the storage of potential energy referred to above.

This theory offers an explanation of plastic dissipation. Its picture of the motion of atoms into new permanent relative positions is precisely a microscopic analysis of the establishment of a permanent set. Dissipation, however, takes place at strains so small that it is difficult to see how permanent change in position of atoms

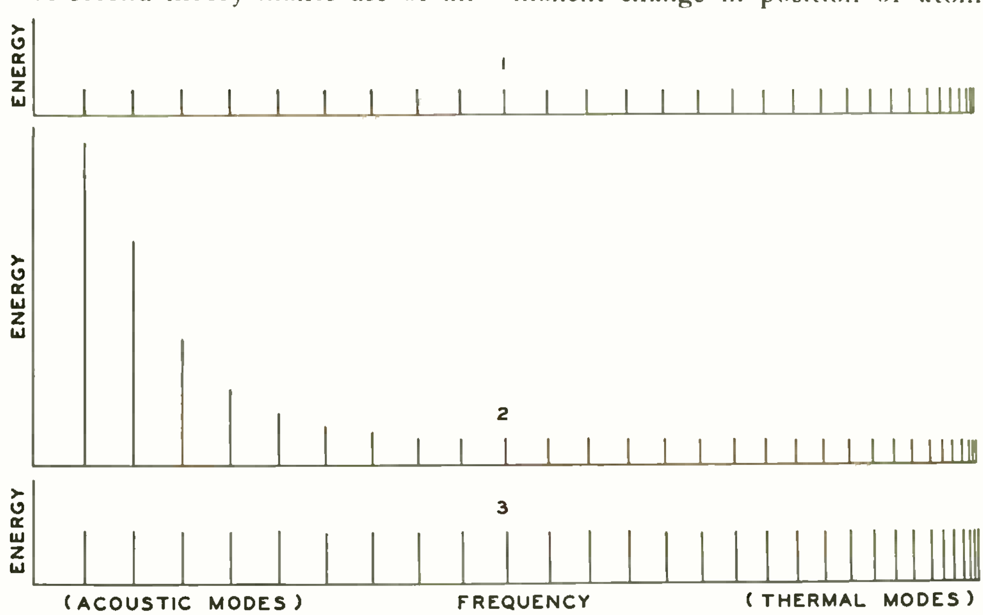



*Fig. 3—Possible frequency spectrum of a solid* (1) *before it is struck,* (2) *just after it is struck,* (3) *some time after it is struck. Equipartition of energy between modes is assumed, and the diagram is simplified to that for twenty-nine beads*

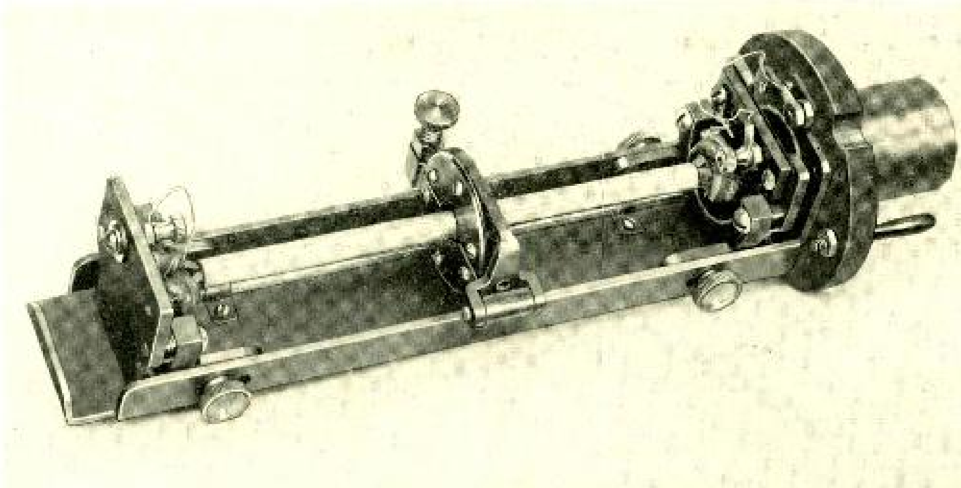


*Fig. 4—A cylindrical bar of the solid is held at its center and driven at its ends in its fundamental compressional mode*

is possible. Dissipation can be observed when a bar is strained by less than one hundred-thousandth of its length. If this bar were so magnified that two adjacent atoms appeared one meter apart their average deflection by strain would appear less than one-tenth millimeter.

It is, however, possible that the "plastic" hypothesis may explain the phenomenon at these very small strains. Two neighboring atoms will generally be oscillating irregularly due to thermal vibrations. There is a force of attraction between these atoms tending to keep them together, while the thermal agitation tends to break them apart. The net attraction is therefore less as the temperature is increased, and it must vary also with the relative orientations of these atoms. Owing to the forces exerted more or less at random by other atoms on this pair the relative stability of the pair may be in some cases extremely critical so that it is conceivable that a strain, no matter how small, may upset the relative positions of such a pair. This will change their relative potential energy and at the same time dissipate energy in heat by further exciting their minute vibrations. Other pairs in the same sample may be under the influence of a large net attractive force such that small strains cannot displace them. This makes the problem one of statistics.

If the numerousness of the extents of individual deflections follow some familiar statistical distribution law, curves of statistical frequencies of deflections might appear as in Figure 1. Here it can be seen that no matter how small the average deflection (and thus the overall strain) some atoms would still be so largely deflected as to pass over one another, resulting in permanent change in position. In this direction the impact theory must be further developed to explain how permanent displacements result from very small strains and thus to identify viscosity with plasticity.

In the meantime it seems profitable to examine a third theory, offered in direct explanation of what is above referred to as viscosity. It proposes a mechanism for the transformation of energy from vibration of the bar to vibrations of the atoms without the supposition of violent impacts between atoms resulting from large relative motions. This mechanism makes use of notions from the theory of mechanical vibrators. A line of particles, each vibrating about a fixed position in the solid, is regarded in terms of the simplified analogy of a string of beads, in which each bead is free to move about a position determined by its attachment to the string. The purpose of this consideration is amply fulfilled by regarding only those motions of the beads which are transverse to the direction of the string.

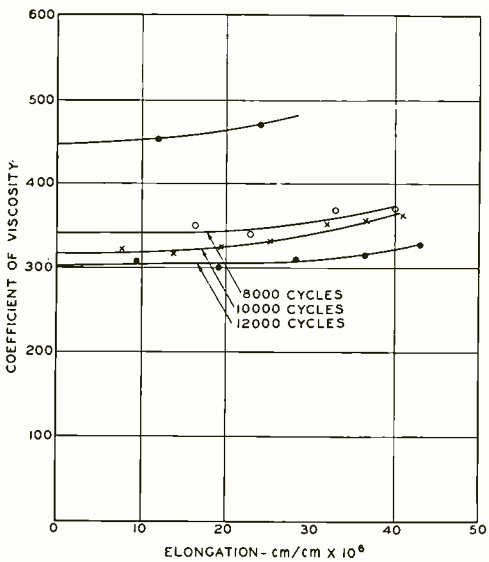



*Fig. 5—Coefficient of viscosity of aluminum measured at different amplitudes and frequencies of strain*

A string of beads can vibrate transversely in several ways. These ways of vibration are called its "normal modes", or its "fundamental" and "harmonics". The frequencies of these harmonics increase with the number of nodes in the vibrating string and the mode of highest possible frequency is that in which there are as many nodes as beads. From Figure 2 it is apparent that two adjacent beads move nearly alike at the low-frequency harmonics, with greater velocity relative to each other at higher harmonics, and with maximum relative velocity at the highest harmonic.

When, as with a line of particles composing a solid, these "beads" are exceedingly numerous, there is a correspondingly large number of possible modes of vibration. Vibrating at the fundamental and at low harmonics, trains of adjacent particles move very nearly alike. This collective motion constitutes a bulk motion of the material, generally at an acoustic frequency. Vibrating at high harmonics the line of particles has many nodes and the vibrations have very high frequencies, far above those of the acoustic range. In these modes moreover adjacent particles are moving rapidly with respect to each other. Vibration in these high modes may be regarded as thermal vibration of the particles—as heat in the accepted sense. The frequencies of these thermal vibrations in solids are of the order of $10^{13}$ cycles per second and correspond to the frequencies of the infra-red or heat rays of the light spectrum.

Viscous dissipation, then, is a phenomenon in which the acoustic modes of vibration, excited when a solid is struck, gradually feed their energy into the thermal modes. It is assumed that energy is at all times associated with all possible modes and is distributed between them according to some law. After the amplitudes of the lower modes have been augmented by a blow or drive of any kind, those amplitudes decrease gradually and the amplitudes of the higher or thermal modes increase until the energy distribution among the various modes is again stable (Figure 3). Indeed the rapidity of decay of the ringing sound of a bar when struck is a measure of its viscosity.

In an ideal string of beads, and in a hypothetical solid fully obedient to the elementary laws of elasticity (Hooke's Law), any of the possible modes may be independently driven in such a way as to leave the other modes unaffected. To account for the feeding of energy from lower to higher modes which is actually observed in viscous dissipation, some type of non-linear coupling between these otherwise normal modes of vibration, a coupling which is non-existent in the hypothetically ideal solid, must be supposed to exist. The determination of the nature of this coupling and of the law of stable energy distribution awaits the results of quantitative experiment and the precise development of a theory.*

*R. L. Wegel*

Experiments are now being conducted in these Laboratories, in which a bar of the solid under study is driven longitudinally at its fundamental frequency and at a low amplitude (Figure 4). The driving energy is continually supplied at a rate which maintains a vibration of constant amplitude. Under these conditions the measured power supplied is equivalent to the viscous dissipation. The technique is difficult because of the necessity for accurate measurement of very low vibration amplitudes and power inputs. Coefficients of viscosity thus obtained for annealed aluminum are plotted against amplitudes (strains) in Figure 5. The upper curve, for an incompletely annealed sample, shows that the internal stresses set up by cold-working the material during manufacture cause a large increase in dissipation. The correspondence, within the limits of experimental error, of the three lower curves for well-annealed samples indicates that viscosity is independent of frequency. The flatness of the curves at low strains signifies that at least within this range, viscosity is also independent of strain. The field of higher distortions is now undergoing investigation.

Though measurements of viscosity are still meager and theories of the viscous mechanism are incomplete, attention to the phenomenon is bringing progress. A time can be imagined when theory and measurement will together make possible the design of apparatus to a new degree of precision. This will be especially valuable with apparatus whose utility is dependent on the internal constants of its materials.

** It will be realized that the foregoing descriptions are based on the concepts of what is now called "classical" or "Newtonian" mechanics. These are undoubtedly inadequate as a basis for a quantitative theory for the same reasons that they do not apply to such properties as specific heat and radiation.*

# Permeameters for Measurements over Wide Temperature Ranges

By G. A. KELSALL
*Magnetics Research*

SOME years ago, in connection with the inspection of core material for loading coils, and other work on magnetic materials, there arose a demand for a quick method of measuring the permeability of toroidal cores at small magnetizing forces. With the method formerly employed, a ring-shaped core of the magnetic material was wound with the requisite number of turns, usually several hundred, and the inductance of the resulting coil was measured with a suitable bridge. The application of the winding was wasteful of time, and, in fact, comprised the greater part of the time required to obtain the permeability. Efforts were therefore made to develop a method which would not require winding the specimen. Not only was a permeameter finally perfected which accomplished this, but later the new method was adapted for measurements at elevated temperatures.

For any measurement of permeability the sample to be measured must serve as the core of a winding. With the new permeameter the winding consists of only a single turn made in two parts, with which the sample may be readily interlinked. The complete apparatus is a special type of transformer. A primary winding is placed directly on a core of high permeability. The secondary winding is an annular copper shell which surrounds both the primary winding and core, and the test sample when it is in place. From the dimensions of the test sample and the increase in inductance of the transformer when the sample is inserted—as measured from the primary terminals—the permeability is computed.

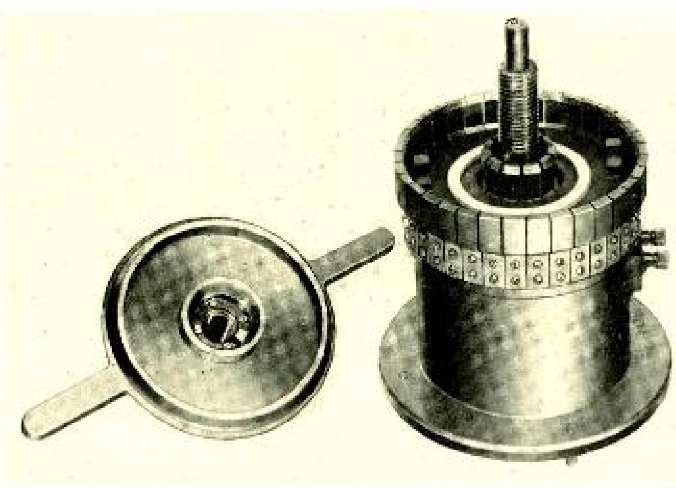


*Fig. 1—The position of the sample and the method of quickly closing the secondary is shown in this photograph*

A photograph of a recent model, which is representative of instruments based on this principle, is shown in Figure 1, and a cross-sectional view is given in Figure 2. The secondary is a cast copper shell enclosing both the primary winding and core, and additional space for the sample to be tested, which is interlinked only with the secondary winding. This space within the secondary is divided by a hard rubber disc into two compartments. In the lower is the transformer core with its primary winding and in the upper compartment is the test sample as shown in the illustrations. The secondary circuit is completed by a cast copper cover which screws on a central stud and wedges itself against a number of bronze spring contacts on the outer rim of the secondary shell. In Figure 2 the cover is shown not quite closed for clearness of illustration.

With this type of instrument, measurements of permeability can be made with the same degree of accuracy and at as low magnetizing forces as by the method requiring a winding. With the instrument in Figure 2, and with a vacuum-tube amplifier in the bridge circuit to increase its sensitivity, routine measments have been made at magnetizing forces as low as .001 gauss.

The general design of the permeameter, especially that of the copper shell, may be altered to suit the maximum and minimum dimensions of the cores to be tested. This is illustrated by the permeameter in Figure 3, which was made for measuring permeability of No. 38 B&S gauge iron wire. This permeameter was designed to measure the permeability of the wire on spools as

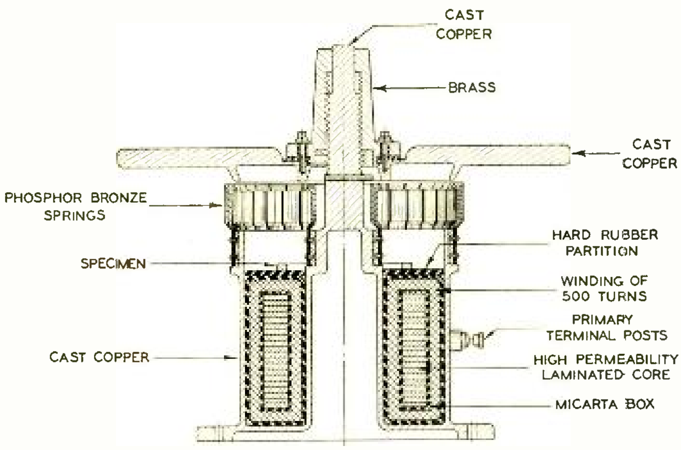



*Fig. 2—A cross-section of the permeameter shows how the cast copper frame serves as a single turn secondary which opens at the top to admit the sample for test*

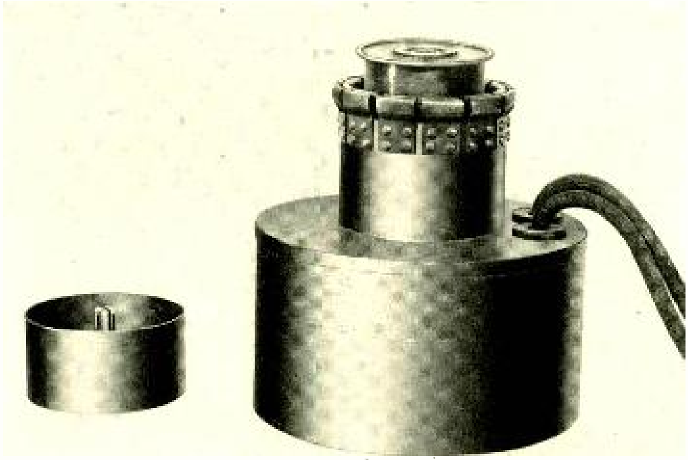


*Fig. 3—A special permeameter designed for testing spools of iron wire*

received from the manufacturer, and the upper part of the copper shell therefore was made to conform to their dimensions. The illustration shows a spool of wire inserted for test.

These permeameters have been used for a number of years by the Manufacturing Department of the Western Electric Company, and have been found of great convenience in the inspection of materials used in the manufacture of magnetic cores. They are also in constant use in our Laboratories in connection with investigations of magnetic materials.

For measurements at elevated temperatures the copper shell is altered in shape and size to provide space for a furnace. A ventilating system is also required to prevent overheating of the primary winding and the copper shell. With these additions the instrument is known as a furnace permeameter. A cross-section of one is shown in Figure 4 and a photograph of it in Figure 5. The permeameter stands on an iron framework which provides space underneath for the ventilating blower.

The center tube of the copper shell has a shoulder which supports the furnace while its upper narrower portion holds the furnace centrally in place. The cover is joined electrically and mechanically to the center tube by a construction shown most clearly in Figure 4. A brass sleeve with a square shoulder at its midpoint is slipped on the center tube. The lower end of this sleeve is slightly tapered, threaded externally, and cut with four vertical slots so that it may be secured firmly at the proper height by means of the lower clamping nut. A large clamping nut above presses the cover against the shoulder of the sleeve, the height of which is such that the outer edge of the cover rests against twelve stop pins. In this way the cover is always in the same position after assembly. The outer periphery of the copper shell which is slotted vertically is firmly pressed against the rim of the cover by a clamping band.

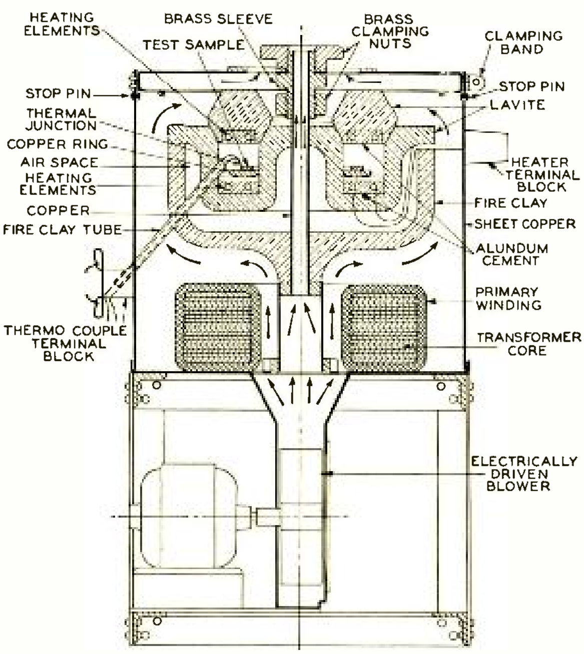



*Fig. 4—A cross-section of the furnace permeameter shows a permeameter construction similar to that of Fig. 2 with the addition of a heating unit and blower*

The transformer core with its associated primary winding is shown in the bottom of the copper shell in Figure 4, and in front in Figure 5 may be seen the primary terminals. Between the primary winding and the lower part of the center tube is space to allow free passage of air from the ventilating blower beneath.

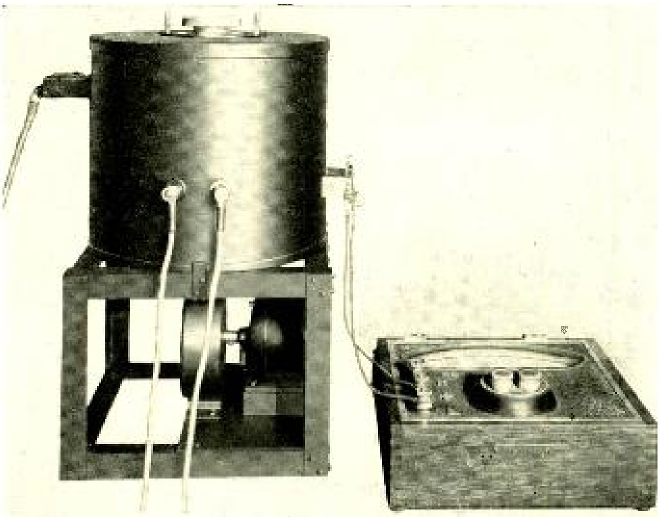


*Fig. 5—The furnace permeameter connected and ready for use*

The furnace in Figure 4 consists of an annular trough cut from a block of lavite, a ring-shaped cover of the same material, and an outside furnace wall of fire clay. An air space between the inner and outer furnace walls provides additional heat insulation. Two heating elements, both wound non-inductively with respect to the other circuits of the permeameter, are provided. One is embedded in the bottom of the trough and the other in the lower face of the cover. Both are covered with alundum cement. Leads for the lower heater are brought out through the furnace partitions and the copper shell as shown in Figure 4, and those for the heater in the cover project through its top and pass through corresponding holes in the cover of the permeameter as shown in Figure 5.

Temperature is measured by a thermocouple welded to the test sample. Wire leads are brought out as shown in Figure 4 and connected in the usual manner to a suitable meter with compensating leads as shown in Figure 5.

In making a test the sample with a thermocouple welded to it is placed in position, the furnace and permeameter covers are put in place, and the apparatus assembled as in Figure 5. The primary terminals are connected to an inductance bridge and measurements made. From this inductance reading the permeability of the sample at room temperature is determined. Current is now supplied to the heaters and successive readings are

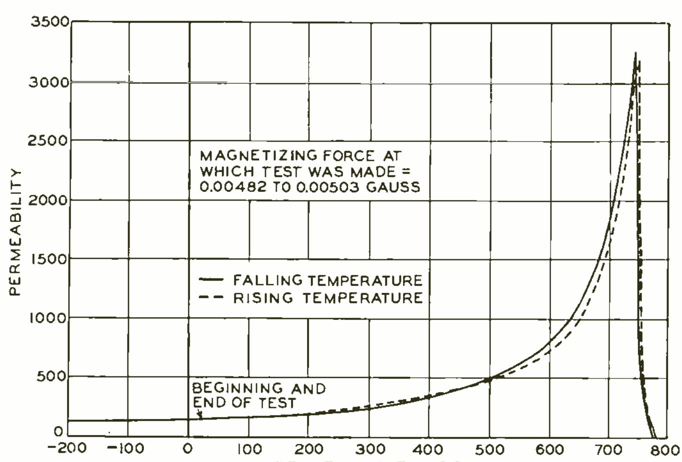
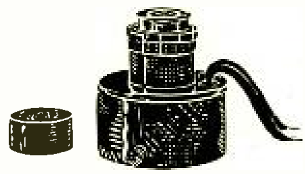



*Fig. 6—Curve showing permeability readings on sample of iron tape as the temperature passed through a complete cycle of nearly a thousand degrees centigrade*

taken simultaneously of temperature and inductance. The maximum temperature at which a sample can conveniently be maintained is about 1000°C., and by filling the unheated furnace with liquid air a minimum temperature of —190°C. is attainable, so that the whole range of the instrument is about 1200 degrees.

The curve in Figure 6 shows the results of a test made at 600 cycles on a ring of iron tape. By means of liquid air the temperature of the test sample was first lowered to — 190°C., then raised to beyond the point at which the core becomes non-magnetic, and returned to room temperature.

The changes introduced to adapt the permeameter for measurements at different temperatures have not impaired its accuracy, the determination of permeability at high temperatures being made with precision equal to that obtained at room temperature.



## *"Transmission Networks and Wave Filters"*

*This book, by T. E. Shea, is the seventh in the Bell Laboratories series published by D. VanNostrand Company. After introducing the subject by a general description of the use of networks, the book develops the practical theory and design first of transmission networks and then of electric wave filters from the principles of electric circuit theory. The author discusses the external performance and conditions for equivalence of networks, desirable impedance conditions at their terminals, and the properties of two-terminal impedance arms. In the application of these results to the special problems of filters, the properties of component filter sections are treated, and then their combination into multi-section filters of the low pass, high pass, band pass, and band elimination types. The book concludes with a treatment of the mathematical resolution, into their sinusoidal components, of steady state waves by Fourier series and of transient waves by Fourier integral analysis.*

# A New Multiple P.B.X.

By R. W. HARPER
*Local Systems Development*

A REDESIGN of the various types of multiple private branch exchanges has been made to take advantage of newer methods of construction and other improvements, and to reduce the number of standards necessary to meet the service requirements. This has been accomplished by the development of a new multiple PBX, known as the 605-A, which, as it can handle up to 1500 lines, will meet most of the demands for multiple PBX service. It can be used in place of any of the three types now employed for installations up to this size and will serve also for use with long tie lines to other private branch exchanges as well as for local calls. With only one multiple board for smaller installations, the advantages of large quantity production will be realized and delivery periods will in general be shorter; in brief, all the advantages of using a stock article rather than a special one will accrue.

Private branch exchanges recently described in the RECORD* have been of the non-multiple type, each station line being connected to only one jack. When one attendant is able to handle all the traffic, the jacks are all in the panel before her but when two attendants are required, they are divided and part placed on separate panels in front of each attendant. Not more than two attendants can be effectively used unless the jacks are multipled because each attendant must be able to reach any of the lines. This requirement led to the development of the multiple PBX. In these each line is connected in multiple to two or more jacks equally spaced down the length of the board so that all the lines may be accessible to every attendant.

Early private branch exchanges of the multiple type were adaptations of central office switchboards, but later, multiple boards designed especially for PBX service were developed. Of these the earliest types were the No. 4 and the 600*, each of which has a capacity of 640 station lines and 120 trunks. A board was also required a little later for the manual portion of a dial PBX and the 700 type was produced, incorporating those features required by this system.

Until recently, therefore, there have been these three multiple boards available for service; each developed to meet more or less particular demands and at different times. Each of the boards was designed to handle calls either between two PBX stations or between a PBX station and any other subscriber reached through a central office. With the increasing use of the PBX, however, there arose a demand for long distance tie lines between widely separated private exchanges operated by the same company. A large corporation, for example, might have its general offices in New York and a factory in Phila-

* *July*, 1928, *pp*. 363-365; *August*, 1928, *pp*. 399-402.

* BELL LABORATORIES RECORD, *Feb*., 1929, *p*. 226.

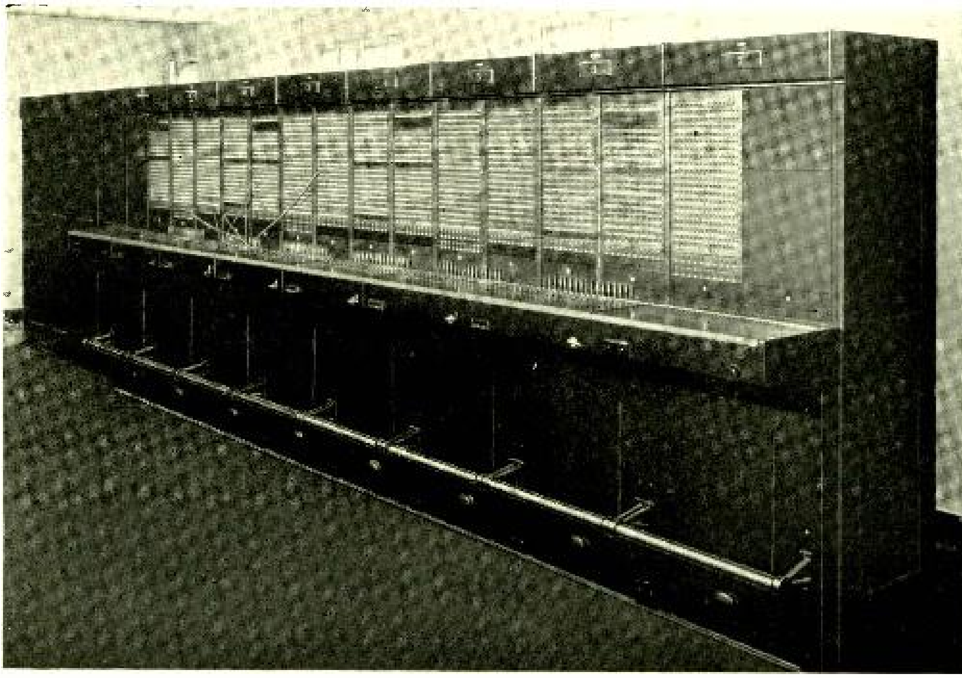


*Fig. 1—A front view of the 605-A PBX*

delphia and perhaps other factories in still different cities, and between these different private exchanges direct tie lines were wanted to expedite interplant communication.

Whenever this condition had to be met, which was quite frequently, special tie-line positions for the board had to be engineered because long distance tie lines require special equipment. These tie-line positions constituted, in reality, a fourth type of multiple PBX, and their special nature caused delays in installation.

Certain minor differences between the types of boards, which existed because they had been designed at different times or for various purposes, were, of course, readily standardized with the new PBX. It was comparatively easy to select one size of frame to replace the earlier multiplicity of sizes; one size of jack could be made to serve for the two sizes used previously and so standardize this feature; even the magnetic busy signals which had been used with all the tie lines and trunks could, with a moderate amount of engineering, be replaced with lamps to attain uniformity of appearance and operation. There were, however, two points of difference between the older types that required much thought and ingenuity to reduce to a single form. One was difference in voltage of the power supply required for the various types of boards. Manual boards are operated at a voltage low enough to allow charging over wires from the central office building whereas dial-type boards required 48 volts to operate the switches. The other point was differences in the cord circuits used for ordinary and for long distance tie line calls.

In front of an attendant at a PBX is a double row of plugs, one directly behind the other. One pair, a front plug and a rear one directly behind it, is used to complete each connection. To the cords attached to these plugs, relays and miscellaneous equipment are connected, making up rather complicated circuits. The equipment used on cords for tie line calls is necessarily different from that required for local calls and has necessitated two types of cords; higher battery voltage is provided in the talking circuit to offset the greater attenuation of the longer lines and many other circuit and equipment details exist which need not be considered here. To avoid this necessity of two types of cords in a new board was thus one of the major design problems.

The solution* was obtained by placing in the tie line circuit the equipment that was necessary only for tie line calls and leaving in the cord circuit only that which was suitable for all types of calls. To make this possible, the tie lines were divided at each end and run into two jacks, each of which was multipled throughout the board. One of the jacks is used when a call, originating at the PBX at the distant end of the tie line, terminates at the local PBX and the other when it is to be extended via another tie line through to another PBX. This scheme supplies 48 volt battery to the PBX station for a terminating call and makes a simple metallic connection between tie lines. It requires one manner of operation when the call is a terminating one and another method when it is a through call. The connection of tie lines to other tie lines is of course not ordinarily contemplated at regularly established rates because of transmission limitations. Where tie lines are specifically designed to meet the transmision requirements they are subject to additional charges for any added equipment or special circuit arrangements which may be required.

The other main obstacle to a universal board was the difference in voltage requirement for the diverse classes of service. The 600 and 604 types of board both normally used low voltage batteries, but if they were equipped for long distance tie lines, 48 volts was required for transmission in addition. All dial apparatus used with boards of this size, however, is designed to operate on 48 volts so that the 700 PBX was arranged for this

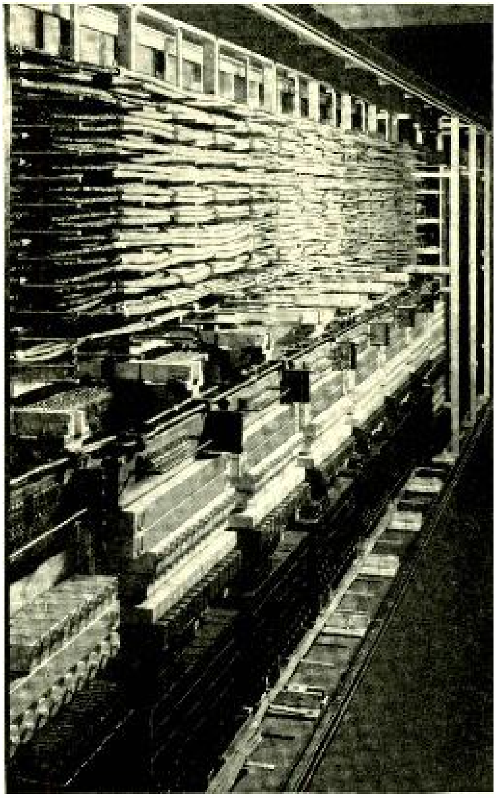


*Fig. 2—A rear view of the new board shows the compact grouping of the relays on their steel supporting structure and the accessibility of the multiple*

* *First used with the No. 3 Toll Board,* Bell Laboratories Record, *June,* 1927, *page* 337.

voltage. Relays and equipment used with the boards had to be designed for the voltage with which they were to be used.

By employing a type of relay recently made available, however, it was found possible to design circuits that would operate on any voltage from 32 to 50. When the board is to be used as the manual part of a dial PBX a 48 volt battery is required and a charging plant is installed at the PBX to maintain the voltage. For all other conditions a lower voltage battery is installed which may be charged either from the central office or from its own local charging plant. This wide range of operating voltage, which is a rather difficult accomplishment, satisfactorily solved the multivoltage requirement for PBX's.

In addition to the improved circuit features the new board incorporates the latest structural advantages. It has a complete inner frame of steel divided into separate upper and lower units, the upper being designed for two twelve-inch panels. The outer woodwork has a walnut finish in order to harmonize better with present day office furniture and woodwork, and the keyshelf is of black phenol fibre which presents a hard durable surface almost immune to scratching. A canvas curtain to prevent noise due to the swaying of the cords is also used with the new board.

The results of several trial installations have been so favorable that the manufacture of the new board is now being placed on a production basis and the 605 board will soon be used for practically all multiple-switchboard requirements up to 1500 lines.

## *American Telephone*

*American Telephone tomorrow will distribute close to 30 millions in dividends, the largest quarterly payment ever made by the company. No change has, of course, been made in the dividend rate but the constant increase in stock outstanding is increasing the distribution. Telephone shareholders, or many of them, will fail to find any better outlet for their dividend receipts than more of the same stock.*

—*New York Sun, October* 14, 1929

# A Thousand-Ampere Choke Coil

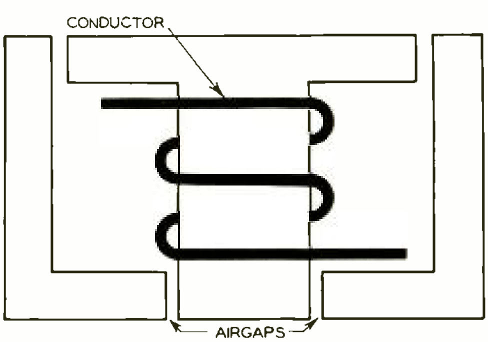
By A. R. SWOBODA
*General Apparatus Development*

ECONOMIES have recently been made possible by the use of commercial* rather than special generators for charging central office batteries. This change was made feasible chiefly because large capacity filters were developed to remove from the generator output the minor current oscillations which would produce noise in telephone circuits. Choke coils are essential elements of these filters and because of the large currents that must pass through them, their design presents several features of engineering interest.

Current flowing in a wire produces a magnetic field in the space around, and pulsations in the current cause variations in the field which induce a counter electromotive-force in every part of the conductor. This electromotive force of self-induction, as it is called, is always opposite to that causing the current changes. Self-induction thus produces a reaction against the current, a choking down of current changes.

How this choking factor, or inductance as it is termed, varies with the conformation of the circuit may be shown by connecting a thousand foot length of No. 10 copper wire — arranged in various ways — to a 110-volt, sixty-cycle alternating circuit. When the wire is laid straight and doubled back on itself once, a current of 110 amperes will flow. If, however, the wire is formed into a coil of a little over nine and one-half inches outside diameter and approximately three inches long, only about seven amperes will flow. By a "simple twist of the wrist" the wire has been endowed with the power to choke down the current from 110 to 7 amperes. If the wire were now wound on a straight silicon-steel core, forming about eight hundred fifty turns on a

* BELL LABORATORIES RECORD, *December*, 1927.



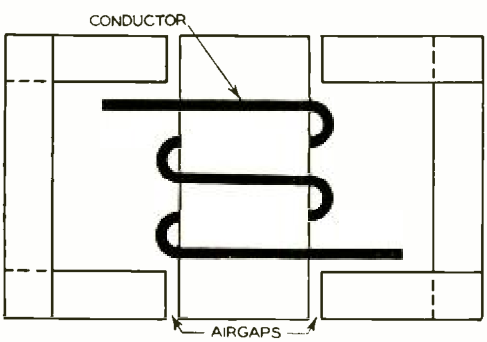




*Fig. 1 — (left) Laminations for the smaller coils are punched in two forms and assembled as shown. Fig. 2 — (right) For the larger coils straight laminations that can be sheared are more economical. The dotted lines indicate how alternate long and short pieces are laid up*

core fourteen inches long by two and one-half inches square, only about nine-tenths of an ampere would pass through it when connected to 110 volts.

Iron has thus enormously increased the inductance of the circuit and dif-

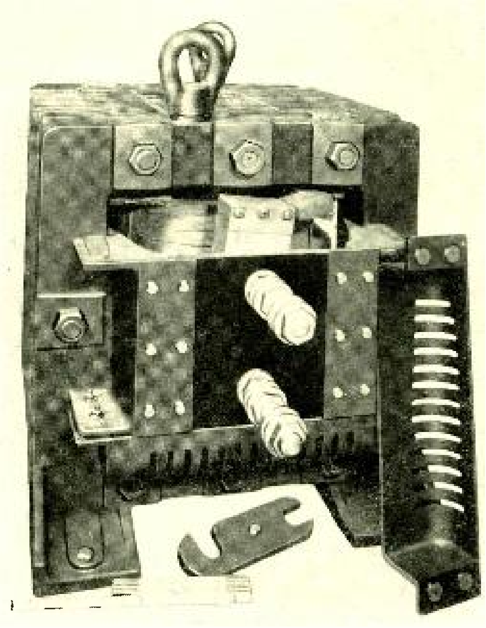


*Fig. 3—Removal of one of the cast-iron cover plates from the* 800 *ampere coil shows the arrangement of the winding around the central leg*

ferent types of iron, or iron alloys such as the permalloys, would produce different effects. The inductance depends, however, on other things besides the material of the core and the design of a choke coil thus requires a careful balancing of many factors.

Choke coils designed for use with commercial charging generators have cores of the shell type built up of many thin laminations of silicon steel. The magnetic material forms a closed path or shell around the coil which is wound on the central leg as shown in Figure 1. This illustration shows one of the smaller coils, the laminations for which are single stampings: "T" shaped for the center and "L" shaped for the two outer legs.

For the larger sizes it is more convenient to build up the core of straight pieces in order that they may be sheared. A choke coil of this type is shown as Figure 2. The straight laminations that compose the outer legs are of two lengths for each section; long and short pieces are laid up alternately so as to form a compact interlocked core as indicated by the dotted lines. The general appearance of such a core and winding is given in Figure 3 which shows an 800 ampere coil with cover plate removed. A cast iron housing completely protects the winding from injury, and openings in the cover plates provide ventilation.

Iron in a choke coil is very desirable because by increasing the effectiveness of the winding it makes possible the use of a much smaller coil than would an air core, and in this way reduces the cost. The value of the current flowing through the windings of an iron core coil, however, has a large influence on the inductance. Current from a commercial D.C. generator, in addition to a large constant component, has a small variable component. The constant component produces in the core a constant magnetic flux density which influences the rate at which the variable component can cause changes in it.

The inductance with respect to the variable portion of the current is changed by changes in the value of the constant portion. For any particular coil there is one value of the constant component of the current for which the inductance with respect to the variable component is a maximum; below and particularly beyond this point the inductance decreases. To reduce the flux density due to the constant component, it has been found that the introduction of an air gap is preferable to the alternative of lengthening the iron circuit since the use of an air gap reduces the size and cost of the coil. The most efficient design, therefore, depends on a balance between size of core, number of turns, and width of air gap.

Cost depends both on the size of the core and on the number and size of turns; either of which may be varied over a wide range for a given inductance. If the inductance is to be kept at a predetermined value and the air gap adjusted to give a suitable flux density, a plot may be made of cost of coil against the number of ampere turns (product of number of turns by the amperes flowing). Such a curve is shown in Figure 4. An indefinite number of similar curves could be plotted for different values of inductance. From such a set of curves and a knowledge of the inductance wanted it is possible to select the most economical size of core and number of ampere turns. As the maximum generator current is known it is necessary

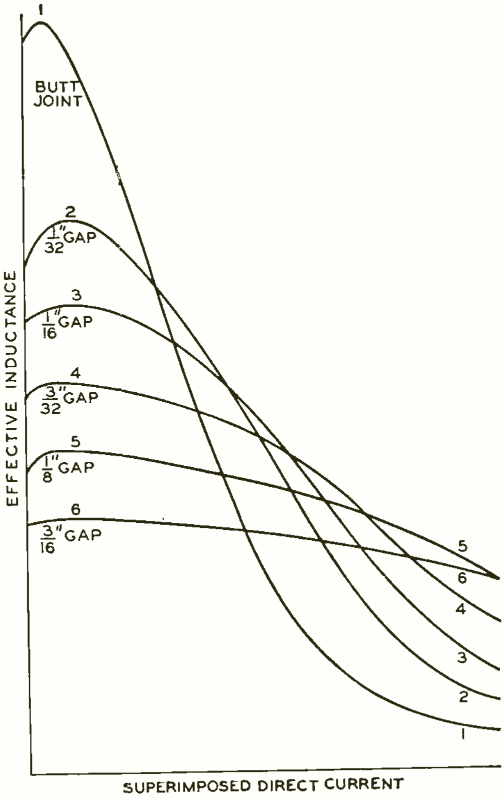



*Fig. 5—For any one coil design a variation of the air-gap considerably modifies the choking action at different currents*

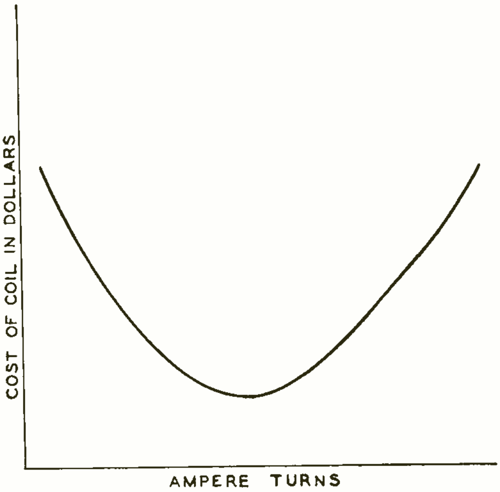



*Fig. 4—A series of curves like the one shown is possible. For each the inductance and flux density are constant.*

only to divide this value into the ampere turns to obtain the number of turns of copper required.

The selection of the proper air gap is an important matter. On Figure 5 is plotted a series of curves all for the same coil but for different air gaps. It will be noticed that as the gap is increased the maximum value of inductance is decreased, but on the other hand it becomes much more constant for different currents. A gap is selected that will give fairly constant inductance over the range of currents expected.

The largest choke coil that has been developed in Bell Telephone Laboratories, which will carry a thousand amperes continuously, is shown on the title page to this issue. One of these coils, coded 15-A, was installed in the Barclay-Vesey project in the New York Telephone Company building on lower West Street. The winding is made up of a conductor of forty-four strips of annealed copper one inch wide by .052″ thick. The total DC resistance of the winding is only .00032 ohm, while the inductance is approximately 1 millihenry. The core has four air gaps each 15/32″ wide and the complete coil, standing over four feet high on a base about three feet square, weighs over two and one-half tons.

To show the range in size of coils used in telephone practice an 83-A retardation coil from a 1-A carrier panel is held in the palm of the hand for comparison. The large coil has magnetic material enough to supply about 25,000 of the small ones. The total copper in the large coil would, if drawn into No. 36 wire, wind 5200 small coils, and 10,800 of the small coils would be required to balance the weight of the large one. The small coil has about 10,000 times the inductance of the large one, but it has nearly 2½ million times as much resistance. Besides it is good for only 1/1000 ampere. The choke coil shown here is the largest coil in size and weight ever installed for central office service.

# Calling Subscribers to the Telephone

By L. J. STACY
*Local Systems Development*

SOME form of alternating current has been used since 1878 for calling subscribers to the telephone. In that year Thomas A. Watson devised the plan of connecting in series with the line at each station a polarized ringer — an electric bell polarized for operation on alternating current. Ringing current was provided by a hand-driven magneto generator. That arrangement was the best available for a number of years, but even when the resistance of each ringer was kept at a minimum, the resistance of a line with many stations was made great enough by the series connection to hinder the transmission of voice currents. In 1890 John J. Carty overcame that difficulty by connecting a subscriber set containing a generator for calling the operator and a high-resistance ringer across the line at each station, rather than in series. That plan was commonly known as the "bridging" bell system. On account of the low frequency of the ringing current and the high voltage it could be given, it was possible to use ringers whose impedance to voice currents was high enough for the requirements of speech transmission on the line.

In spite of the many changes that have since taken place in the telephone plant, the methods of ringing now used have developed directly from those of 1878 and 1890. The simplest conditions of today are presented on so-called rural lines — party lines with a large number of subscribers, usually in the country. On these lines the ringing system now in general use is that brought out by Mr. Carty. At each station a polarized ringer is connected across the line, or from one side of the line to ground, and when ringing current is applied, it flows through and operates all or half of the ringers, depending on the connection. A code is used, with an individual combination of long and short rings assigned to each subscriber. For comparatively short rural lines having a small number of stations, ringers of 1000 ohms resistance and hand gen-

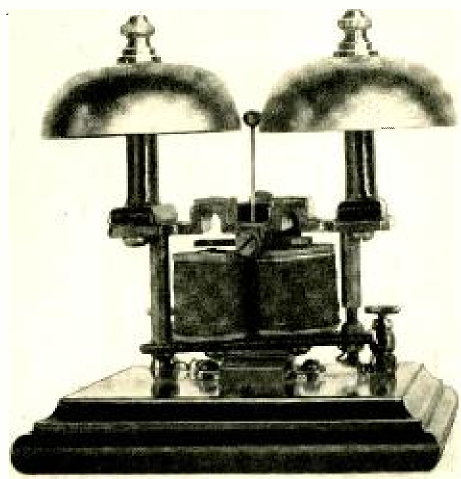


*Fig. 1 — Watson's polarized ringer*

erators having three permanent magnets are commonly used. If longer lines or more stations are involved, it is necessary to use ringers of higher efficiency, with 2500 ohms resistance,

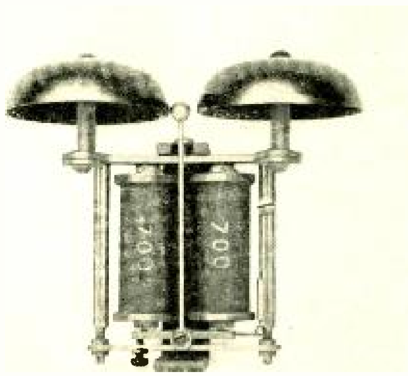


*Fig. 2—A polarized ringer of today, 8-A*

and hand generators built with five magnets, giving higher output voltage.

In larger offices, where it became desirable to use a battery common to all subscribers' lines for talking and for attracting the operators' attention, several changes in the ringing system became necessary. Normally the central-office battery is continuously connected to each line. With ringers connected directly to the line at the stations there would be a continuous flow of direct current, which if large enough would keep the line relay operated and the signal lamp in front of the operator lighted, just as if the receiver were left continuously off the hook. That was avoided, at first, by using ringers of sufficiently high resistance. Subsequently the constant flow of battery current was prevented by connecting a condenser in series with each ringer. Thereupon the ringers were adjusted to prevent tapping during the surge conditions accompanying charge and discharge of the condensers in the ringer sets.

At an early stage in telephone history selective ringing—ringing of one station only—was offered on two-party common-battery lines. Each ringer was connected from one side of the line through a condenser to ground; alternating current applied between ground and either side of the line passed through one ringer only. Semi-selective ringing was given on four-party lines by the same arrangement, but with two ringers connected from ground to each side of the line. Then ringing current sent out on one side of the line operated both of the ringers connected, and a simple code was used to indicate which of the four subscribers was wanted.

The first commercial system giving

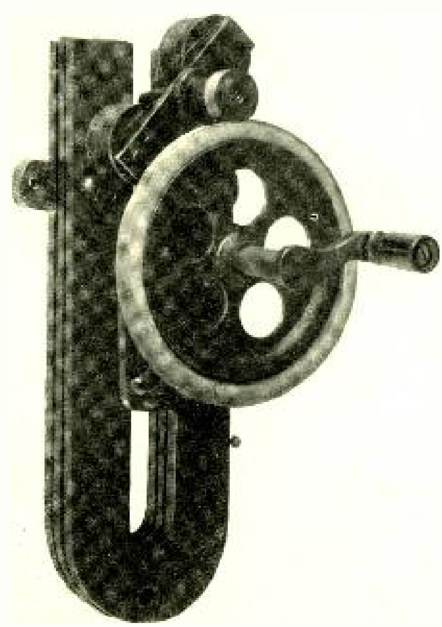


*Fig. 3—Watson's hand generator*

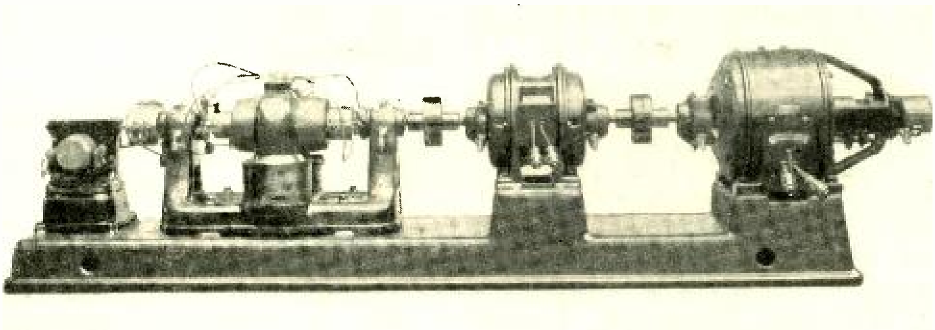


*Fig. 4—A modern ringing machine*

selective ringing for four-party magneto lines was patented in 1896 by Angus S. Hibbard of the Chicago Telephone Company. Two ringers were connected from each side of the line to ground as before, but the connections made to them were of opposite polarity, and ringing was accomplished by pulsating current—either the positive or the negative half-waves of alternating current. When pulsating current of either polarity was applied to one side of the line, it passed through both ringers to that side. On one ringer, suitably poled, each pulse pulled the armature against the tension of the biasing spring so that the clapper struck the gongs, but on the other ringer the pulses pulled in the same direction as did the spring, so that the armature remained at rest against the stop. When used on common battery lines a resistance was placed in series with each ringer to prevent operation of the line relay; there was however a leakage path for battery current at each station. Although still used to some extent in its original form on magneto lines, this ringing system is of interest principally as the forerunner of the better systems in use to-day.

To remove the direct-current path from each side of the line to ground through the ringers when applied to common-battery lines, a system using a relay at each station was devised in 1899 by G. K. Thompson. The ringer at each station was connected from line to ground through the contacts of a relay whose winding was connected across the line in series with a condenser. With the relays normal the ringers were disconnected, but when pulsating current was sent out the relays at all four stations operated and connected the ringers as in Hibbard's system; then the pulsating current flowed through the two ringers on one side of the line to ground and operated the ringer for which the pulsating current was suitable. In offices using this system, however, ringers on individual lines were connected across the line in series with a condenser, as before. Alternating current was used for these, since it is somewhat more satisfactory than pulsating current for operating ringers connected in series with condensers.

With the adoption of superimposed current, the need for alternating current in addition to the pulsating ringing current for four-party lines was ended. The system of superimposed ringing, developed by T. C. Drake and patented in 1904, uses an alternating-current generator connected in series with batteries. The resultant current may be considered as alternating current with the neutral axis displaced from the center line of the wave by the amount of the battery voltage. The action, on four-party circuits, is the same as that of pulsating current. On individual and two-party lines, where a condenser is in series with the ringer, only the alternating current component can flow. Voltages of the a-c. and d-c. components of the ringing current are regulated at any particular office within limits which depend on the types of ringers in the area served.

Meanwhile the sources of ringing current and the means for its control had received attention and development, just as had the ringer circuits themselves. The demand for operating convenience with resultant economy made it necessary first to do away with the need for turning a generator handle. In the transition to a central source of ringing current, various devices were used, marking successive

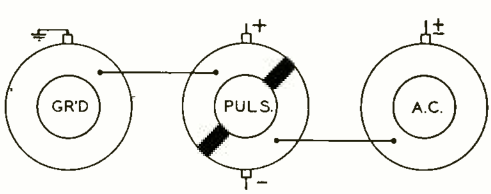



*Fig. 5—Ringing machine connections to give pulsating current*

steps toward reliability and convenience. One of these, known as a pole changer, is used extensively today in the smallest offices. It is a relay with vibrating armature, the contacts of which connect alternately with battery contacts of opposite polarity. In larger offices, for many years the

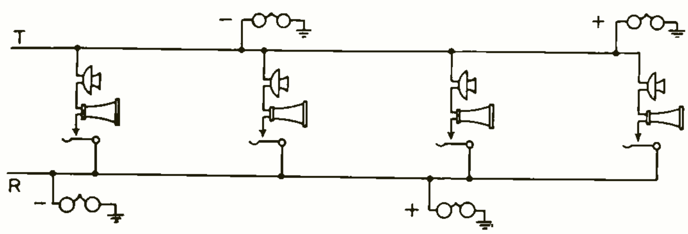



*Fig. 6—A. S. Hibbard's circuit for full selective ringing*

source of ringing supply has been motor-driven generators, to which the name "ringing machines" has been given. For alternating current the output was used directly, but when pulsating current was first used the generators were installed in pairs, each supplying current of one polarity only. Later one generator was made to do the work of both. It was equipped with a third collector ring divided into two equal segments, insulated from each other; one was connected to the alternating current ring, and the other to the ground collector ring. Two brushes 180 degrees apart then collected half waves of alternating current, one giving positive and the other negative pulsating current. For superimposed current no such construction is needed, but merely an ordinary alternating-current generator connected in series with batteries.

When ringing machines came into use, the ringers in service had been designed to operate at the voltage and frequency given by hand generators. It was natural therefore that the voltage and frequency of the ringing machines were governed accordingly. Thus 75 to 110 volts at 16 2/3 cycles came to be standard. With a two-pole generator, this frequency corresponds to 1000 revolutions per minute, a speed readily obtained with direct-current motors. When alternating current became generally used for power, it became desirable to use an alternating-current motor for driving

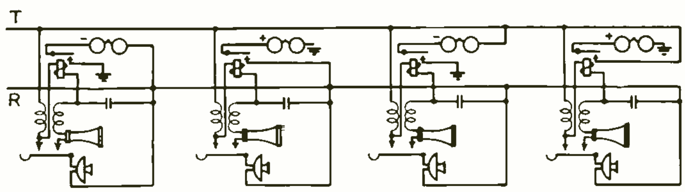



*Fig. 7—The four-party circuit now used for full selective ringing*

at least one ringing machine in each office. This was done by connecting the motor to the ringing generator with a belt, since with 60-cycle power it is impossible to obtain a speed of 1000 revolutions per minute directly. As before, a reserve machine was still furnished to be driven by the central-office battery.

The development of induction motors made it possible to build sets with the motor and generator connected directly rather than by a belt, if the ringing frequency were changed to 20 cycles. The maintenance and cost advantages of this change were so great that it was made about 1917, and the ringing machines directly connected to six-pole induction motors were standardized for new installations in place of the belt-driven sets. With 60-cycle power these operate at 1200 revolutions per minute and produce 20-cycle ringing current. To secure uniform frequency at all times, the reserve machines which operate on the central-office battery were also changed to give 20-cycle current. The actual frequency is somewhat less than the 20-cycle nominal value, since it is cut down about two-thirds cycle by the slip of the induction motor.

Regardless of its source, ringing current must be controlled for connection to the desired line. Even with hand generators, a ringing key was provided in each cord circuit for connecting the generator. Later there were commonly as many as five keys in the cord and trunk circuits of subscriber switchboards, for selective ringing on four-party lines with pulsating current, and ringing of individual lines with alternating current. In any case it was at first necessary for the operator to press one of the keys during each interval when ringing current was sent out, and thus to give the call a certain degree of attention for the duration of ringing.

This need was ended by "machine ringing", the system whereby ringing current is intermittently connected to a subscriber's line, either automatically

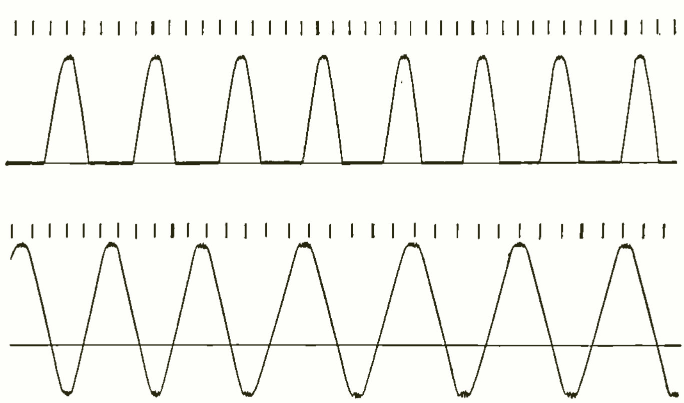


*Fig. 8—(above) Pulsating ringing current. Fig. 9—(below) Superimposed ringing current*

or by the momentary depression of a key, after the operator has plugged one of her cords into the jack of the called subscriber. Thereafter ringing current is connected to the line at regular intervals until the subscriber answers or the connection is taken down.

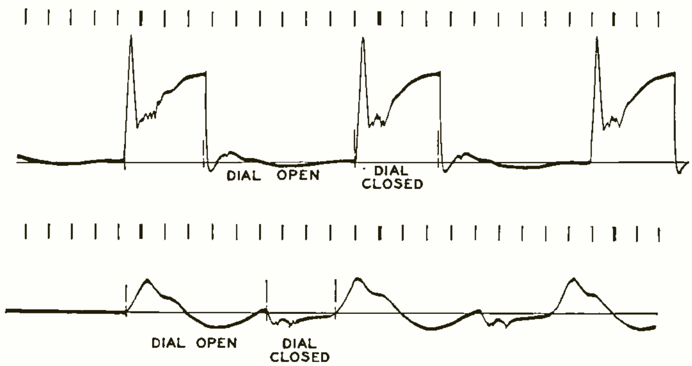



*Fig.* 10—(*above*) *Current in subscriber's line during dialing.* *Fig.* 11—(*below*) *Current in ringer during dialing*

During each revolution an interrupter mounted on the ringing machine connects ringing current to the line for two seconds, and connects direct current for four seconds. This direct current is supplied so that the called subscriber's answer—removal of his receiver—may be recognized immediately even though it comes during one of the silent intervals, and that the line may be ready at once for conversation to start.

To disconnect ringing current in a machine ringing system and to establish a through talking path, each ringing circuit is equipped with a tripping relay which operates on the increased current when the receiver is removed from the switchhook. These relays must all operate on direct current, and in addition on ringing current—some of them are designed and adjusted to operate on alternating current, some on pulsating current, and some on superimposed current—but they must not operate on any current passing through them before the subscriber answers. Such conditions are in themselves exacting, but they are made much more so by variation in ringing voltage and frequency, and by differences of several hundred ohms in the resistances of the various lines. Closer limits for voltage and speed of the ringing machines were therefore established to increase the assurance of reliable operation.

With the introduction of dial systems, further problems in ringing arose from the charging and discharging of the station condenser during dialing, and resultant tapping of the ringer. On party lines, and lines with extension telephones, this resulted at times in calling a person at one of the other stations. Ringers at dial stations, even for individual lines, were poled and adjusted to prevent tapping; as a result, it became much more difficult for them to operate on the usual ringing current. Voltages of the ringing machines were modified correspondingly, and new sets of limits established for panel and step-by-step offices. Superimposed current is used where full selective ringing is offered on four-party lines, and alternating current for ringing other lines. In new offices, in areas not having four-party selective lines, alternating current with a small amount of superimposed direct current is used to facilitate the operation of the relays which trip machine ringing. This direct current however has no effect on the ringers in these areas. In the older manual offices there will still be found all of the ringing voltages and frequencies which have been standard, but in the newer offices the limits are the same as for the corresponding dial offices.

In many cases the line to which ringing current is applied will not have a ringer connected to it at all. It may be a line to a private branch exchange, or to a special operator's position, at which a visual signal is wanted. In such cases the ringing current must operate a relay controlling a lamp in front of the operator. These "ring-up" relays must operate under any normal ringing condition, and must not be operated by any other current flowing in the circuit during its use. Their story, however, like those of other pieces of ringing apparatus, belongs by itself rather than with a brief history of general ringing conditions.

Thus from the time when the first telephone switchboard was installed, the problem of calling subscribers has been to let them know positively and quickly that some one wished to speak to them. The signal must be distinct and reliable, so that there can be no doubt that it is genuine, and even on party lines there should be no tapping or accidental ringing to cause confusion or annoyance. The present polarized type of ringer has met the increasingly exacting demands of a rapidly expanding service, and while other forms of signals have been considered, none have been suggested that seem at all likely to replace it.

# Standard Housings for Portable Test Sets

By G. T. FORD
*Equipment Development*

THAT telephone service may always be available to the subscriber when it is desired requires continual testing of both circuits and apparatus. Inspection alone is not sufficient; special testing equipment of one form or another has always been necessary. For some of the work it may be mounted on fixed frames or desks, but much of it must be mounted in portable form so that it may be moved from place to place. The test sets used for making operation tests and for maintaining equipment within central offices are sometimes placed on a "tea wagon" which can be wheeled to the desired location when a considerable amount of equipment is required, or for smaller amounts of equipment test boxes are used that are carried where desired by the maintenance man. In this paper are described new housings designed particularly for these types of test sets.

Before the introduction of the newly designed housings a large number of types, differing in size and details of construction, were used. These various housings had been designed at different times as the need for them arose, and the size and arrangement of the equipment had been determined by the requirements of each particular test circuit being accommodated. This resulted in the production of a large number of different size housings and due to the type of construction being used at the time the various sets were developed, and to the large number of sizes, there were few of the framework parts that could be applied to more than one set.

A study was made for the purpose of designing if possible a small number of housings similar in exterior appearance and construction, and of such a range in size that they could replace the large number previously in use. The object was to secure a design that could be made in comparatively large quantities, so as to secure a reduction in manufacturing cost as well as a uniform quality. In addition, an en-

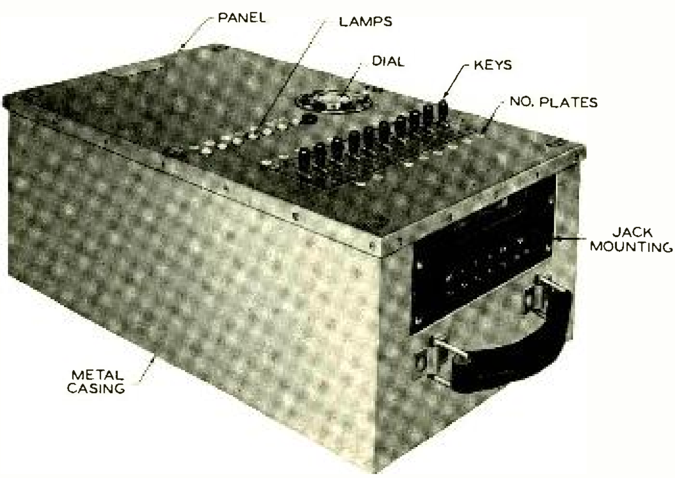



*Fig. 1—External appearance of the new test set in one of its larger sizes*

deavor was made to obtain a design which was rugged in construction and yet gave accessibility to all apparatus so that it could easily be kept in working order.

With the design finally adopted it was found possible to employ five sizes for practically all central office maintenance test sets of the box type. The smallest is of such dimensions that it may be held in the tester's hand when in use and so is known as the Hand size. The next size may be used on the small ten-inch rolling ladder and has been designated Small Ladder size. In like manner the sets which may be used on the twelve- and fourteen-inch ladders have been designated Medium-Ladder size and Large-Ladder size respectively. The test set shown in Figures 1 and 2 is the Large-Ladder size. The largest of the five standard sizes is required for test circuit equipment which cannot be placed in the fourteen-inch-ladder size and yet does not require the space provided by a wagon type test set. This set is of such size that it may be conveniently placed on a table having a top twenty-four inches long by twelve inches wide and is known as the Table size.

The design adopted has two principal parts. The fundamental structure is a panel faced with phenol fibre which forms the top of the test set and corresponds roughly to the key-shelf of the previous type. The panel is of three ply construction, being a maple board with one-sixteenth inch phenol fibre glued on each side. The exposed surface of the phenol fibre is rubbed to a dull jet-black finish which presents a pleasing appearance as well as a durable surface. The four edges of the panel are protected by commercial type aluminum moulding, which matches the finish on the casing described later. The keys and lamps usually appearing on the key-shelf are mounted on this panel, and all other apparatus is suspended from the under-surface.

When the set is assembled, the panel is screwed to a sheet metal casing about one-sixteenth inch thick (No. 16 gauge) with a baked-on aluminum finish. No apparatus is mounted directly on this casing, its primary purpose being to furnish a housing enclosing the apparatus and protecting it from mechanical injury. With this arrangement the panel and its equipment can be removed as a

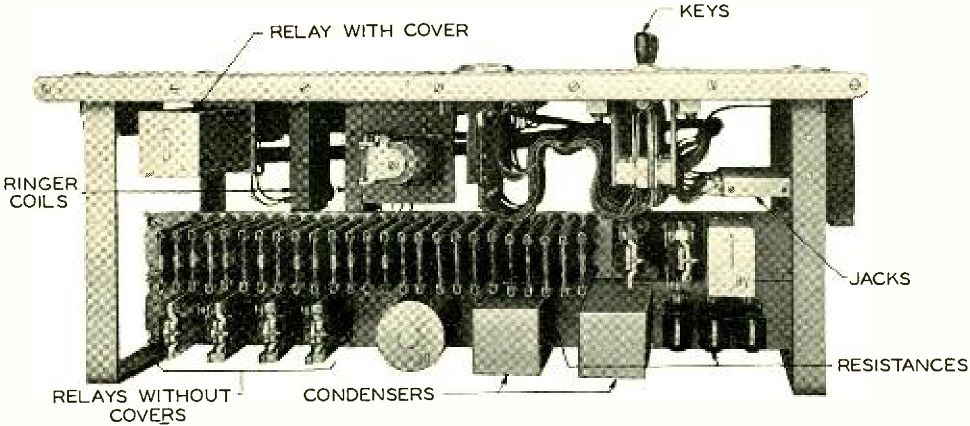


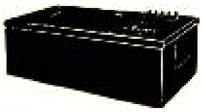

*Fig. 2—Panel of test set removed from the casing showing the mounting of all equipment on its under surface and the two supporting brackets*

unit from the casing for inspection or adjustment and if necessary could be used in service without the casing. Two "U" shaped bars fastened to the under surface of the panel, one at each end of the set, serve as a support for the panel when it is removed from the casing and as a guide or centering device while it is being placed into the casing. These bars also support brackets to which the relay mounting plates are attached.

A metal casing was adopted, rather than one constructed of wood, to obtain a casing of simple yet rugged design suitable for withstanding unusual knocks and falls to which these test boxes are at times subjected while in service. A model of the metal casing and one of simple wood construction were made for the purpose of making comparative tests under the most unusual service conditions. By these tests it was demonstrated that, for constructions comparable in price, the metal casing could better withstand the more severe shocks. In addition, the metal casing, being considerably thinner than the wood, allows a larger cubic content to be contained in a box of the same outside dimension and consequently slightly more equipment in the same size of housing.

The new design permits the panel, the casings, and all minor mechanical parts to be made up in large quantities and stocked. When an order is received for a particular test circuit, the panel is taken from stock and drilled for the equipment required. There are approximately fifty circuits now being furnished in portable test sets. Each of these is different in that each requires different apparatus and a different arrangement of wiring in order to accomplish its purpose. It is possible with the new design to accommodate the equipment for any one of the fifty circuits in one of the five sizes adopted as standard, without making any change in the construction.

On account of the variety of places where these test sets are used, several factors were considered in setting the sizes such as the space available on the steps of rolling ladders and on the top of rolling tables upon which the portable sets are sometimes placed. Size is a prime consideration and consequently the various sizes of casings were determined in such a manner that there would be the least possible waste space. Cost studies indicate that appreciable savings will be made by the adoption of the new design, due principally to the arrangement for production of the framework in large quantities.



# Adjustment Provisions for Central Office Apparatus

By F. A. COX
*Local Systems Development*

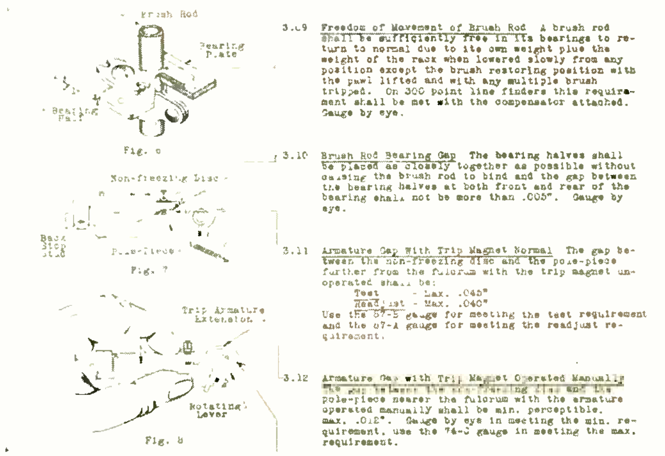
IN the design of modern telephone circuits and apparatus there are two important and related factors which must receive most careful attention. The equipment as a whole must give satisfactory service to the subscriber, and it must be designed so that it can be economically manufactured and maintained. Economical maintenance presumes, among other things, that the equipment, once placed in service, shall continue to function for a reasonable period without readjustment. The quality of the equipment, therefore, must attain a certain level, but it must not exceed this by an amount which will cause unwarranted cost for manufacture.

Among the criteria of quality in telephone apparatus is the closeness with which adjustable values approach the standard determined by the designer. Practical considerations require that some departure from the standard be tolerated; the limits of this tolerance are as much a part of the design as the standard value itself. These limits are carefully worked out to insure continuous satisfactory operation with reasonable maintenance, and yet not make the manufacturing cost excessive. To provide for the adjustment of apparatus within the proper limits, very definite requirements must be made available to the installation and maintenance forces. This is accomplished by the Requirements and Adjusting Procedures for adjustable central office apparatus, prepared by Bell Telephone Laboratories and issued as a part of the Bell System Maintenance Practices.

These Requirements and Adjusting Procedures are the result of a constantly growing demand for detailed information not only as to the requirements governing the adjustable features of central office apparatus, but as to the methods, tools, and equipment necessary for adjusting the apparatus to meet these requirements. The need for information of this nature was recognized many years ago even for the relatively small amount of adjustable apparatus in manual offices, and such information has long been available for manual central office apparatus, particularly regarding the electrical requirements for relays.

The program for supplying this information to the field was given great impetus by the introduction of dial systems with their greatly increased quantity and complexity of apparatus. In the dial systems all the operations other than dialing, necessary to establish an ordinary local connection between subscribers, are mechanical and automatic; each is dependent on the operations preceding it for the correct performance of its own function. Current margins and time factors have been introduced. Relays are required to operate, release, or fail to operate—as the circuit requires—on small differences in current. They are also required to operate or release slowly or quickly as may be necessary to perform their functions.

In addition, an entire new array of


Brush Rod
Bearing Plate
Bearing Pawl
Fig. 6
Non-freezing Disc
Back Stop Stud
Pole-Piece
Fig. 7
Trip Armature Extension
Rotating Lever
Fig. 8

3.09 Freedom of Movement of Brush Rod A brush rod shall be sufficiently free in its bearings to return to normal due to its own weight plus the weight of the rack when lowered slowly from any position except the brush restoring position with the pawl lifted and with any multiple brush tripped. On 300 point line finders this requirement shall be met with the compensator attached. Gauge by eye.

3.10 Brush Rod Bearing Gap The bearing halves shall be placed as closely together as possible without causing the brush rod to bind and the gap between the bearing halves at both front and rear of the bearing shall not be more than .005". Gauge by eye.

3.11 Armature Gap With Trip Magnet Normal The gap between the non-freezing disc and the pole-piece further from the fulcrum with the trip magnet unoperated shall be:

Test - Max. .045"
Readjust - Max. .040"

Use the 67-B gauge for meeting the test requirement and the 67-A gauge for meeting the readjust requirement.

3.12 Armature Gap with Trip Magnet Operated Manually The gap between the non-freezing disc and the pole-piece nearer the fulcrum with the armature operated manually shall be min. perceptible. max. .012". Gauge by eye in meeting the min. requirement. use the 74-C gauge in meeting the max. requirement.

*Fig. 1—Part of typical page of "Requirements" section of a complete "Requirements-and-Adjusting-Procedures" section of the Bell System Maintenance Practices*

mechanical devices is required which performs functions previously taken care of by the hands, voice, hearing, or vision of the telephone operator. These devices are designed to operate within close margins of time or travel, the requirements for which, once established, must be met not only in manufacture but during installation, and in maintenance under service conditions.

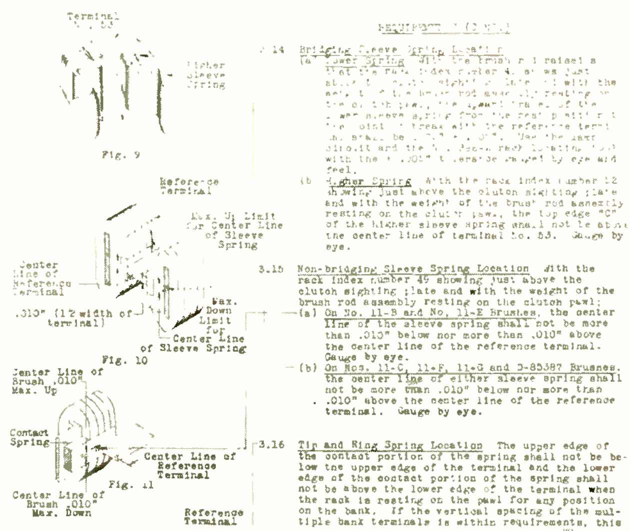
The first apparatus adjusting information for installation and maintenance purposes in dial systems gave the requirements only. These were given in two specifications, each covering the apparatus peculiar to a dial system. Apparatus already well known through its use in manual equipment was not included. These specifications satisfied the needs of the first jobs when the systems were new and maintenance problems still to be learned. The Telephone Companies supplied men to be trained during installation so that when the equipment was turned over to them by the Western Electric Company, the newly trained men could successfully carry on the maintenance work. As the dial systems grew in importance, the need for complete and uniform maintenance instructions became more and more apparent until finally it was made a function of the Laboratories to specify not only the requirements for the correct performance and adjustments of apparatus, but the procedures for meeting them. From this point the introduction of the specifications, which were later incorporated as a part of the Bell System Maintenance Practices, began.

To facilitate distribution, and the keeping of the requirements and maintenance information up-to-date, the general specification for each of the dial systems was divided into a number of individual specifications, each covering apparatus of a given type or of similar types having the same requirements. At the same time the program was extended to include mechanical requirements for relays and keys because of the need for more accurate adjustments imposed by the dial-system circuits. The scope of the program has since been further extended to include all apparatus requiring maintenance readjustment, not only in the panel and step-by-step systems, but in manual and toll systems, manual and step-by-step PBX's, and power equipment.

Because of the diversity of the apparatus in the dial-system circuits and the close adjustments imposed, it is no longer practical to test and readjust on an overall "circuit operation" basis, a method commonly known as "tuning". Instead, each piece of apparatus is given a definite adjustment within specified limits and when this has been done for all the component apparatus of the circuit, the circuit will function without further adjustment.

To derive the greatest benefit from this method of adjusting however it is desirable to establish a point of test somewhere between the lower limit of satisfactory operation and the manufacturing requirements, by means of which apparatus which is nearing this lower limit may be detected before failure actually ensues. Consequently where the operating range of the apparatus permits, two sets of field requirements have been established. The first, based on the manufacturing requirement, is used by the adjuster and known as the readjust requirement; the second, falling somewhere between this readjust requirement and the point of circuit failure, is used in checking previously established adjustments and is known as the test requirement. The margin between the test and the readjust requirements serves not only as a safety zone in which the apparatus will operate satisfactorily, but also helps to compensate for the personal element, since the adjuster and checker may not always be in complete agreement as to the correctness of an adjustment.

There is always a fair margin between each test requirement and the lower limit of satisfactory operation. Circuit failure should occur only when an individual adjustment passes this limit or when a group of adjustments at or near their limits on several inter-related pieces of apparatus produces a combination which exceeds the lower limit for the whole circuit. In some cases, owing to manufacturing limitations, the margin between the best commercial adjustment that may be applied in the shop and the lower limit of satisfactory operation, is in-




3.14 Bridging Sleeve Spring Location
(a) Lower Spring [illegible] feel.
(b) Higher Spring With the rack index number 52 showing just above the clutch sighting plate and with the weight of the brush rod assembly resting on the clutch pawl, the top edge "C" of the higher sleeve spring shall not be above the center line of terminal No. 53. Gauge by eye.

3.15 Non-bridging Sleeve Spring Location With the rack index number 49 showing just above the clutch sighting plate and with the weight of the brush rod assembly resting on the clutch pawl;
(a) On No. 11-B and No. 11-E Brushes, the center line of the sleeve spring shall not be more than .010" below nor more than .010" above the center line of the reference terminal. Gauge by eye.
(b) On Nos. 11-C, 11-F, 11-G and D-85387 Brushes, the center line of either sleeve spring shall not be more than .010" below nor more than .010" above the center line of the reference terminal. Gauge by eye.

3.16 Tip and Ring Spring Location The upper edge of the contact portion of the spring shall not be below the upper edge of the terminal and the lower edge of the contact portion of the spring shall not be above the lower edge of the terminal when the rack is resting on the pawl for any position on the bank. If the vertical spacing of the multiple bank terminals is within requirements, this

*Fig. 2—Page of the Requirements and Adjusting Procedures showing requirements for multiple-brush adjustments*

sufficient to permit the establishment of individual limits for test and readjust. In this case the same limit is used for both.

The test requirement is used not only by the installation checker who follows the installation apparatus adjuster, but also by the Telephone Company when apparatus is turned over to it by the Installation Department of the Western Electric Company. In general the manufacturer aims at an adjustment better than the readjust requirement for individual apparatus; the installer aims at the readjust requirement or better; and the installer's checker expects to find the apparatus within the test requirements with a fair proportion of it at or near the readjust limit.

Experience has shown that it is not always advisable, in adjusting apparatus, to work to the actual readjust value or limit. Each adjustment must be analyzed to determine the ideal value toward which it should be pointed. In some places the natural wear of the apparatus in operation tends to bring it near the minimum limit, while in others wear tends to bring it towards the maximum limit. In the former case the adjuster is advised to work toward the maximum limit whereas in the later case he is advised to work toward the minimum. For other adjustments, such as contact pressure on base metal contacts, the maximum limit is established to guard against excessive wear of parts. Here the requirement specification will probably advise the adjuster to work to the mean of the limits since high average pressures will tend to excessive wear while low average pressures will favor unsatisfactory contact.

| SPRING | | | SEGMENT | | RACK NOTCH NUMBER | TEST AND READJUST LIMITS | | |
|---|---|---|---|---|---|---|---|---|
| DESIG. | EDGE | POSITION | EDGE | NUMBER | | MAX.LOW | IDEAL | MAX.HIGH |
| A | TOP | ABOVE | TOP | 5TH | SEE NOTE A BELOW | .003" | .010" | .017" |
| B | BOTTOM | ABOVE | BOTTOM | 5TH | 43 | | .010 | .020" |
| C | TOP | COINCIDE | BOTTOM | 45TH | 43 | .005" | | .005" |
| O | TOP | BELOW | BOTTOM | EACH SEGMENT | 10,21,32, 43,54,65, 76,87 & 99 | PERCEPT | EQUAL | PERCEPT |
| | BOTTOM | ABOVE | TOP | | | | | |
| T R S | BOTTOM | ABOVE | BOTTOM | - | 0 | PERCEPT NO 0 | | PERCEPT NO 99 |
| | TOP | BELOW | TOP | - | 99 | | | |

1-D COMMUTATOR

*Fig. 3—Table of commutator brush settings from a section of the Bell System Maintenance Practices showing the allowable range of adjustment*

In preparing the first adjusting procedures it became apparent that, owing to the complexity of the adjustments involved, it would not be possible to describe the work adequately in words alone. Illustrations were essential not only to show the proper use of tools and gauges but to indicate the exact points of application of the various requirements. The practice, therefore, is to give illustrations for both requirements and procedures. An illustration is provided wherever it is felt that any doubt could exist either as to the meaning of the requirement or to the proper methods of adjustment to meet it.

In their present form each section of the Bell System Maintenance Practices containing Requirements and Adjusting Procedures, consists of three parts. The first covers the scope of the individual section together with general paragraphs of information and definitions applicable alike to the requirements and the adjusting procedures. The second contains the requirements and their illustrations. The third contains the adjusting procedures and their illustrations, a separate series of methods and procedures being given for each requirement except where the adjustment for one requirement will affect the adjustment for others.

Before the establishment of these specifications, later incorporated as part of the Bell System Maintenance Specifications, as the authorized source of such information, and for some time after they had been in use, it was customary for the Telephone Companies to prepare their own instructions for maintenance men. Owing, however, to the improved form in which the Requirements and Adjusting Procedures are now prepared, to the completeness of the information contained in them, and to the illustrations which make clear the various requirements and methods of adjustment, the Telephone Companies are discontinuing the preparation of their own method instructions and making use of the Standard Maintenance Practices.

It has been the practice since the first issues of the original requirement specifications were prepared, to distribute preliminary issues to the Installation and Manufacturing Departments of the Western Electric Company and to the American Telephone and Telegraph Company for comment. Copies sent to the Installation Department have been distributed to its field zones for comment. In this way comments and suggestions have been gathered from all interested departments and these have been considered in conference and adopted whenever by so doing the maintenance practices would be improved.

## *A Four-Year Index for the Record*

*Incident to the binding of Volume 7 of* Bell Laboratories Record, *a four-year cumulative index has been prepared for the magazine, from its first issue in September,* 1925, *through August,* 1929. *An innovation is the addition of subject-headings to the index by title. The pamphlet will be useful not only to those who wish to bind their files of the magazine, but also to those who refer to the bound volumes in the Library. Copies may be requested by memorandum addressed to the Bureau of Publication.*

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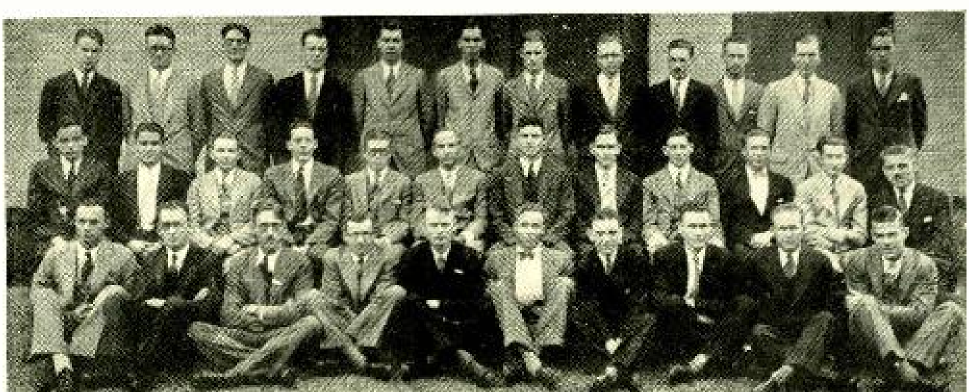

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# Introducing the New College Men

TIME and time again in articles on business administration we encounter reference to the Bell System's policy of planning its program of expenditure for five and even ten years ahead. The curve showing this expenditure may be taken as a fair criterion of the corporate growth of the organization. The tremendous expansion of the Bell System, therefore, is indicated by the forecast for the next five years of scheduled gross additions to plant which will amount to more than half of the present total plant investment.

It is obvious the Laboratories' program of research and development must keep pace with, if not exceed, the continuing growth of the Bell System. At the present time the total personnel of the Laboratories, exclusive of the Tube Shop, approaches the 5,000 mark and the budget during the past year increased from fifteen to nineteen millions of dollars. Additions must be made to the personnel as well as to the Laboratories buildings and equipment. So it is not surprising to learn that a total of about 350 college trained men from all parts of the country, and in some cases from abroad, have been added during the past year to the Laboratories staff. These men have become members of our organization and will aid in working out the added problems of research, apparatus design, systems and outside plant projects that the increasing growth of the Bell System imposes on the Laboratories.

Quite naturally these young men find that our business is extremely complex, and that a considerable groundwork of information is necessary before they can take up their new duties with confidence. To help lay this foundation it is the custom of our Educational Department to conduct a brief but intensive introductory survey during the summer of each year.

During this instruction the general organization of the Bell System is explained in order to present the purpose of the Laboratories and its place in that system. This is followed by a general description of departmental functions and activities. Members of the technical staff represent their own departments in explaining their particular fields the problems encountered and their facilities for solving them. The talks are often associated with visits to appropriate laboratories where further explanations and demonstrations are given. Trips to telephone central offices of both manual and dial types are conducted to show typical examples of the conditions under which service is rendered to the public. Having described the many parts of the business and, in so doing, having shown their interrelationship, the survey is concluded by a summary of company policies and of opportunities provided for continued study. Each new member is assigned to a type of work consistent with his training and propensities before he enters the survey in order that during the course he may be alert for those bits of information which will aid his orientation in his chosen field of work.

The group just issuing from the introductory course, like its predeces-

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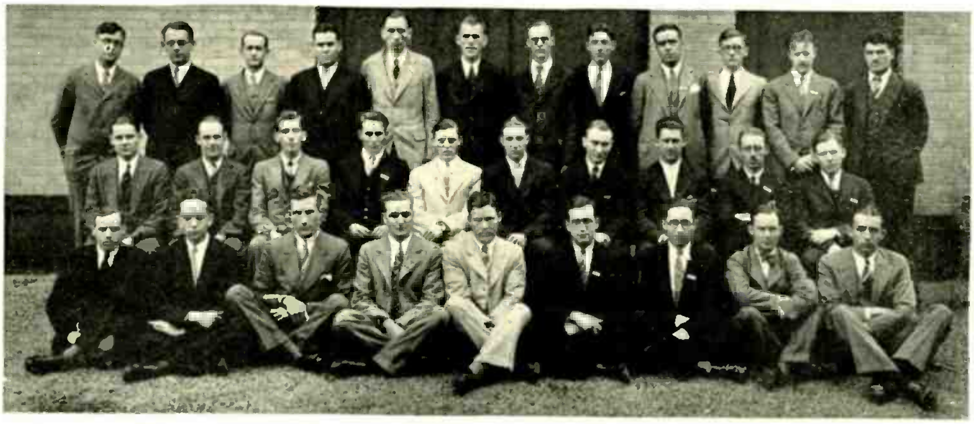

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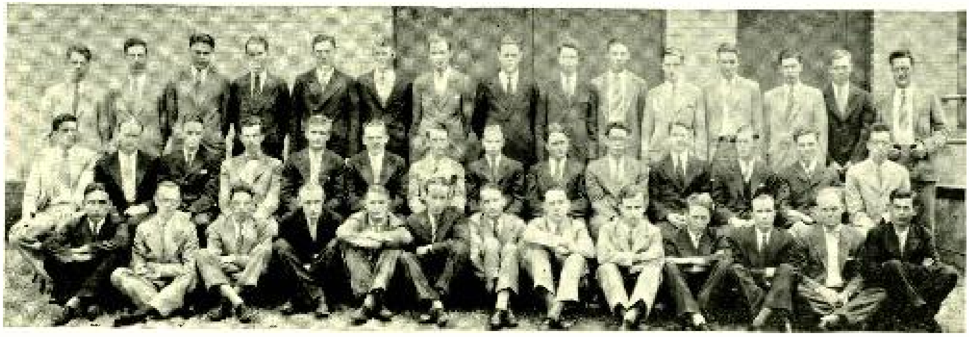

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sors, represents educational institutions in every section of the United States and in some foreign countries as well as various other departments of the Bell System. Wide representation is distinctly advantageous in that it brings together men with common interests but with varied backgrounds of experience. The Associated Operating Telephone Companies by keeping in close contact with the engineering colleges and describing our work to qualified students have greatly assisted our Personnel Department in the selection of new employees.

The Laboratories expects these new members to bring with them the habit of study and the susceptibility to instruction which has characterized their previous training and hopes that they will utilize the facilities offered for further study and advancement. They will soon begin to realize—what those of us who are older at the business know so well—that employment marks not the end of one's education but rather its beginning. On its side, the Laboratories will not forget that although dedicated to the achievement of distinctly practical ends, it must cooperate with the members of its organization in broadening their knowledge of electrical communication. To this end and to supplement the introductory courses, many other courses both in and out-of-hours have been arranged.

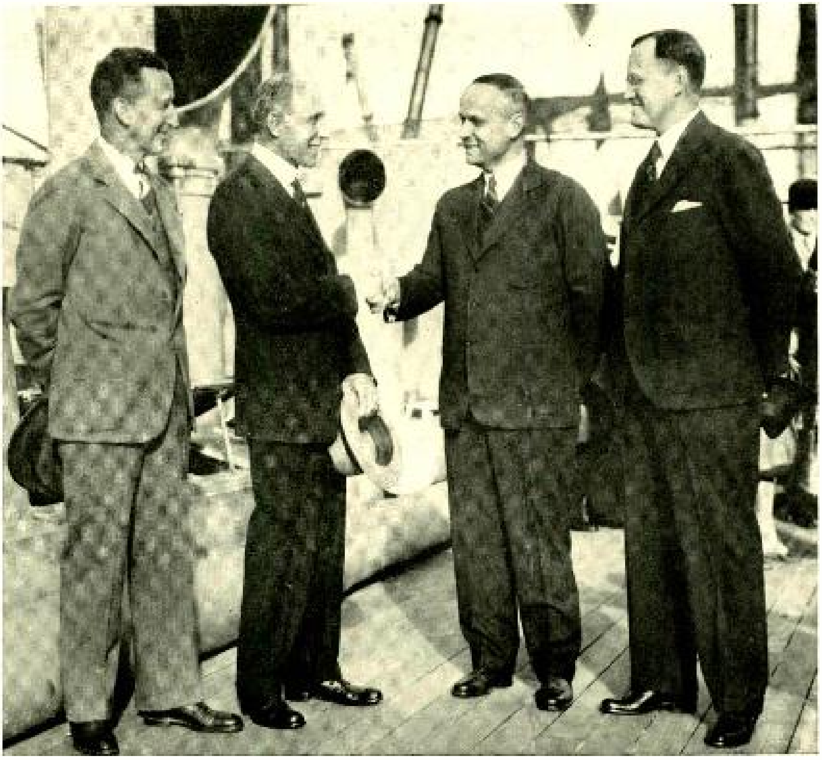
# *The Month's News*

IN

STORIES AND PICTURES

INCLUDING

NOTES OF THE CLUB



*F. J. Reagan and N. R. Powley of the Pacific Telephone and Telegraph Company bid Dr. Jewett goodbye as he and F. F. Lucas leave for the World Engineering Congress in Tokio*

# News Notes

PROMINENT among the additions to the facilities of the Laboratories during the month of October was a new Ford tri-motor all-metal monoplane of a type having a rated capacity of fourteen persons. In the purchase of this plane, destined to be the largest and most complete flying radio laboratory in the world, the Laboratories is following its established policy of making pioneer studies of all phases of electrical communication. The plane has been specially designed to adapt it to research work, and will be used for the development of radio apparatus for aircraft communication from the earliest experimental stages through to the final testing of the finished apparatus under actual flight conditions.

Underwood & Underwood

*Executives and engineers of the Apparatus Development Department which will make use of the plane to develop apparatus for aircraft communications. Left to right they are: F. S. Bernhard, E. L. Nelson, R. S. Bair, F. B. Woodworth, T. Durfee, R. L. Jones, D. A. Quarles, F. M. Ryan, O. M. Glunt and A. R. Brooks*

Construction of the plane was completed during the week of October 6 at the Ford Plant at Dearborn, and on Friday of that week Capt. A. R. Brooks, chief pilot of the Laboratories, took off from Detroit in the plane and flew through to Hadley Field, making an over night stop at Cleveland. The distance from Cleveland to Hadley Field was accomplished in three hours and twenty minutes.

For the convenience of Laboratories men who will carry on development studies with the new plane, it has been equipped with two large laboratory benches and a variety of antennas. There will be two trailing-wire antennas and two stream-lined vertical rod antennas mounted on the plane. In addition, supports have been erected on the wing-tips for the mounting of various experimental types.

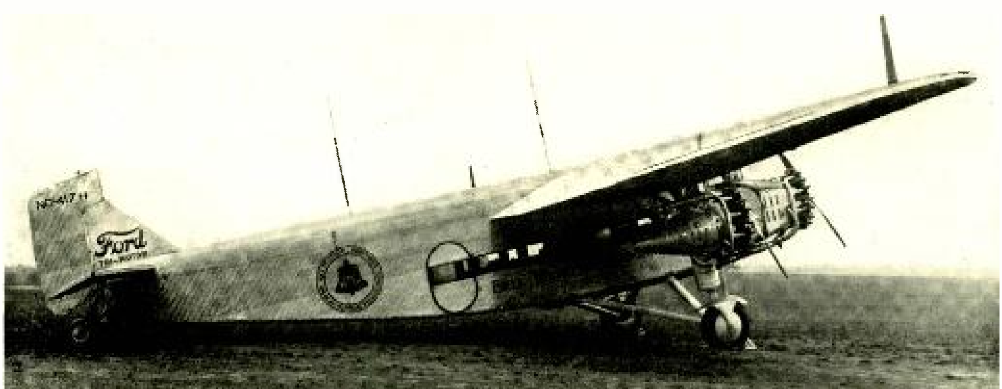
Power will be supplied from generators and storage batteries. The motors of the plane are arranged so that engine-driven generators may be used for supplying power either directly to the apparatus or to storage batteries. Suitable mountings for wind-driven generators have also been provided.

As soon as the plane arrived at Hadley Field, work was started on equipping it with a Western-Electric two-way radio-telephone system for communication with ground. This apparatus will be capable of operation anywhere on the frequency band from 1500 to 6000 kilocycles. There will also be installed a low-frequency receiver to operate on the 250-500 kilocycle band. This is the broadcast range used by the government to send out weather information and directional radio signals.

In addition to developing radio apparatus the plane will be used to mea-

Underwood & Underwood

*Interior view of the new Ford plane showing a temporary installation of apparatus. In the picture from front to rear are R. S. Bair, F. B. Woodworth, F. S. Bernhard, and F. M. Ryan*




Underwood & Underwood

*The new giant tri-motored Ford monoplane built for Bell Telephone Laboratories. Notice the mast-type antennas with which it is equipped* sure the strength of radio signals under various conditions. This will supplement the work which has already been done in the Fairchild plane operated by the Laboratories. The Fairchild plane will remain in service, but its carrying capacity — four persons — is not sufficient for the experiments now planned.

There are several special features built into the plane to make it more useful for the purpose for which it was designed. All the ignition and power wires and the spark plugs of the motors have been carefully shielded to avoid interference with radio signals. All the metal parts of the plane have been bonded together to minimize further the interference from this source. In addition the plane is equipped with an intercommunicating telephone system to permit people in various parts of the plane to talk with one another, as well as with ground.

The piloting of the plane will be in the charge of Captain A. R. Brooks, who flew the plane from Detroit. Captain Brooks and F. S. Bernhard, of the radio development group, supervised the aeronautical and radio features of the plane during its construction.

### Administration

President F. B. Jewett was among the group of Bell System officials that exchanged greetings with Australian telephone officials on September 25 over the telephone from New York to Sydney. The occasion was an informal demonstration of the practicability of connecting the A. T. & T. transatlantic telephone channel and the new short wave channel operated by the British General Post Office between Great Britain and the Australian Continent. It is expected that the circuit, which extends 15,000 miles, may soon be opened for commercial use.

The variance in time between the two places gave an interesting aspect to the demonstration. The Bell System officials talking from New York at 4 o'clock in the afternoon on September 25 were informed by their Australian colleagues that it was 6 A.M. the day following at Sydney.

Dr. Jewett delivered an informal talk at Stevens Institute of Technology at Hoboken, entitled *Why Study Physics and Chemistry,* before the members of the freshmen class during Orientation Week.

On October 6, Dr. Jewett left for San Francisco, where he embarked on the S.S. "President Jackson" for the World Engineering Congress to be held in Tokio, Japan. On September 26, with P. Norton, he attended the dinner of the American Committee of the Congress held at the Astor Hotel. During the early part of the month he was present at the Presidents' Conference at Yama Farms.

An interview with Dr. Jewett appears in the November issue of the *Popular Science Monthly* under the caption "Tying Europe to America by Telephone Wires".

H. P. Charlesworth has been appointed chairman of the general committee in charge of the annual Winter Convention of the American Institute of Electrical Engineers which will be held in New York during the last week in January.

### Research

On October 16, Dr. Frank C. Whitmore, Dean of the School of Chemistry and Physics of Pennsylvania State College, spoke before members of the Chemical Research group in the auditorium. The subject of his talk was *Modern Tendencies in Industrial Organic Chemistry.*

R. A. HEISING has been nominated for president of the Institute of Radio Engineers.

G. G. MULLER was at Oakland, California, during part of October in connection with instruments to be used for airplane communication.

*While the Leviathan was in New York, from October* 10 *to* 12, *G. Thurston, F. B. Llewellyn and I. E. Fair were among those at work on the experimental radio telephone apparatus*

H. A. LARLEE was at Hawthorne to confer on the handset and other telephone instrument matters.

R. M. BURNS, H. E. HARING and C. L. HIPPENSTEEL visited New Orleans to investigate cable-sheath failure due to corrosion.

C. W. BORGMANN attended the Cleveland meeting of the American Institute of Mining and Metallurgical Engineers. From there he went to Altoona and to Pennsylvania State College in connection with American Society for Testing Materials affairs.

MESSRS. C. W. Borgmann, L. Ferguson, A. G. Russell and D. C. Smith attended a meeting of the American Electrochemical Society at Pittsburgh.

MESSRS. B. L. Clarke, L. E. Krohn and H. H. Lowry attended the American Chemical Society meeting at Minneapolis.

MESSRS. J. F. Eckel, W. C. Ellis, J. E. Harris and E. E. Schumacher were at the Cleveland meeting of the American Institute of Mining and Metallurgical Engineers.

A. N. GRAY visited Hawthorne in connection with rubber insulated telephone cords.

J. E. HARRIS and E. E. SCHUMACHER visited Hawthorne in connection with lead cable work.

A. R. KEMP has returned to the Laboratories after spending five months at Nordenham, Germany, in connection with submarine cable development.

MESSRS. J. H. Ingmanson, W. S. Bishop, A. N. Gray and G. S. Mueller attended a meeting of the Rubber Division of the American Chemical Society at Atlantic City.

J. H. SCAFF visited the Bureau of Standards in Washington to examine apparatus for the determination of gases in metals.

A. G. LANDEEN and E. PETERSON are with the Pacific Telephone and Telegraph Company at Avalon, California, making tests on the Catalina cable. The tests are being made to supply data for use on the transatlantic telephone cable system.

HARVEY FLETCHER gave a paper before the joint session of the American Public Health Association and the American Association of School Physicians at Minneapolis. His subject was *The Progress of Hearing Tests in the Public Schools of the United States.* Mr. Fletcher also attended a meeting of the National Safety Council on Noise and Its Relation to Accidents, held at Chicago.

Mr. Fletcher has been named by Health Commissioner Wynne of New York City on the committee of seven appointed to investigate noise conditions and report findings tending toward the elimination of the evil.

A paper on the phonograph audiometer and its use in the detection of deafened children was presented by J. B. Kelly before the Indiana League for the Hard of Hearing at Indianapolis.

### Apparatus Development

F. F. Lucas left for Tokio on October 2 to attend the World Engineering Congress where he will deliver a paper entitled *On the Structure and Nature of Troostite.* He will also represent the American Society for Steel Treating as their official delegate. While en route Mr. Lucas stopped in Washington where he was a guest at a formal dinner given by the Japanese Ambassador.

The 1920 medal of the Royal Photographic Society of Great Britain has been awarded to Mr. Lucas in honor of his photomicrographs of living tumor cells taken by means of ultra-violet light. These photomicrographs show for the first time his new method of optical sectioning.

H. A. Anderson addressed the Pittsburgh section of the American Society for Steel Treating on October 3. His subject was *Telephone Materials and the A. S. T. M. Die Casting Investigation.*

J. N. Reynolds and H. F. Dobbin were in Hawthorne during September for conferences on new dial system apparatus.

Messrs. H. O. Siegmund, D. C. Lloyd, B. F. Runyon and R. L. Tambling have been engaged in studies of precious metal contacts in pilot wire regulators at installations in Kingston, New York, Allentown and Newcastle, Pennsylvania, and Wheeling, West Virginia.

G. W. Folkner visited Hawthorne in connection with manufacturing problems on panel multiple brushes.

H. A. Bredehoft spent a month at Hawthorne for engineering training.

J. A. Csepely visited Penn Yan, New York, in connection with relay investigations.

R. T. Staples and H. Wagner attended the Pioneers Picnic at Camp Sherwood.

J. C. Herber visited Gainesville, Florida, where he inspected and checked the transmitting apparatus of station WRUF operated by the University and State of Florida.

A. L. Dunn visited The Ball Company in Newark in connection with trunks for the portable recording equipment.

R. V. Terry spent several days at Rochester in conferences at the Bausch & Lomb Company.

### Outside Plant

E. M. Honan was at Dallas to observe results on a trial shipment of specially finished drop wire installed by the Southwestern Bell Telephone Company. Before returning, Mr. Honan visited the H. H. Robertson Company at Pittsburgh to discuss physical requirements of materials to be used for weatherproofing braid on rubber insulated wire.

C. R. Moore visited M. Klein and Sons Company at Chicago in connection with the manufacture of linemen's climbers. Mr. Moore also visited the Indiana Wire and Steel Company at Muncie to observe processes of strand manufacture.

A. W. Dring visited the Bell Telephone Company of Pennsylvania at Philadelphia to observe preliminary field trials on redesigned distribution cable terminals.

A. H. Hearn and L. M. Lindenmuth were in Texas, Mississippi and Alabama inspecting experimental treatments of southern yellow pine poles at suppliers' plants located in these states.

R. C. Eggleston was in Mississippi and Alabama making a study of knot distribution in the current production of southern yellow pine poles.

R. H. Colley made a trip to Raleigh, North Carolina, to attend a conference with representatives of the National Electric Light Association and the engineering staff of the University of North Carolina to discuss the results of strength tests on poles.

L. S. Ford of Hawthorne has been in New York for general cable conferences.

R. E. Alberts, who was formerly located at Kearny, was transferred to Baltimore to take care of the current engineering in connection with the manufacture of lead covered cable at the new Point Breeze plant of the Western Electric Company. R. C. Jones was transferred from Hawthorne to Kearny to replace Mr. Alberts.

## Systems Development

James G. Ferguson has returned from the Pacific Coast where he spent nearly three months supervising the installation of the step-by-step PBX equipments on the airplane carriers *Saratoga* and *Lexington.* The equipment on the *Saratoga* was tested at sea under warfare conditions with satisfactory results.

C. Borgmann visited Cincinnati in connection with central office equipment matters.

G. E. Bailey went to Detroit, Chicago and Des Moines, Iowa, on matters concerned with recent toll and pneumatic tube installations.

M. E. Maloney was at Chicago in connection with equipment designs on the 750 PBX.

E. K. Eberhart discussed with officials of the Underwriters' Laboratories at Chicago some questions regarding the design of window ventilators with a view toward obtaining the Underwriters' approval of the Bell System ventilator.

A. E. Petrie visited the General Electric factory at West Lynn to discuss the salvaging of "M" type charging generator parts.

H. T. Langabeer went to Chicago to attend a survey conference on power plants for dial PBX's.

H. L. Mueller discussed the design of PBX battery cabinets with the manufacturer in Philadelphia.

G. V. King was at Piney Point, Maryland, to observe during gun fire the operation of a recently installed dial PBX on the U.S.S. "Oklahoma".

L. J. Stacy visited the New York Telephone Company at Albany to obtain information on the results of the trial installations of eight-party semi-selective ringing on rural lines at Troy and Olean.

W. J. Lacerte made several trips to Stamford, Connecticut, in connection with the initial installation of message rate trunks.

G. H. HUBER was at Sacramento, California, during September in connection with the trial installation of a volume limiter for controlling the volume on type "C" carrier.

E. P. BANCROFT is still in the field engaged on the Canadian Pacific Railway carrier telegraph project.

DURING THE latter part of September A. M. Koerner went to Davenport, Iowa, in connection with superposition tests of voice carrier telegraph on type "C" carrier telephone.

C. C. LANE was at Rockland, Maine, in connection with tests on a contact counting device which records the number of contacts made between swinging open wires.

## PATENT

DURING THE PERIOD from September 7 to October 5, 1929, members of the Patent Department visited the following cities in connection with the prosecution of patents: Washington, W. C. Kiesel and E. C. Laughlin; St. John's, Newfoundland, B. H. Jackson.

From February 1 to September 1 of this year, patents were issued to the following members of the Laboratories staff:

E. W. Adams
L. M. Allen
H. B. Arnold
C. C. Barber
W. C. Beach
A. F. Bennett (2)
A. S. Bertels
H. S. Black
L. J. Bowne
E. Bruce
E. T. Burton
H. D. Cahill
W. L. Casper
H. C. Caverly
R. W. Chesnut
A. J. Christopher (2)
P. P. Cioffi
E. H. Clark
A. I. Crawford (2)
J. L. Crouch
G. C. Cummings
A. M. Curtis (2)
G. C. DeCoutouly (3)
J. W. Dehn
H. W. Dudley
G. W. Elmen (7)
F. S. Entz (2)
J. C. Field (2)
J. R. Fry
J. C. Gabriel (2)
J. J. Gilbert (2)
C. L. Goodrum
F. H. Graham
H. C. Harrison (2)
R. V. L. Hartley
R. A. Heising (8)
H. Hovland
H. E. Ives (3)
A. G. Jensen
R. L. Jones
W. C. Jones
R. P. Jutson
A. W. Kishpaugh
W. A. Knoop (2)
J. A. Krecek
M. E. Krom
A. G. Landeen
C. E Lane
V. E. Legg (2)
G. A. Locke
M. B. Long
H. H. Lowry (2)
H. W. MacDougall
W. A. Marrison
W. J. Means
L. E. Melhuish
V. F. Miller
F. Mohr
C. R. Moore
E. R. Morton
C. E. Nelson
E. L. Nelson
E. L. Norton
A. A. Oswald (2)
R. M. Pease
R. E. Peoples
H. Pfannenstiehl
J. G. Pfeiffer
W. A. Phelps
W. B. Prince
H. M. Pruden (2)
D. A. Quarles
R. L. Quass
H. T. Reeve
C. D. Richard
V. L. Ronci
R. M. Sample
J. C. Schelleng (2)
A. H. Shangle
O. A. Shann
H. O. Siegmund (3)
C. A. Sprague
L. J. Stacy
F. A. Stearn
E. J. Sterba
G. H. Stevenson
R. Stokely (2)
H. M. Stoller (3)
G. Thompson
W. V. Thompson
A. L. Thuras
G. M. Thurston
H. W. Ulrich (2)
E. Vroom (3)
R. L. Wegel (2)
C. L. Weis, Jr.
E. C. Wente (3)
C. H. Wheeler
J. H. White
H. Whittle
F. M. Wiese
R. R. Williams
S. B. Williams
I. G. Wilson (2)
J. R. Wilson

## INSPECTION ENGINEERING

A. F. GILSON attended the inaugural survey conferences held at the plants of the Automatic Electric Company in Chicago and the Highway Trailer Company in Edgerton, Wisconsin.

E. J. BONNESEN made an introductory trip to St. Louis preparatory to assuming the duties of Field Engineer in that area.

R. J. NOSSAMAN and J. H. SHEPARD were in Albany to conduct an investigation of step-by-step apparatus. While on this trip Mr. Shepard visited Rochester, Syracuse and Utica.

G. D. EDWARDS visited the Chicago plant of the Kellogg Switchboard and Supply Company during the first week in October where he discussed plans for the inauguration of inspection surveys with that company.

D. S. BENDER was in Providence where he visited the Outlook Association's Radio Broadcasting Station WJAR.

DURING THE latter part of August and the first three weeks in September, the members of the Field Engineering force were called upon to visit an unusually large number of cities in connection with routine investigation work.

T. L. Oliver visited Charlotte and Columbia, North Carolina; and Knoxville, Tennessee.

J. A. ST. CLAIR was in Los Angeles and San Diego, California.

W. E. WHITWORTH made a trip to Denver, Colorado.


D. S. BENDER visited Manchester, New Haven, and Stamford, Connecticut; Atlantic City and Trenton, New Jersey; and Boston, Lawrence, Springfield, and Worcester, Massachusetts.

A. M. ELLIOTT was in Albany, Syracuse, and Utica, New York.

G. GARBACZ visited Canton, Columbus, Cincinnati, Toledo, and Youngstown, Ohio.

C. A. JOHNSON was in Milwaukee, Wisconsin, and Champaign, Illinois.

R. C. KAMPHAUSEN visited Indianapolis and South Bend, Indiana, and Niles, Michigan.

H. W. NYLUND spent the week of September 15 in Kansas City, Kansas; Oklahoma City and Tulsa, Oklahoma; and Dallas, Texas.

I. W. WHITESIDE, during the same week was in Baltimore, Maryland; Richmond and Charleston, West Virginia; and Washington, D. C.

PERSONNEL

G. B. THOMAS addressed the members of the introductory course for technical men of the New Jersey Bell Telephone Company at Newark, on the Laboratories and its work.

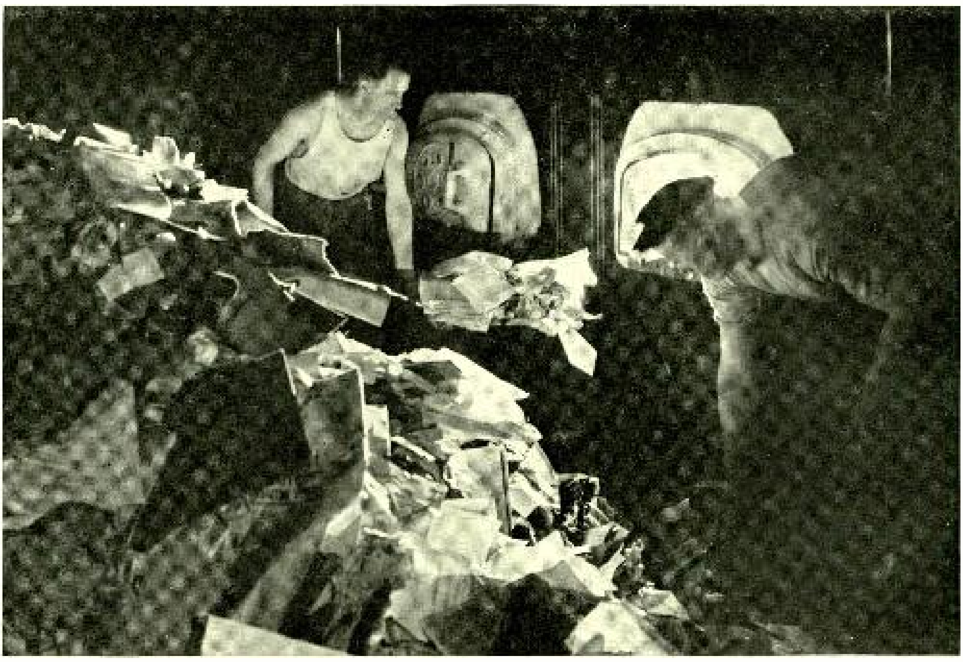
PUBLICATION

PAUL B. FINDLEY presented a demonstration of sound pictures at a meeting of Bell Telephone men at Pittsburgh.

W. C. F. Farnell visited Baltimore during the middle of September to advise the Chesapeake and Potomac Telephone Company regarding the operation of the model of their 1879 switchboard. This early switchboard together with a section of the modern multiple board was mounted on the company's float that participated in the historical pageant in celebration of the 200th anniversary of the founding of Baltimore. As shown in the accompanying illustration the float depicts the first fifty years of the telephone in Baltimore. The construction of the two model boards shown on the float was supervised by George K. Thompson of the American Telephone and Telegraph Company.

STAFF

PETER CASEY, a pipe-fitter in the Building Shop, died September 17, 1929, at the age of 34 years. Mr. Casey's service with the Laboratories dated from December 30, 1925.



*DEAD ASHES TELL NO TALES*

*Secrecy is the reason why we dispose of our waste paper by burning it in the furace. Waste paper, of course, has a salvage value; nevertheless the discarded blueprints, letters and specifications that daily find their way into the waste baskets may or may not contain secret information, so no chances are taken. The waste paper is gathered up several hours after the close of work, and the nightly accumulation forms a pile fully twice as high as that shown in the photograph.*

*In a sense, too, this pile made up largely from obsolete blueprints, old specifications and so forth, which have been supplanted by new, symbolizes the progress of the Laboratories' work, the sloughing off of the old and the taking on of the new. Pete Larkin and Jack Bane each morning shovel the paper into a furnace specially arranged to secure complete combustion of such materials.*

# Club Notes

AGAIN this year the Laboratories Club will hold a Christmas Poster Contest open to all members of the organization. Those desiring to participate should submit their posters to D. D. Haggerty not later than Monday, December 2. All posters should measure twelve by sixteen inches; be made up in not more than three colors; and carry space for a Christmas greeting to be inserted after the winning entry has been chosen.

The entries in the contest will be judged by a committee of commercial poster artists. As in past years, the successful poster will be reproduced and displayed on the company bulletin boards during the holiday season.

A prize of ten dollars in gold is offered for the winning design.

### Strikes, Spares and Splits

The Bowling League began its season September 27 at Dwyer's Manhattan Alleys, 1680 Broadway. This is the ninth season for the League and its fourth at the Manhattan Alleys.

Considerable difficulty is being experienced by Chairman Kendall and Secretary MacDougall in trying to accommodate all the men who wish to bowl regularly. One hundred and sixty men bowl in the four regular groups and twenty additional men are bowling on the four extra alleys reserved by the Club.

However, the thirty six alleys contracted for by the Club are not sufficient, and negotiations have just been completed for four alleys at the K. of C. Hotel, Eighth Avenue and Fifty-first Street.

Bill Trottere, who is the new chairman of the substitute committee, and C. E. Lane, who is assigning the new bowlers, should have no trouble in keeping the forty alleys full, as 307 men in all have signed up for bowling.

L. E. Parsons is chairman of the prize committee which has selected prizes for the coming season. Most of the prizes are different from those of past years. They will be on display in the Club trophy case in 2-D, outside the entrance to the restaurant.

Bowling is the most successful activity of the Club and no inducements are needed to bring the men out. The executive committee of the League, however, is working on a plan to provide prizes for the special bowlers, not members of the League groups A-B-C-D and consequently not eligible for regular group prizes. The additional prizes will be awarded on the basis of a plan to be announced later.

### On the Green

Eagles, birdies, and par golf were so common in the fall tournament held at the Salisbury Country Club on Saturday, September 28 that the members of the committee were dizzy before all of the cards had been turned in. Although the handicap committee made some drastic cuts after the June tournament, the high scores for the September tournament will doubtlessly make it necessary for the committee to go to work again and slash the handicaps of over one-third of the men competing.

It is quite evident that many of our players surpassed even the Pros in time spent in practicing on the links. Almost all of the prizes were won by men who have never before gotten into the charmed circle of prize winners — which should do much to encourage the golfers who have competed for a number of years and never won a prize.

In Class "A" the old guard of low handicap men came through as usual. E. H. Clark, H. W. Wood, and H. L. Downing were tied for low gross, each with 83. A. W. Lawrence won low net in this class, shooting a gross 88 and a net 69. F. F. Farnsworth had a net 70 and was tied for second and third low net prize with Wood, Clark and Downing. While they did not win prizes J. G. Roberts, C. H. Achenbach and O. Cesareo all broke 99. This is exceptionally fine golf for course No. 5 at Salisbury. The yardage for this course is 6700.

Class "B" men turned in some very fine scores. H. B. Briggs won the desk-clock first prize for low gross, his score of 89 establishing a new record for this class. H. N. Bick won his first prize with a gross 90 and net 64 and carried off the trophy for low net. J. W. Woodard beat Old Man Bogey with a net 65 winning the Wahl desk-set, the prize for second low net. B. B. Webb, who plays all his golf at Mount Tabor, had a gross 90 and net 66 winning the wallet. Webb admits this is better than his best score on his home course although Mount Tabor is 900 yards shorter than Salisbury. Possibly the Long Island air helps the Jersey golfers.

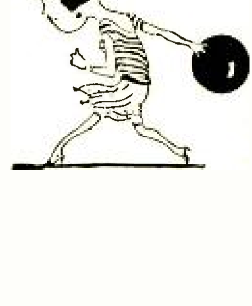
P. B. Fairlamb won low gross in Class "C" with a snappy 94. Fairlamb is another golfer who is coming along mighty fast and from all indications will keep the boys in Class "A" company next June. Bill Malone and W. A. Drake were tied for first and second net prizes, both having 67. Malone won the play-off, taking the trophy, and Drake won the desk-set. J. E. Greene and F. A. Hoyt both finished with 70 for third low net. Hoyt won the play-off for the prize.

The play-off for the ties in "A" Class was held at the Old Country Club in Flushing on Saturday, October 5. F. F. Farnsworth was obliged to leave October 2 for the west on company business and did not take part in the play-off. H. W. Wood repeated his score of September 28 completing the 18 holes at Flushing in 83. H. L. Downing's gross 87 and net 74 won second low net prize and E. H. Clark won third low net, with gross 89 and net 76.

Three indoor tournaments will be held during the coming season. The exact date and location of the first tournament held early in December will be posted on the Bulletin Board.

### Women's Bowling

When the smoke had cleared away on Friday, October 4, at Dwyers Bowling Alleys, it was found that Leona Feil had bowled over all opposition to the tune of 187 score — which is



the highest score ever recorded by our bowlerettes. Not far behind Miss Feil were Antoinette Kelly with 172 and Anna Cooper with 160. From this is is apparent that our "regulars" are improving rapidly.

For those girls who are desirous of learning how to bowl, two alleys have been engaged at the Hotel Shelton on Friday nights. These girls are under the able guidance of J. G. Dusheck. The girls who bowl at the Shelton are indeed fortunate because the pool is located just across the hall from the alleys — and what is more refreshing than a dip in the Shelton's spacious pool after bowling?

Marion Kane is the chairman of the substitute committee.

## Health Course

Beginning this year the Women's Health course is to be included in the Bell Laboratories Club's activities. The course has been scientifically planned under medical supervision and members of the Club especially trained will act as lecturers. The object of the course is to study the normal human body and how appropriate exercise and diet lead to health. It also includes instruction in simple first aid and care of the sick.

The keynote to Happiness is Health. Everybody wants to be happy, and it is easier to keep well than to get well.

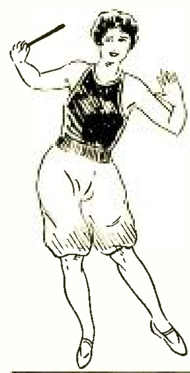
## Glee Club

With an enrollment of 130 men and women — an increase of 75 new members over last season — The Bell Laboratories Glee Club began its rehearsals on October 9 in the Women's Rest Room on the 11th floor. The interest shown in the Glee Club is very encouraging to those who have had its welfare at heart. No little credit should be given to our director, Mr. Vere S. Richards, who has been re-engaged to carry on the good work he started last season. Following the example set last season, our ultimate goal is a finished and praiseworthy performance at the combined concert and dance to be held during the Spring of 1930.

The Glee Club Committee comprises Miss Ada Van Riper and P. H. Betts, assisted by E. J. Fogarty.

## Tap Dancing Class

If you see a group of girls going through some queer antics — don't be alarmed. In all probability, they belong to the Tap Dancing Class which is being held under the direction of Billy Newsome in his studio at 45 West Fifty-seventh Street on Tuesday evenings from six to seven o'clock. Forty-three girls have enrolled for this interesting activity, among them being quite a few members from Hudson Street. The class started October 1 and will continue for ten weeks. During the course, Mr. Newsome will analyze all practical tap dancing steps — and this phase of the work alone should prove very interesting to those who have been mystified by the intricate tap dancing seen in the theatres. This is an ideal manner in which to combine healthful exercise with recreation — a combination which is very beneficial to the modern business girl.



Miss Marianne Grimm on extension 1153 will be glad to give further information.

### Mixed Bridge Party

In the quiet atmosphere of the conference room on the twelfth floor, the first mixed bridge party of the season was held on September 23, 1929. It was through the good offices of Mr. Glunt that the Club obtained the use of this room for the occasion. Sixty players were on hand when the first bid was made.

Miss M. A. Gauch won the first women's prize with a score of plus 1946, Miss M. E. Stein was runner-up with a plus 1583 score, and following her closely was J. G. Dusheck, who took the first men's prize with a score of plus 1470. Miss M. Murtagh tucked away the third women's prize; H. W. Bode won the second men's prize; C. L. Deelwater the third men's prize; Miss E. J. Pritzkow, the fourth women's prize; Miss F. Harold the fifth women's prize; R. V. Rice the fourth men's prize and R. A. Clark the fifth men's prize.

### Women's Tournament

When the leaves start turning red and by various other phenomena, we know that Fall is with us again, our fancies lightly turn to bridge. And what is more fitting for this time of the year than the bridge tournament for women, which started on September 29 and is to continue for ten weeks up to and including December 3. This tournament is progressing very nicely, and so far no casualties have been reported.

Miss M. Lynch on extension 1146 will give yon any information you may desire.

### Swimming

Judging from the large attendance at the Carroll Club on Mondays, Wednesdays and Thursdays, the women's swimming classes have apparently started with a big splash! One hundred and twelve girls have enrolled for the course and by all indications, the next swimming course will have to be enlarged to include four nights at the Carroll Club pool. By enrolling in one of these classes now, we are sure that next summer's waves will hold no terrors for our future Gertrude Ederles. Miss Catherine Tully on extension 218 has charge of this activity.

*The Bell Telephone Company-owned properties represent a capital investment of approximately sixty-five million dollars in land and two hundred and ninety-five millions dollars in buildings. This is probably the largest group of buildings belonging to any one organization in the United States. During* 1928, *one hundred and twenty-two new buildings and thirty-nine additions to buildings were erected. The program for* 1929 *includes two hundred new buildings and eighty major additions. There are roughly six thousand buildings in the Bell System, of which almost half are company owned.*

*—R. S. Coe, "Bell System Buildings"*

# Contributors to this Issue

A. R. SWOBODA graduated from the University of Nebraska with the degree of B.S. in 1903, and at once entered the Student Course of the Western Electric Company in Chicago. Later he was transferred to the West Street factory in New York where he specialized in power-plant design for central offices. He subsequently returned to the University of Nebraska as instructor in Electrical Engineering and in 1907 obtained his E.E.

Returning to the telephone field, he spent several years with the Kellogg Switchboard & Supply Company, working on the design of power equipment and telephone subsets. In 1911 he reentered the Western Electric organization, serving first in the Physical Laboratories and later with the development group on telegraph, transmission maintenance, public address, and apparatus development. His most recent work—covering the last four years—has been coil design.

F. A. COX has had a broad and varied career in the telephone industry, which began in the Switchboard Cabling Department in Clinton Street in 1897. He was one of the original members of the Engineering Inspection Department in 1901, and served in the Equipment Engineering group in New York from 1902 to 1905.

The next twelve years were devoted to foreign service; nine of them being spent as Equipment Engineer and Chief Engineer in Antwerp, and three as engineer in charge of the first Western Electric machine switching installation in Australia.

Mr. Cox returned to the Laboratories in 1919 and since that time has been developing the requirement and adjusting information and specifications for central office apparatus.

G. T. FORD, after receiving a B.S. degree in Electrical Engineering from the University of Tennessee in 1912, joined the Western Electric Company at Hawthorne. He spent one year in the student course there and then en-

*F. A. Cox*

*A. R. Swoboda*

*G. T. Ford*

tered the Engineering Department where he was engaged in the preparation of equipment specifications for telephone switchboards until 1919. At this time he was transferred to Bell Telephone Laboratories where he has been engaged in equipment development in the Systems group.

G. A. KELSALL graduated from Rose Polytechnic Institute in 1906 with the degree of B.S. in Electrical Engineering. The following three years he spent with the General Electric Company at Schenectady and with the Indiana Steel Company at Gary, and in 1909 went to Michigan State College as Instructor in Electrical Engineering. Since 1912 he has been with Bell Telephone Laboratories. For five years he worked on loading coils in the physical laboratory, during which time he developed the permeameter and permeameter furnace. From 1917 to the present time he has been with the Research Department employed in the investigation of magnetic materials.

R. W. HARPER's telephone career began as soon as he came to America from Scotland. After three years with the Plant Department of the Cincinnati and Suburban Bell Telephone Company, and seven years of wide field experience with the Installation Department of the Western Electric Company, he entered the Engineering Department of the Michigan Bell Telephone Company in 1917. During the World War he served in the Signal Corps, and at its conclusion he joined these Laboratories. His work here has been in circuit design, especially, for the past six years, that of private branch exchanges, on which he now supervises the work.

L. J. STACY received the A.B. degree from St. Lawrence University in 1909. After six years of school teaching, he entered the University of Chicago for two years of graduate study in physics and mathematics. In the radio division of the Signal Corps in 1918 he rose to a second lieutenancy, then returned to Chicago to receive the Ph.D. degree in 1919, and later that year entered the Systems Development Department of these Laboratories. He has been concerned with ringing and tone studies and other special technical problems in the local central office laboratory, and now supervises a group devoted to this work.


*G. A. Kelsall*


*R. W. Harper*


*L. J. Stacy*