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# The Perminvars, a Group of New Magnetic Alloys

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WHEN iron, nickel and cobalt are melted together in certain proportions, and the resultant alloys are suitably heat treated, their magnetic properties are unusual and fundamentally different from those of other magnetic substances. These unusual properties are found at low and medium magnetizations, but as the alloys approach saturation the magnetic properties gradually become similar to those of other substances.

Development of alloys with these properties resulted from the discovery in these Laboratories that cobalt affected one of the permalloys in an unusual manner. We were at that time investigating the magnetic properties of a series of permalloys in which a few per cent of a third metal was added to the nickel and iron. One of these alloys contained cobalt. Magnetic measurements indicated that up to moderate field strengths the permeability of this nickel-iron-cobalt alloy was constant to a remarkable degree. The constancy was materially better than for soft iron, notwithstanding the fact that the initial permeability was several times higher. This was unusual, as small permeability-variation ordinarily is found only in materials with low permeability. Measurements of other magnetic properties were equally surprising. When the hysteresis loop was traced for a cycle which carried the flux density up to a few thousand gauss, it was found to have an extraordinary form in that it was sharply constricted in the middle. These and other differences indicated that in this alloy we had discovered a distinctly new type of magnetic material.

This discovery aroused a great deal of interest for it was recognized that a magnetic material possessing these properties was of great scientific and technical importance. In order to develop the possibilities which this alloy suggested, an exploration of the whole field of the iron-nickel-cobalt

*A more detailed description of the alloys investigated and their magnetic properties will be found in the September issue of the* Journal of the Franklin Institute.

series was undertaken. It was, of course, apparent that the alloy which had aroused our interest must be one of a group of compositions which possessed similar properties in a greater or less degree.

In this survey alloys varying in ten per cent steps in composition and including the whole range of the ternary series of these metals were made up and their magnetic properties were tested. Approximately one-third of these alloys shared in such unusual magnetic properties. From this group a few were selected which appeared to be specially suited for magnetic uses in electrical communication circuits. An interesting example is the composition forty-five per cent nickel, twenty-five per cent cobalt and thirty per cent iron, which has in addition to the unusual magnetic properties a fairly high initial permeability.

Production of these alloys has as yet been in limited quantities. For the survey, alloys were cast in two-pound ingots and mechanically reduced into 0.125 inch x 0.006 inch tape by J. H. White. A considerable number of larger lots of some of the compositions have also been made by him. One of the compositions has also been made on a small commercial scale by the Hawthorne Works of the Western Electric Company. Our experience with these alloys has been that when good grades of commercial materials are used, the castings are readily reduced mechanically to the desired dimensions, and the magnetic properties from the different castings of the same compositions are quite uniform.

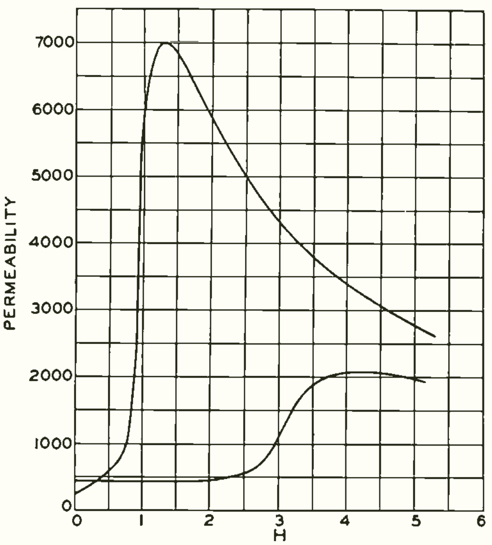


*Fig. 1—Permeability curves for Armco iron (above) and for one of the perminvars (below)*

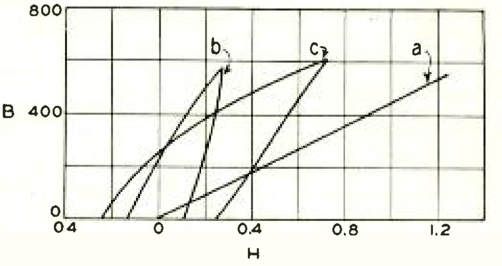


*Fig. 2—Upper halves of hysteresis loops: (a) perminvar, (b) silicon steel, (c) Armco iron*

We felt that these alloys were so unique as regards magnetic quality that they should be grouped in a class under a common name which should readily distinguish them from other materials. From the large number of suggestions "perminvar," a name proposed by V. E. Legg, was selected as the most suitable. This name is a combination of the first parts of "permeability" and "invariable," and therefore recalls one of the unusual characteristics of these alloys.

The perminvar properties are developed by heat treatment. The alloys are heated at 1000° C for a short time and then cooled. The rate of cooling from 600° C to 400° C determines the degree to which these properties are developed. The best results are obtained when the rate is such that it takes about five hours to cool through this temperature range. With faster cooling the perminvar properties are less marked, and they disappear altogether when the cooling is so rapid that it takes only a few seconds to cool through the critical range. Above 600° and below 400° any convenient rate may be used; but it must not be so rapid that strains are set up in the alloys.*

Measurements for the composition forty-five per cent nickel, twenty-five per cent cobalt and thirty per cent iron specially heat treated are plotted in the figures. The curves in Fig. 1 illustrate the permeability characteristics for this composition and in addition for a sample of annealed Armco iron. For magnetizing forces below 1.7 gauss, the permeability is substantially constant, the variation being less than one per cent. This constancy is remarkable for a magnetic material having an initial permeability approaching 500 and therefore nearly double that of iron. Within the same range of field strengths the permeability of the iron sample rises from an initial value of 250 through a maximum of 7,000 at a magnetizing force of 1.3 gauss and decreases to 6,000.

Another property of perminvar closely related to the constancy of permeability is the extremely small hysteresis loss in the range of magnetizing forces and flux densities in which the permeability is constant. This is illustrated in Fig. 2 where line *a* represents the plot of the upper half of the hysteresis loop for a maximum flux density of approximately 600 gauss. Curves *b* and *c* are similar plots for silicon steel and Armco iron. While the hysteresis loops for Armco iron and silicon steel have considerable areas amounting to thirty-three and fourteen ergs per cubic centimeter per cycle respectively, there is no measurable area for the perminvar alloy. Although the ballistic method of measurement, which was used in obtaining these curves,

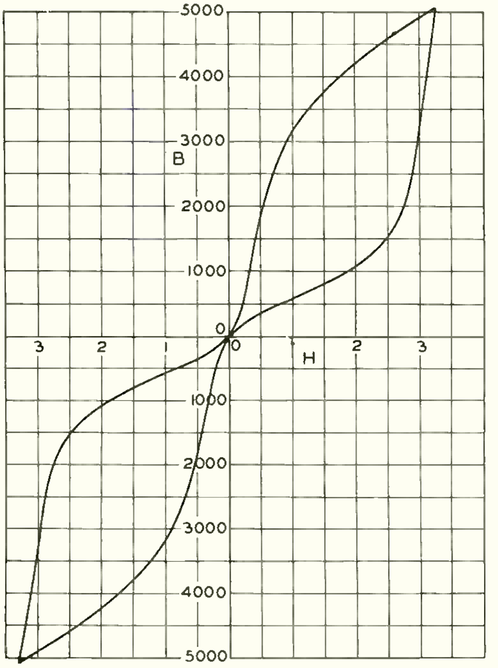


*Fig. 3—Complete hysteresis loop for one of the perminvars. Note its constriction at the zero point*

does not readily indicate very small losses, it is evident that the losses in the perminvar alloy are of a different order of magnitude from those of the other two materials. With more sensitive methods it was found that the hysteresis loss at a flux density of

* *Heat treatments and magnetic measurements in the development of these alloys were carried out by G. A. Kelsall and those associated with him in investigating magnetic materials.*

100 gauss was .024 x $10^{-3}$ ergs per cubic centimeter per cycle. In this regard, the best material previously known was permalloy, which under similar conditions had more than 1000 times this hysteresis loss.

These alloys are of special interest as magnetic core materials for apparatus used in the telephone plant where the magnetizing forces do not exceed the limits of constancy of permeability. The data apply to perminvar in the form of rolled sheet-metal; however the availability of the perminvar alloys in the form of highly compressed powder extends further than the probable field of application of these alloys.

Tests on experimental coils with perminvar cores have shown that some of the improvements in transmission quality predicted from the magnetic characteristics are realized. Among these improvements is a reduction in the "flutter" of transmitted speech caused by simultaneous telegraph operation. Modulation between currents of various frequencies in coils with perminvar cores is also greatly reduced as compared with coils having cores of other magnetic materials. Preliminary tests have indicated that perminvar alloys should be very efficient for continuous loading of telephone conductors. It would thus appear that perminvar may take its place beside permalloy as a magnetic material of fundamental importance in electrical communication.

## *To Build More Telephones*

*Stock with a par value of* $185,000,000 *was subscribed in* 265,000 *applications received during the recent offer by the American Telephone and Telegraph Company. This left unused less than half of one per cent of the rights offered the stockholders. It is interesting to compare this figure with that of the* 1926 *stock offering in which over one per cent of the rights were unused. Eighty-four per cent of the new stock was paid for outright on or prior to August first, the closing date for subscriptions.*

# Hunting Features in the Panel System

By E. L. ERWIN
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HUNTING is the process of running over a group of trunks or lines all of which go to the same office or equipment and choosing for use the first one that is not busy. It is the second of the two types of selective processes that underlie all methods of telephone switching. The other, distinctly different, is a sort of intellectual effort which selects a group of trunks with a single action. In the panel system the first type of selection is performed by the sender with a translator or decoder;* the second type is performed by various forms of hunting circuits.

In a manual exchange the two processes may be seen in their simplest form. Suppose, for instance, that a subscriber calls a large department store located in an area served by another central office. On receiving the number wanted the originating operator by an act of memory locates the group of trunks running to that particular office. This is the first type of selective process. For it the operator must know the position on the board in front of her of the trunks running to the office called. Having located the desired group of trunks she runs along them, testing each with the tip of her plug, till she finds one that is not busy and plugs into it. Busy trunks have their sleeves grounded, and as the tip of her plug touches the sleeve of each trunk a click occurs in her head-set if the trunk is busy. The absence of a click indicates that her plug is at an idle line and immediately she connects into it. This is the hunting feature. It is a continuous process, as the operator's hand moves from one trunk to another in order until she finds one that is not being used.

At the called office the two pro-

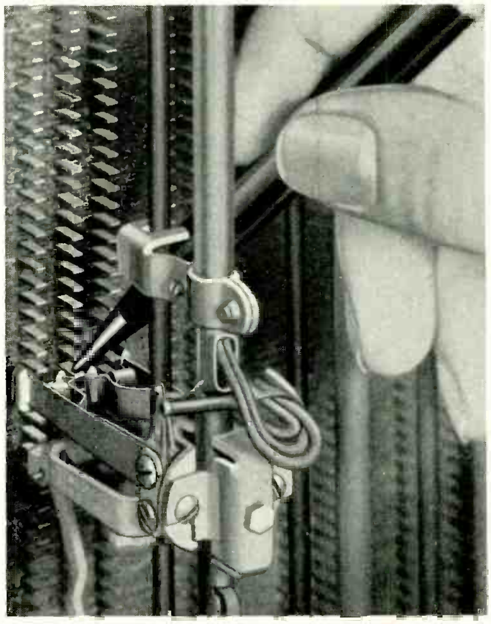


*Fig. 1—Hunting with panel-type selectors is done by the brushes shown which are moved up in contact with the lugs by a drive below the field of the camera.*

cesses are repeated. The second operator answers the call on her incoming trunk, receives the number from the first operator, and then, by

* BELL LABORATORIES RECORD, *Nov.*, 1926, *pp.* 77-81, *and May*, 1928, *pp.* 273-277.

memory, locates the group of lines running to the department store wanted. Following this she runs the tip of her plug over these lines till she finds the first idle one. This procedure is, again, the successive testing or hunting process.

Although finding an idle trunk or line is the most common use of the hunting feature it has been developed in the panel type of dial system also for the line-finders, used for finding and connecting to a line on which a call is coming in, and for the sender-selectors used to choose an idle sender. The sender apparatus is required for only a small fraction of the calling time and so, as the equipment is expensive, it has been found economical to provide but a small number of senders for a large number of lines. This requires a sender-selector to choose and connect to the first of the group of senders not in use as each call comes in.

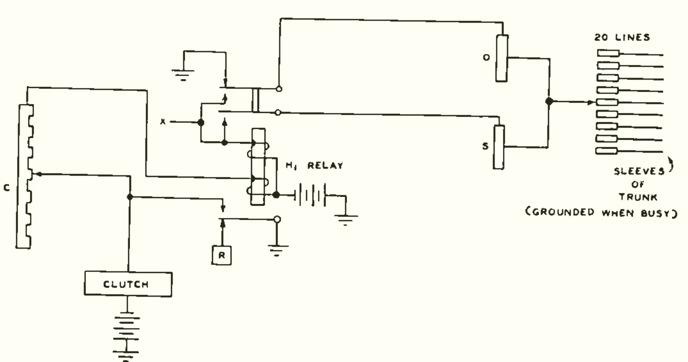



*Fig. 2—Trunk selectors use one of the simpler forms of hunting circuits requiring only one relay and three contacts.*

Hunting circuits and equipment vary somewhat with the class of work they perform but regardless of use there are always two things that they must accomplish. First, the hunting contact or brush, playing the part of the operator's plug carried from jack to jack by her hand, must have the power to move over a group of stationary contacts connected to the trunks or lines, as the case may be; and second, simulating the coordination between the operator's ear and her hand, it must be able to recognize an idle line and stop at it.

On panel-type selectors the multiple of the outgoing trunks terminates in small rectangular projections in the bank which may be seen in Figure 1. The movable brushes travel upward with all brushes in contact with the bank terminals. A clutch engaging with a continuously rotating cork roller at the bottom of the panel is the means of controlling the upward travel. In every case the upward motion is started by some action arising outside of the hunting circuits themselves. The action, however, generally uses one of the hunting relays, and the connection through which this starting is brought about is marked by an "x" on the diagrams.

The motion of the brushes of the selector is maintained, or stopped when an idle trunk is reached, by a contact on the hunting relay as may be seen through a study of the circuit diagram shown as Figure 2. The center row of terminals of the outgoing trunks is shown at the right of this diagram and the arrow on the connection coming up to them from the left indicates the moving brush. The upward motion is started by a connection of ground to "x," which operates the hunting relay ($H_1$) and energizes the clutch through the bottom contact. The hunting relay is held closed by a current flowing, through the two upper contacts in parallel, to the brushes and outgoing trunks which are grounded when they are in use. As long as the brush is in contact with a grounded terminal, therefore, it continues upward, but when an idle, or ungrounded, terminal is reached the hunting relay releases, and by so doing releases the clutch, and puts a "busy" ground on the trunk through the normal connection of the top contact.

Two features in addition to the two fundamental ones already mentioned are often included in hunting circuits: a centering device and the overflow terminal. To insure proper contact of all brushes with their corresponding lugs of the outgoing trunk it is necessary that the brushes be in line with about the center of the lugs. To accomplish this the rod that carries the brushes up along the bank terminals is equipped with the equivalent of a ratchet, and a small pawl drops into place to prevent it from falling back for each centered position of the brushes. If the hunting relay released very quickly, however, the brush might not be quite up to the centered position, so that the pawl would not be in the holding position and the brush would drop back one terminal and land on a busy line. The centering commutator (C), however, insures that the motor continues till the brush is centered on the lug. This commutator has a series of conducting and insulating segments (indicated on the diagram by depressions) and the whole is so mounted that the insulated segment breaks the contact at the proper time to center the brush on the lug. When the commutator

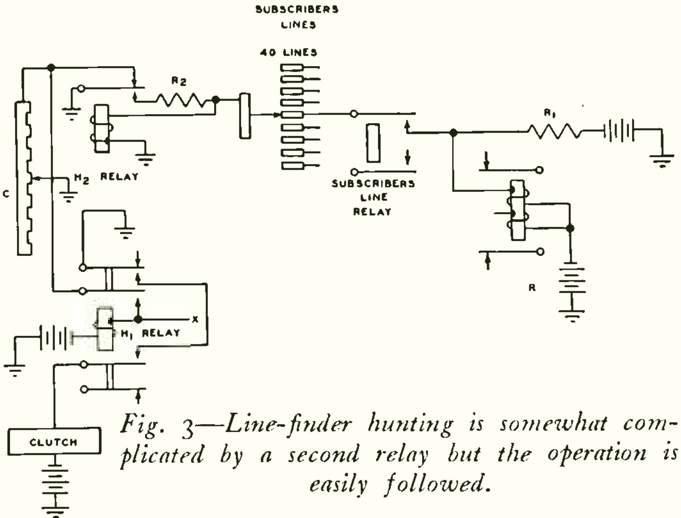



*Fig. 3—Line-finder hunting is somewhat complicated by a second relay but the operation is easily followed.*

brush is on a conducting segment it will be noticed that the hunting relay will be held operated even though the brush spring is on an idle trunk. After an idle trunk is found, therefore, the up motion continues till an insulating segment on the centering commutator is opposite its brush and this insures the centering of all the brush springs on their corresponding bank terminals.

The overflow-terminal feature provides against the possibility of an elevator hunting by the top of a group in which all the trunks are busy. The top lug of the group is not a trunk but merely an ungrounded, blank connection. When this lug is reached the hunting relay releases, and to prevent the top blank lug from being grounded an insulated segment is placed on the overflow commutator (O) in a position corresponding to the overflow terminal. When this top lug is reached, therefore, the hunting relay releases, thereby stopping the motion of the brush, and the top terminal is kept ungrounded by the insulating segment on the overflow commutator so that other brushes arriving at this top level may likewise be stopped.

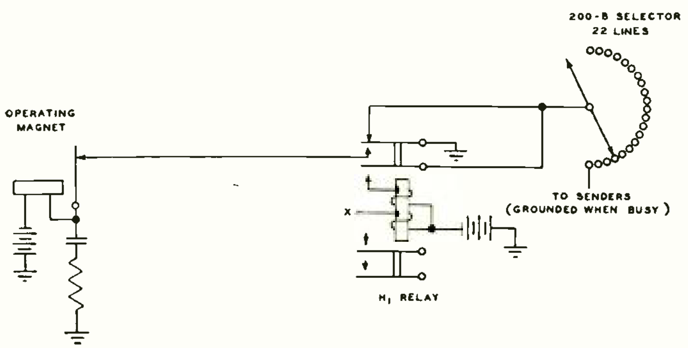



*Fig. 4—Sender-selectors in their first forms attained a maximum of simplicity.*

In the hunting circuit for the panel-type line-finders, Figure 3, similar fundamental features may be found although many of the details are different. Here the brushes run over a group of idle lines till the one is reached that is placing a call, and then connection is made to that one. This calling line has battery through a resistance connected to the hunting terminal in the bank. Two relays are used; one ($H_1$) is brought in to start the hunting motion and is held operated by a back contact on the other, or hunting relay, which is brought in by the battery on the calling line. A centering commutator is used here also and holds $H_1$ operated till the brush is properly centered.

For the sender-selectors different types of hunting circuits and switches have been used. The circuit shown as Figure 4 uses a rotary switch of the 200 type which is moved around step by step from one contact to another by a magnet shown at the left. The circuit arrangement is similar to that of the trunk selector. The hunting relay is brought in by a ground connection on the "x" lead and, on closing, operates the magnet through one contact and through another holds itself closed by the ground on busy sender-circuits. When an idle sender is reached the relay releases and grounds the hunt lead through a back contact to hold it busy. No centering device is necessary as the operating magnet moves the brushes just one full step each time. Also no overflow provision is required as, after passing over the semi-circle of twenty-two contacts,

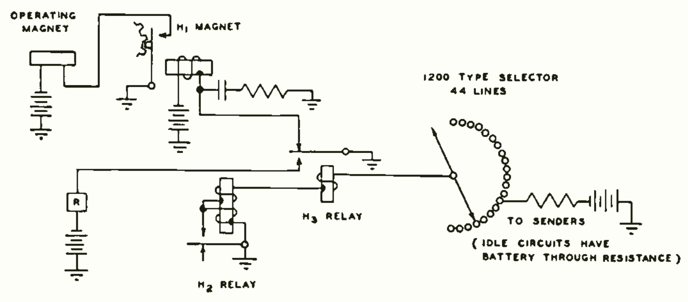



*Fig. 5—The* 1200 *type sender-selector was complicated by the addition of a double test and requires in all two relays and two magnets but the circuit is readily traced.*

the switch completes the circle and continues until an idle sender is found.

An improvement on this circuit is shown in Figure 5. Here also a rotary switch is used but it is of the 1200 type and the rotation is continuous instead of step-by-step. A close-up view of this switch showing the contacts, which are similar to those of the 200 switch, is given in the accompanying illustration. A centering device is incorporated in the magnet $H_1$. When an idle sender is found and the $H_3$ relay operates, the connection to $H_1$ is broken. The contact controlling the driving disk can not open, however, unless the lug on the back of it is opposite one of the depressions in the notched rim which rotates with the switch. The lug and notches line up when the brushes are centered on the bank terminals. This circuit also requires no overflow provision as the selector continues to rotate till an idle sender is found.

With the No. 200 type sender-selector arrangement, two selectors testing the same terminal at the same time would permit two calls to be connected to one sender. These double connections would occur most frequently during the busy hour, and would consequently interfere with service when it is most needed. This lack of protection against double connections led to the development of the rotary link with its double-test hunting scheme. With this when the brush first locates an idle sender sufficient current flows to operate $H_2$. As this operates it changes the circuit conditions by shorting out one of its own windings. With this change sufficient current would flow to operate $H_3$ and stop the turning motion, if in the meantime another selector had not landed on the same terminal and also operated its $H_3$ relay. In such a case neither selector would complete its operation but would continue to hunt, so that the chance of a double connection would be eliminated.

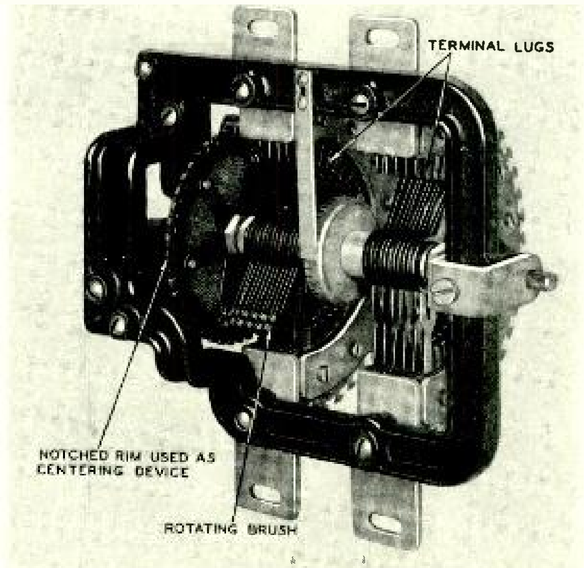



*Fig.* 6—*A close-up view of the* 1200 *type selector showing the brushes, contact lugs, and the notched rim used for centering.*

The latest type sender-selector is of the panel-link type. Like other panel-type hunting circuits it uses a centering device and the circuit is similar to that of the 1200 type, but with a superior type of double test.

In this circuit $H_3$ is operated to start the hunting travel and in turn operates $H_1$ which holds $H_3$ operated and energizes the drive magnet. There is a circuit through two coils

(A and B) of $H_2$ but as they are in opposition nothing results. When an idle sender is found, however, current flows through coil "B" and a third coil (C). These overpower "A" and cause $H_2$ to operate and close its contacts. This changes the circuit conditions by drawing a greater current through the opposing coil "A" and also draws a heavier current through "C" which is of low resistance. The closing of $H_2$ releases $H_1$ and would as a consequence release $H_3$ and complete the connection

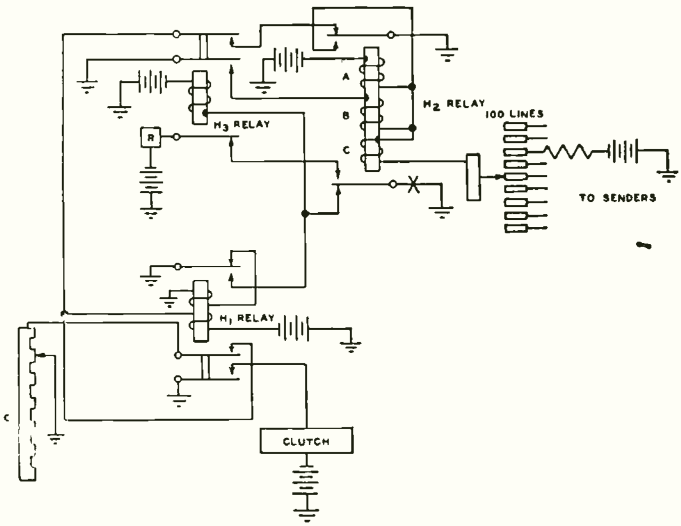



*Fig. 7—A panel-link selector uses a more complicated circuit but the advantages gained are well worth while.*

were $H_3$ not made slow releasing. With the changed condition in the circuit holding $H_2$ operated it would release again if another selector had in the meantime made contact on the multiple to this same sender and operated its $H_2$ relay also. If no other selector has made contact, or if one makes contact but its $H_2$ remains unoperated, $H_3$ releases after a few hundredths of a second and completes the circuit.

Hunting circuits for panel-type private branch exchanges are somewhat similar to the line-finder circuits and contain no features that cannot be understood from the preceding discussion. A centering commutator is used but no double test is felt necessary. A second test of the line similar to that of trunk hunting is made, however, after the sequence switch is advanced.

This summary of the hunting feature in the panel system gives a glimpse of typical panel circuits and mechanisms and shows how steps performed by operators in the manual system are here accomplished by relays and other electrical equipment connected in suitable circuits. The hunting feature itself is, of course, only a small part of the process of completing a call. It is set in action by other equipment making suitable connections to a point of the hunting circuit and when the desired line or trunk is found a third set of relays and circuits operates, the initial step often being through apparatus marked "R" in the circuits shown.

In all hunting circuits the operator's hand holding a plug should be visualized, rapidly passing over a row of jacks, touching each with the tip of the plug, and finally connecting to the first idle line. The circuits and relays indicated on the sketches are only substitutes for the motor nerves, ears, and intellect of the operator,

# Cable Terminals

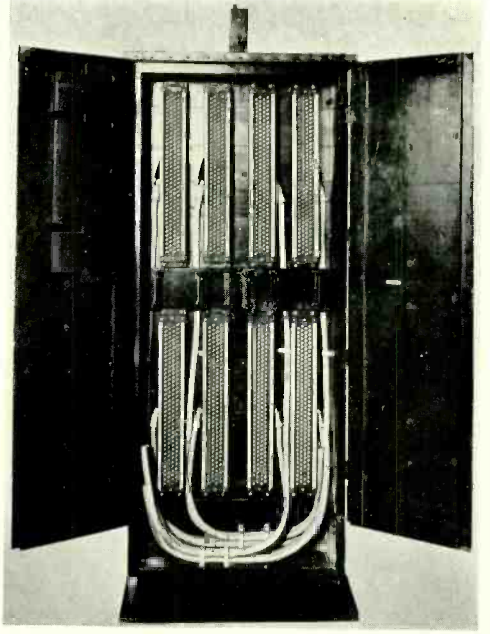
By A. W. DRING
*Apparatus Development Department*

TO join two or more aerial cables, the BB terminal is used where it is desired to have access to the conductors for testing and cross-connecting, and where fuse protection is not required. The BB terminal includes an outer wooden box, made of tongue-and-grooved lumber and thoroughly painted for protection against the weather, which may be fastened to the telephone pole. Within it are mounted "sealing chambers" of the binding-post type. The sealing chambers are long, narrow boxes of cast-iron with the cable entrance on one side. The panels which carry the binding post connections for the cable conductors are of hard rubber and cover the front of the chambers. Two fanning strips of hard wood are fastened the full length of each panel to faciliate the running of cross-connecting wires.

The boxes have single doors up to the 101 pair size and double doors for the larger sizes, up to 404 pairs. Space is provided at the bottom for splicing the stubs from the sealing chambers to the incoming cables.

The B cable terminal — a type which is now practically obsolete — is similar to the BB except that half of its sealing chamber capacity is designed for the attachment of fuses. This terminal was designed to form the junction between aerial and underground cable, the purpose of the fuses being to protect the central-office equipment in case the aerial section should accidentally come in contact with some electric light or power circuit. The B type terminal has been made in the same sizes as the BB.

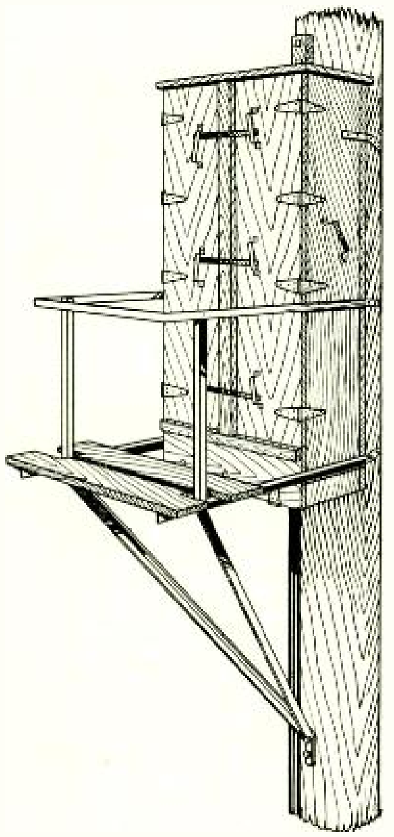
Where cables are to be connected to open wires, of considerable length however, some form of protection against lightning is required. This takes the form of protector blocks,



*BB type terminal for 303-pair cables*

the carbon faces of which are spaced a few thousandths of an inch apart. One block is grounded and the other is connected to the open-wire line.

The EA and EU terminals fill this need. They include boxes similar to the B type except that they are equipped with an inner and outer door to give better protection from the weather. They are now made only

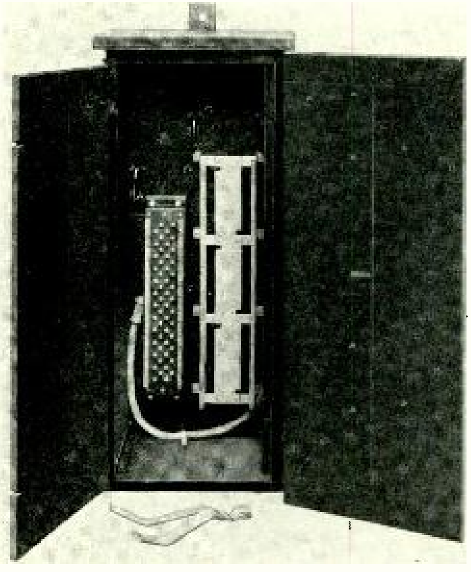


*Sketch showing a balcony used with either B or BB type terminal*

in twenty-six pair size. The difference between the EA and EU is the type of protection they afford. The former, which is the one illustrated in the accompanying photograph, has a binding-post chamber on the left side and on the right a supporting framework for mounting the open-space cut-outs. The latter differs from the EA only in that a fuse chamber replaces the binding-post chamber. The open-wire lines are connected to the protectors and the cable is spliced to the stub from the binding-post or fuse chamber.

To facilitate the making of connections at the B, BB, EA and EU terminals, a platform with guard rail is provided on which the workman can either sit or stand. These balconies, as they are called, are made in two sizes to fit the different terminals.

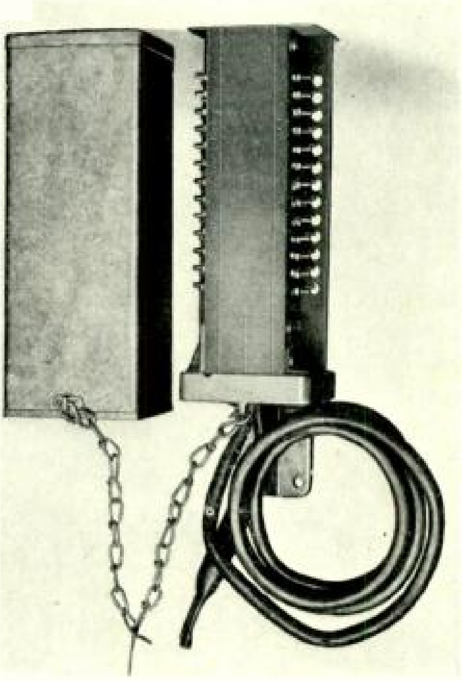
One of the recently developed terminals (the "C" type) takes advantage of many years experience and was designed to replace the old No. 8 and supplement the 14 type, described in the RECORD of last month. It follows very closely the style of the No. 8 but the supporting bracket and enclosing cover are rectangular instead of round. Also the entire sealing chamber is above and rests on the supporting bracket which gives the wooden parts better protection against weather. The wooden face panels are given a new finish that in-



*EA terminal, with the protector mounting on the right* sures a better insulation resistance. The drop wires enter at the bottom as with the No. 8 and pass through the supporting bracket between the fanning strip and the pole. Only three sizes, 10, 16 and 26 pair, are furnished as the class of service for which they are used seldom requires larger terminals.

Throughout this diverse line of cable terminals may be observed the same fundamental parts necessary for any terminals, which in one form or another have existed from the first. There is first a sealing chamber into which the end of the cable is run; second, some form of connector passing through the wall of the sealing chamber to which the ends of the cable conductors are fastened inside the chamber, and the outgoing wires on the outside; and third, the optional feature of electrical protection in the form required under the conditions. These three things are the fundamental elements of cable terminals and in their variety of treatment make the several different types.

Another important class, known as building terminals, is used inside buildings. These are made by outside suppliers under specifications prepared by the Laboratories. The terminals described in this article and



*A 26-pair type C terminal, showing modifications from the older No. 8 type*

in a preceding article by A. F. Gilson* are all for outdoor use and are of Western Electric manufacture.

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* BELL LABORATORIES RECORD, *July*, 1928, *pp.* 366-370.

# The Grid-Current Modulator

By CLYDE R. KEITH
*Research Department*

CARRIER current communication* requires that the voice frequency currents from an ordinary telephone be changed to higher frequencies for transmission and then back to voice frequencies at the receiving terminal. Frequency bands above the voice range are used in order that the carrier frequencies may not overlap either the normal voice transmission range or other carrier frequency bands. It is then possible to transmit simultaneously several groups of high-frequency currents over a pair of wires without interfering with each other, and to separate the different groups at the receiving terminal.

To take a numerical example, if two currents of 1,000 and 10,000 cycles respectively are passed through a modulating device, many new frequencies will be produced, prominent among which are the first "sum" and "difference" frequencies, 11,000 and 9,000, respectively. Modulators as a class come in the category of circuit elements that do not obey Ohm's law. In ordinary metallic conductors, the current is proportional to the voltage, but in vacuum tubes, iron-core coils, certain crystals, and various forms of rectifiers, the relation does not hold. Figure 1 gives some examples of current-voltage curves which can be used for modulation.

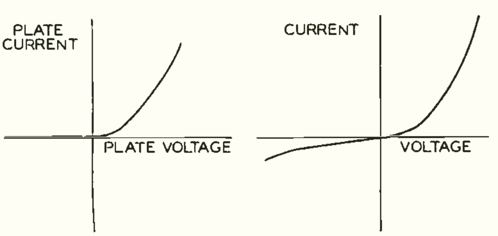



*Fig. 1—Characteristic curves: left, that of the plate circuit of a vacuum tube; right, that of a rectifying crystal*

One of the most usual modulators uses the non-linear relation between plate voltage and plate current in a three-electrode vacuum tube and is consequently called a plate-circuit modulator. Although the signal or carrier or both may be applied to the grid, modulation is made to take place primarily in the plate circuit by operating the tube so that the voltage induced in the plate circuit is substantially proportional to the applied voltage. This condition holds rather closely until the grid becomes positive with respect to the filament.

However, if the grid is allowed to become positive with respect to the filament, it is also possible to produce modulation by means of the non-linear relation between grid current and grid voltage. This method is therefore called grid-current modulation since it takes place only when conductive* grid current flows during

* *Multiplex Transmission by Carrier Currents, J. W. Horton,* BELL LABORATORIES RECORD, *Vol. 1, p. 147, December, 1925.*

* *This explanation neglects the current through the capacity between grid and filament since its effect is comparatively small at voice and carrier frequencies.*

at least a part of each cycle of input voltage. Since grid current can flow only when the grid is positive, as shown in Fig. 2, the relation between current and voltage is evidently non-linear for positive and negative voltages. Consequently, when carrier and signal voltages are applied, modulation between the two produces currents of sideband frequencies in the grid circuit. Voltages due to these currents are then amplified by the plate circuit and all other frequencies are suppressed by high impedances in the plate circuit. This allows all the power available in the plate circuit to go into sideband output, since none is used by the flow of carrier and signal currents as is the case with the plate-circuit modulator.

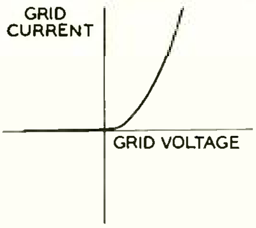


*Fig. 2—Relation between grid current and grid-filament voltage*

Our recent laboratory investigations have demonstrated that for certain applications, grid-current modulators have some important advantages.* They are particularly suited for use in circuits where high modulating efficiency and high output level are desired. When laboratory models of representative modulators are compared, it is found that (using the same tubes and plate voltages) the grid-current modulator gives a maximum power output eight times as high and a maximum plate power efficiency five times as high as the plate modulator. While this increased output requires sixty per cent higher plate current, a proportionately high output level may be obtained with a grid-current modulator when it uses the same plate current as the plate-circuit type. The carrier input current, although about twice that required for the plate modulator, can still be obtained from a single oscillator tube of the same type.

The operation of a grid current modulator may be most easily understood by referring to the circuit of Fig. 3 which represents the general form. It consists of sources of signal and carrier voltages in series with an external impedance and the grid-filament circuit of the tube. In series with the plate-filament circuit are simply a current-measuring instrument and an output impedance. Since the new frequencies which result from modulation are obviously not produced in the input generator or in the external impedance, they must be considered as having their origin in the variable impedance of the grid-filament portion of the circuit. Therefore the grid-filament path may be considered as a generator of "sideband" frequencies and of other modulation products.

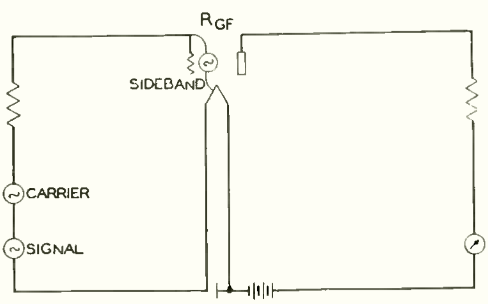


*Fig. 3—General form of a modulator circuit*

This generator has like all generators an internal resistance, sym-

* *Grid Current Modulation, E. Peterson and C. R. Keith,* Bell System Technical Journal, *January,* 1928.

bolized in Fig. 3 by $R_{GF}$, and, as is the case with ordinary generators, the terminal voltage — between grid and filament — is equal to the generated voltage minus the drop caused by the current through the internal resistance. The voltage drop in the generator is small when the external impedance is high so that little current flows. Consequently the grid-filament voltage at sideband frequencies is a maximum when the external impedance at these frequencies is large compared to the internal impedance. This is accomplished in practice by means of tuned circuits, retard coils, or filters, depending on the frequency of the sideband.

Since the sideband components generated within the grid-filament impedance of the tube result from the carrier and signal voltages impressed on this impedance, the sideband voltage will also be a maximum when the power inputs at these frequencies are a maximum. This may be calculated by the usual formulae for obtaining the maximum power from a source of current having a fixed impedance and voltage, and is found to occur when the external and internal impedances are properly "matched." Therefore the external impedance of the signal and carrier sources should be equal to the grid-filament impedance at these frequencies. These impedance relations for maximum sideband voltage on the grid are summarized in the adjoining table.

In this connection the question may be raised as to how one can assign a definite value to the grid-filament impedance when it varies throughout the cycle. By definition the impedance of a circuit element at a certain frequency is the quotient of voltage by current, both being at the stated frequency. Consequently in the steady state, with a fixed voltage of a particular frequency impressed, there must be a definite current component of this frequency which determines the impedance. The grid-filament impedance has been measured in actual circuits by means of a special bridge which does not affect the flow of current components other than the one at the frequency of the measurement. When using 101-D tubes under the usual operating conditions, the grid impedance at carrier frequencies amounts to a resistance of about 75,000 ohms.

Having obtained the maximum

*Optimum Relation of External to Internal Impedances*

| Type of Modulation | Frequency | Impedances in Grid Circuit | Impedances in Plate Circuit |
|---|---|---|---|
| Grid Current | Signal | Match | External high compared with internal |
| | Carrier | Match | External high compared with internal |
| | Sideband | External high compared with internal | Match |
| Plate Current | Signal | Match | External low compared with internal |
| | Carrier | Match | External low compared with internal |
| | Sideband | External low compared with internal | Match |

sideband voltage on the grid, it remains only to determine the impedance relations in the plate circuit for maximum power output at sideband frequencies. There are at the same time various other voltages on the grid which will produce currents of corresponding frequencies in the plate circuit depending on the external output impedances to these frequencies. If carrier and signal currents are allowed to flow in the plate circuit, they will modulate each other and so produce voltages of sideband frequencies which will combine with the voltages of the same frequencies produced by grid-current modulation. But it can be shown that the sideband voltages from these two sources are in opposite directions, so that their sum is less than the larger one alone. Therefore, since the sideband voltage induced in the plate circuit by grid current modulation is the larger, the maximum sideband output power is obtained when both carrier and signal currents in the plate-circuit are reduced to a minimum. This is accomplished by making the external output impedance high compared to the plate impedance at carrier and signal frequencies. However, the plate circuit should act as an amplifier to the sideband voltage developed on the grid by grid current modulation. Consequently the sideband power output is a maximum when the external output impedance matches the plate impedance at sideband frequencies. These optimum plate impedance conditions for a grid current modulator are obtained by means of transformers and filters, or, if the frequency separation is great enough, by tuned circuits.

In some cases it may be desirable to utilize plate-circuit modulation rather than grid-current modulation.

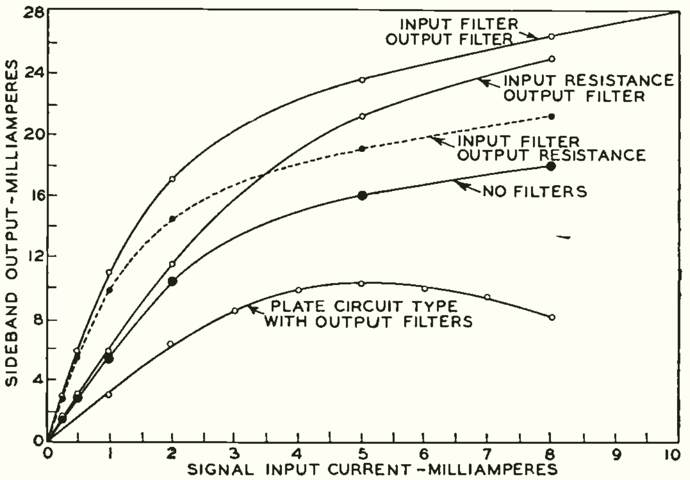
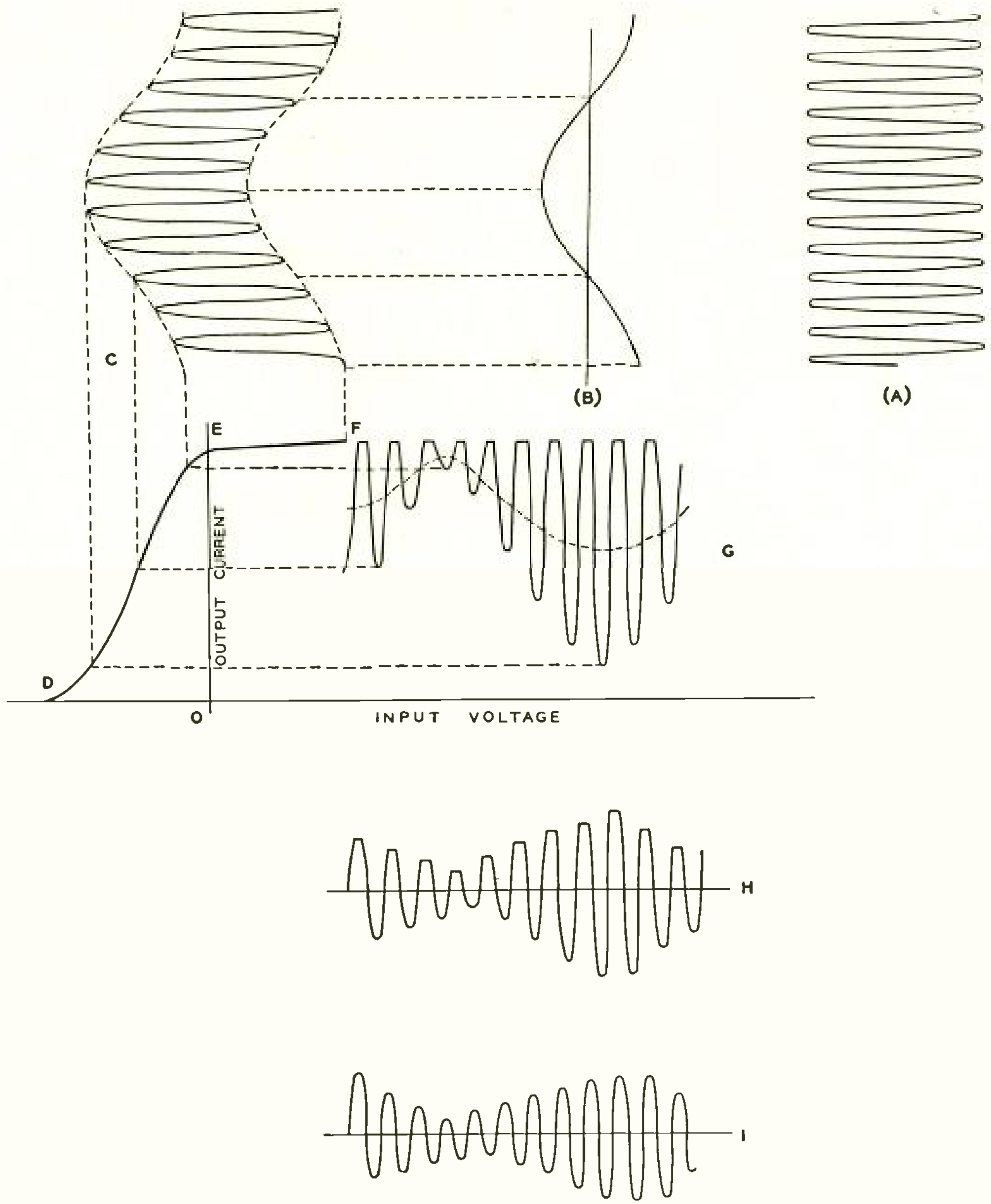



*Fig. 4—Sideband output of a balanced grid-current modulator using* 101-*D tubes*

The optimum impedance conditions may then be determined by the same line of reasoning as used above except that in this case grid modulation is made a minimum and plate modulation a maximum. These impedance conditions for the maximum plate modulation are listed for comparison in the table.

In both plate and grid circuits the optimum impedance conditions for maximum sideband output can often be met more easily with a balanced circuit than with a single tube. The general impedance relations are still the same as listed in the table but since part of the currents are balanced from both input and output circuits, the impedances to these frequencies

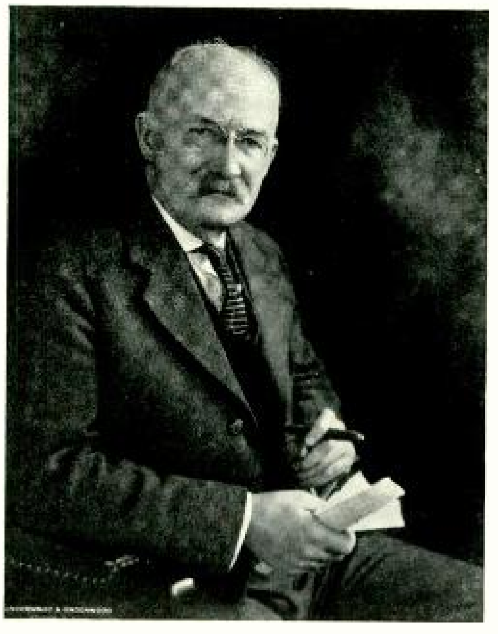



*A graphic portrayal of how grid-current modulation takes place. A and B are carrier and signal currents, respectively, and C is the current which results from their flow through the ordinary "linear" conduction of the input circuit. DEF is the characteristic "non-linear" curve of a grid-current modulator. When the wave C is applied to this conductor its form is changed to that of G by the planing off of half of each wave. Since the mid-point of the new wave is itself a sine-wave, as shown by the dotted line in G, there remains in the new wave a component of the same frequency as the signal. Removing this component by means of a filter leaves the wave H. Sharp corners in this wave indicate that it contains components of still higher frequencies than the carrier (A). When these are removed, we have I, a modulated wave* may be provided by separate impedance units. Since the grid-current modulator was developed primarily with a view to its possible application to carrier telephone circuits, experimental work has been confined for the most part to balanced circuits in which the carrier is suppressed. Such a circuit is capable of giving an output of half a watt of single sideband when using 101-D tubes at 120 volts plate potential. Typical curves of single-sideband output are given in Fig. 4 showing how the output may be increased by using the proper filters in input and output circuits. The maximum plate power efficiency is then about fifteen per cent, as compared to about three per cent for a typical plate-circuit modulator. Listening tests have shown that these modulators will give about 10 TU greater sideband output than a typical plate-circuit modulator using the same tubes and plate battery with approximately the same distortion.

In the preceding discussion of the effect of external impedances on the output of a grid current modulator, no consideration was given to any frequencies other than signal, carrier, and sideband. However, the impedance to direct current has a considerable effect in the grid circuit. Since current can flow in only one direction through the grid-filament path, the voltage produced when it flows through an external resistance is unidirectional. This voltage creates a negative bias on the grid, which may become so high that the grid is positive with respect to the filament during only a very small portion of a cycle. It is during this portion of the cycle that modulation occurs, and so there results a considerable decrease in the output power available for large input voltages. Thus the external grid impedance should always be as low as possible to direct current.

The familiar grid-leak-and-condenser detector so universally used in radio receiving sets operates so far as the grid circuit is concerned very nearly in accordance with the above principles. In this case the external grid impedance consists of a resistance shunted by a condenser, giving a high impedance to voice frequencies but allowing the carrier and sideband input circuits to approximately match the grid in impedance. The grid leak also has a high resistance to direct current, which limits the maximum signal output just as has been explained in the previous paragraph. However, the external plate impedance is usually low compared to the plate resistance, instead of high compared to it, as shown in the table for optimum impedance conditions. This is due to other effects at the high frequencies and low amplitudes for which it is ordinarily used.

Tests made with carrier-frequency input to a detector tube have shown that a considerable increase in maximum output has been secured by replacing the grid leak with an inductance coil having a compartively low resistance to direct current. Under these conditions the fixed grid potential should be adjusted by a potentiometer to about that of the center point of the filament. Although this adjustment may vary to some extent with different tubes, it is not critical for large input voltages. The increased load-carrying capacity may be judged from the fact that with sufficient carrier frequency input an ordinary cone-type loud speaker may be operated from a balanced grid-current detector using two 101-D tubes.



## *Harry Bates Thayer*

*After nearly a half century of continuous service in the Bell System, Harry B. Thayer, Chairman of the American Telephone and Telegraph Company, has retired.*

*Entering the Western Electric Company in* 1881, *Mr. Thayer became a Vice-President in* 1902 *and President in* 1908. *He was instrumental in the erection of our building at* 463 *West Street and had his office here for many years; the Engineering Department, which later became Bell Telephone Laboratories, was one unit of the organization which he headed. In* 1919 *Mr. Thayer became president of the American Telephone and Telegraph Company. When he resigned that office over three years ago to become Chairman it was with the idea, now accomplished, of gradually relinquishing his responsibilities to the Bell System interests he had served so faithfully and long.*

# Insuring Central-Office Power Supply

By C. W. VAN DUYNE
*Systems Development Department*

FOR simplicity and reliability it would be difficult to better the power equipment used with the very first telephones installed. No battery or generator was required. The lungs and vocal cords of the persons conversing furnished all the power used for talking and pencil taps on the receiver diaphragm supplied the only power used for calling. No question of a reserve power supply could arise, for if the talker was there the power was too, as they, talker and power supply, were one and the same.

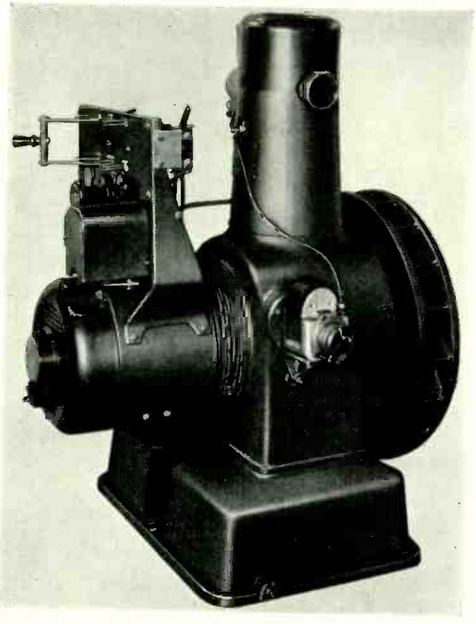
This primitive simplicity of power supply existed, however, for only a very short time; the carbon transmitter—so desirable for all lines except the very shortest—brought a need for direct current. As sources of power, various types of primary electric cells were first used. Then came the common-battery system with its storage battery, and dependence on central station electric power for recharging.

The storage battery for small offices is engineered to have a reserve capacity large enough for a day's service where suitable engine reserve is used. In the event of a failure of central station power of more than a day, reliance is placed on internal-combustion engines, permanently installed for the larger offices, and mounted on wheels for transportation to smaller offices as required. At different times and places various forms of internal combustion engines have been employed. Some used kerosene as fuel, others illuminating gas, and others, gasoline.

As time went by, it became evident that the benefits and economies usually realized from any standardization program were available in this field also. Accordingly it seemed desirable to survey completely the entire field of stand-by power units for central offices, and to standardize on a definite and small but adequate range of sizes to cover all demands at a minimum of overall costs and charges.

The entire range of sizes has been divided into three groups: the first covers only the smaller offices such as the Number 9; the second includes all the intermediate and large offices; and the third covers only those offices in very large cities where several central offices may be located in a single building. The developments finally selected to fill the intermediate group have already been described in the RECORD and the apparatus for the largest size offices will be discussed at a later date.

For the smaller offices three sizes of farm-lighting generator sets manufactured by the Westinghouse Electric and Manufacturing Company have been adopted. These have a single-cylinder, vertical, kerosene engine connected to a direct-current generator, and are manufactured in quantity production at low cost. A nation-wide service organization is available to facilitate the obtaining of replacement parts. The engine is of the four-cycle air-cooled type with



*Generator end of a Westinghouse set. The flywheel, in the back, acts as a fan for cooling the engine.*

high-tension magneto ignition and splash lubrication. The same engine is used for all three sizes but the generators are of different current and voltage ratings to suit the different types and sizes of batteries used. The smallest in current rating is 10 amperes at from 120 to 160 volts; the next is rated 25 amperes at from 22 to 65 volts; and the largest 45 amperes at from 22 to 33 volts. For the most part the standard Westinghouse set is used, but some special features have been added, as described below, to adapt the sets better to telephone applications and to increase the safety of operation.

The engines are equipped with governors which function to maintain the speed practically constant under variable load conditions. If the governor should become deranged, however, the characteristics of the engine are such that the speed might become dangerously high under light load conditions. To prevent this, a simple centrifugal overspeed trip has been developed. If the speed of the set reaches about 100 revolutions above the normal operating range due to governor failure, the centrifugal device functions to ground the ignition and stop the engine.

A crank case breather has also been developed for the engines furnished for use in the Bell System. The breather consists essentially of a ball check valve in a pipe, one end of which is connected to the crank case and the other to the air intake of the fuel-mixing valve. When the set is in normal operation the suction of the fuel-mixing valve at the top of the breather tube maintains a partial vacuum in the crank case, drawing into the engine cylinder any poisonous carbon monoxide gas which might be present in the crank case and preventing its escape to the engine room. Also, due to the reduced pressure in the crank case, oil leaks are prevented from the main engine bearings to the outside.

In telephone offices of the Number 11 type the 48 volt battery has a smaller current rating than the 24 volt battery and should be charged at a lower rate. For this reason and to permit charging different batteries in other applications a special control panel has been designed. It is mounted on the generator and carries a double-pole double-throw switch, ammeter, voltmeter, voltmeter switch, fuse for generator overload protection, rheostat for controlling the battery charging rate, underload breaker to disconnect the generator from the battery in case of reverse current, and also a switch to start the engine by using the generator as a motor.

Equipped in this manner a light and compact unit is available for the smaller offices as may be seen from the accompanying photograph. It covers the requirements of a certain important group of central offices for standard units and does so at a notable saving in cost.

## *Variation in the Length of the Day*

*The observed change of rate of the earth's rotation consists of two parts, one a slow decrease in rate due to tidal friction and similar causes, and the other an irregular discontinuous change in rate, sometimes increasing and sometimes decreasing, of which the cause is as yet unknown. Due to the steady decrease in rate, the length of a day has increased, on the average, about* 0.0025 *second per century during the last three centuries. The other variation is considerably larger, as well as irregular, but due to it the length of a day has never been observed to vary by more than* 0.0036 *second from the mean for the century. These figures are taken from "Nature" for January* 21, 1928.

*In an article, "Facts About Frequency Measurement" which appeared in the* RECORD *for August, W. A. Marrison wrote, "But the astronomers tell us that at the present rate the length of a day will change about one second during ten years." At his request, the inaccuracy of that statement is being corrected by this note. There seems to be no need for alarm as to the inconstancy of the earth's rotation, at least as far as present methods of frequency measurements are concerned.*

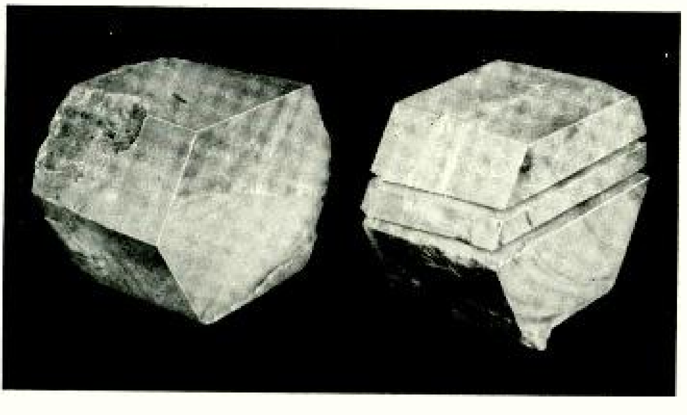
# Frequency Control for Broadcasting

By J. C. HERBER
*Apparatus Development Department*

EVER since the number of broadcasting stations in the United States increased to several hundred, the average listener-in has found at times that one or more of his favorite programs was ruined because of a high pitched whistle or tone received along with the program. Broadcast listeners are naturally interested to know the cause of this form of disturbance and the steps being taken to eliminate it.

The radio or carrier wave sent out by a broadcasting station is at a frequency between one-half and one and a half million cycles per second. The particular carrier frequency used by a broadcasting station is assigned by the Federal Radio Commission, and these assignments are 10,000 cycles apart. Thus one station may operate at 550,000 cycles, another at 560,000, a third at 570,000, and so on, up to one and a half million cycles. These frequencies of course can not be heard but serve merely, as the name indicates, to "carry" the broadcast program to the distant receiver. If two adjacent carrier waves are received by a radio receiver a beat frequency is produced as result of detection, which is equal to the difference between the carrier frequencies. This difference-frequency is 10,000 cycles if both stations are on their assigned frequencies. A 10,000 cycle note is not objectionable, since few radio receivers can amplify and fewer loud speakers reproduce this tone.

Theoretically, therefore, a 10,000 cycle interval between broadcast carriers should cause no interference at the radio receiver. Actually, however, it has been very difficult for broadcasting stations to maintain accurately the frequency of their transmitters and as a result instead of a 10,000 cycle beat note one of the order of 1,000 or 2,000 cycles is often present which may be of such intensity as to disrupt the program being received. This state of affairs has led the Federal Radio Commission to adopt strict regula-



*Natural quartz crystals, from one of which a slab has been cut* tions regarding the departure allowed from the assigned carrier frequency.

To enable the broadcasting stations equipped with radio transmitters built by the Western Electric Company to meet the requirements of the Federal Commission and to maintain the frequency of these transmitters not only constant but correct to a high degree of accuracy a choice of two methods was possible. One is to supply very accurate frequency measuring apparatus; the other, which is the method adopted, exercises a direct control of the frequency by utilizing the piezo-electric properties of crystalline quartz or, as it is commonly known, "rock crystal."

Piezo-electric effect is a name given to the property certain crystals have of generating electrical charges on some of their surfaces when they are subjected to mechanical pressure. This process is reversible; that is, if an electric potential is applied to certain surfaces of the crystal, the crystal will mechanically distort itself and change its shape. Not only the whole crystal but a thin slab of it if cut in certain ways will exhibit the same characteristics. If alternating voltage is applied to the surface of such a slab it will expand and contract in perfect synchronism with the alternations of the applied voltage. This vibration of the crystal plate attains a noteworthy magnitude however, only if the frequency of the applied alternating voltage is the same as the natural period of mechanical vibration of the crystal. These interesting properties were not made use of until several years ago when the interdependent electrical and mechanical properties of the quartz plate were incorporated with the oscillating properties of the vacuum tube, the combination being known as the piezo-electric oscillator or more commonly, the quartz crystal oscillator, or "crystal oscillator."

Simply stated the operation of this device is as follows: Some of the electrical energy developed by the oscillator tube is used to "drive" the crystal. This causes the crystal to vibrate mechanically, generating

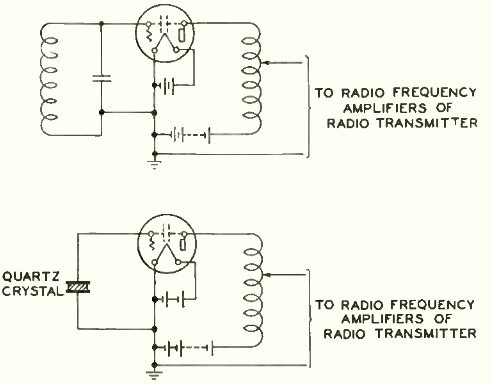



*Fig. 1—Schematic diagram showing the similarity between a tuned grid oscillator and a crystal-controlled oscillator*

charges on its surfaces which are fed back into the input circuit of the tube. Thus an electro-mechanical oscillator or generator of high-frequency currents is obtained in which the tube drives the crystal with the crystal determining the frequency at which the tube oscillates.

As actually used, the crystal plates are slabs or slices cut lengthwise out of the natural quartz crystal. These finished slabs themselves have come to be called "crystals." The photograph shows an uncut natural quartz crystal and another with a slab cut out of it which has been laid back in place to show how the cut is made. After a slab is cut out of the crystal proper its sides and ends are cut off and the surfaces are carefully ground so that they are very smooth and accurately parallel to each other. The crystal plates in their finished form are approximately one and a quarter inches square. They are mounted between lapped metal plates and are connected as shown in the simplified schematic Figure 1, which also serves to show the analogy to an oscillator employing an electrical tuned circuit.

Thickness is the factor which determines the frequency of vibration; the thicker the crystal, the lower the frequency. A crystal for example having a natural period of 550,000 cycles per second is approximately 0.141 inch thick, while one which vibrates at 1,500,000 cycles per second is only 0.052 inch thick.

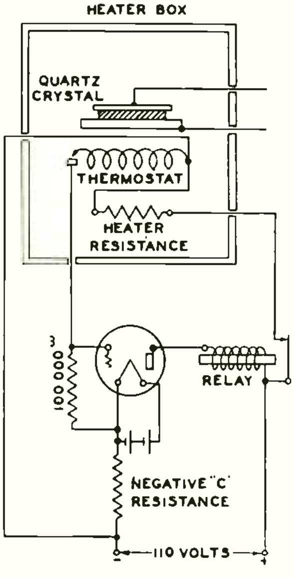


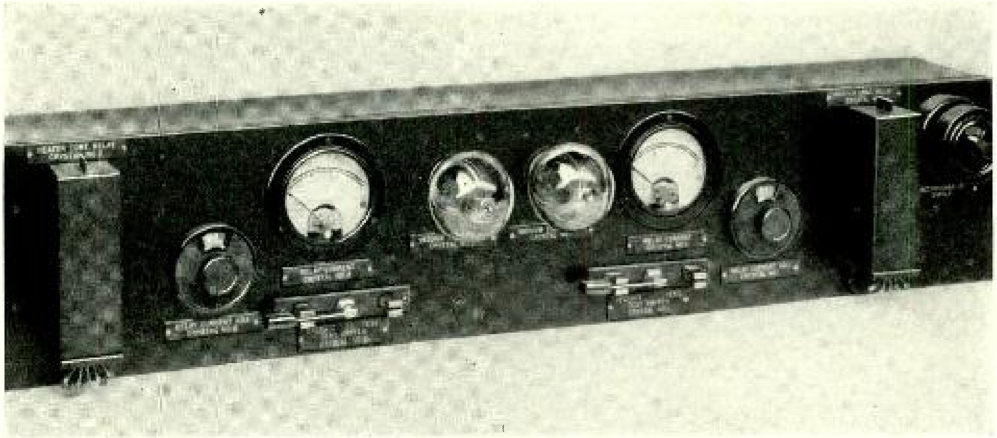
*Fig. 2—Simplified diagram of the temperature control circuits*

It was soon realized that even if great care was exercised it was practically impossible to grind the crystal as accurately as desired. This can be readily appreciated from the fact that a million-cycle crystal changes 100 cycles if only eight millionths of an inch in thickness are ground off. Another factor which also affects the crystal frequency is temperature and this property is made use of to accurately control the rate of vibration.

The coefficient of elasticity and the density, and therefore the natural period of vibration of the crystals, change with the temperature, as for any other mechanical object. The variation in their natural period of vibration with temperature may be either positive or negative, depending on the cut of the crystal, and varies in amount from about 30 to 80 cycles per million cycles per degree Centigrade change in temperature.

Thus a crystal may be ground to only approximately the correct thickness, and the desired frequency accurately obtained by controlling the temperature at which the crystal operates. Thus the ultimate fine control of frequency may be by temperature and not by grinding. In addition, by maintaining the crystal at a constant temperature, changes in frequency due to changes in room temperature are avoided.

To obtain temperature control of the crystal it is necessary to house it in a heat insulated box and to control the temperature of the interior by thermostatic means. The crystals are so ground that the frequency is correct at some temperature between 50° and 70° C. This is higher than any outside air temperature which is likely to be encountered anywhere, therefore some heat must always be supplied to the box to maintain the temperature at the proper point. The walls of these boxes are heavily lined with a heat insulating material. Inside of the chamber is mounted a pair of metal plates with the crystal between them, a heater unit, and an ad-



*Front view of temperature control panel, with equipment for two crystals*

justable thermostat which maintains the temperature of the crystal constant by opening and closing the heater circuit at such intervals that the total amount of heat supplied is just enough to maintain the box at the temperature for which the thermostat is adjusted.

The thermostat is so sensitive that it can not be used to open and close the heater current for the box directly. Instead the thermostat controls the operation of a vacuum tube, the tube in turn controlling a relay which opens and closes the heater circuit. A simplified circuit diagram is shown in Figure 2. When the temperature inside the box is less than that for which the thermostat is adjusted, the thermostat is open and the grid of the tube is connected to the filament through the 100,000 ohm resistance. A relatively high plate current is obtained under this condition which operates the relay, and current flows through the heater resistance supplying heat to the box. When the box has been heated to the temperature to which the thermostat has been adjusted the thermostat closes and connects the grid to the negative 110 volt connection which places a negative potential on the tube and decreases the plate current to a small value. The relay therefore releases, opening the heater circuit. As soon as the box cools a little the thermostat opens again and the process is repeated. The net result is that the heater circuit is opened and closed at short intervals (about once a minute) allowing the heater to give off a series of heat impulses which are smoothed out by the large metal lower plate on which the crystal rests.

By these means the crystal itself is kept at a very uniform temperature despite considerable variation in the surrounding room temperature. As a result the frequency of a radio transmitter, controlled by one of these crystals whose temperature is carefully regulated, should be at all times correct within a relatively few cycles. By maintaining the frequency with such accuracy, the beat notes produced by stations in different channels will be kept very close to 10,000 cycles. As has already been pointed out this frequency is well outside the range of audibility and so will never become a source of annoyance.

# Work of Laboratories Involved in New Telegraph Company Contracts

PRESIDENT Walter S. Gifford of the American Telephone and Telegraph Company has just announced contracts with the Western Union Telegraph Company and Postal Telegraph-Cable Company that "will undoubtedly have a far-reaching effect on the development of electrical communications in the United States. In order to provide the best possible telephone service at the least cost, the American Telephone and Telegraph Company carries on continuous research and development and, as is well known, maintains a nation-wide network of telephone toll and long distance lines. Some of the developments of its Bell Telephone Laboratories have been incorporated in ocean telegraph cables, resulting in a large increase in capacity of words transmitted. Other developments and inventions of the Bell System can be utilized on telegraph lines, and also enable additional circuits required by telegraph companies to be superimposed on telephone toll and long distance lines. With the view to placing these developments at the service of the public, the American Telephone and Telegraph Company decided to make them available to telegraph companies and offered a series of non-exclusive contracts which have now been executed.

"Among them is one for the use of plant which should ultimately result in eliminating to a large extent the present duplication of parallel pole lines and wire circuits since, by the use of proper apparatus, it is possible to telephone and telegraph simultaneously over telephone toll and long distance wires. By this new arrangement many of the advantages that would accrue from the consolidation of all electrical communications will be obtained, and at the same time, the complete independence of the telephone and telegraph companies will be maintained.

"A contract has also been entered into by which the telegraph companies may lease the apparatus developed through Bell System researches and inventions so that under certain conditions several telegraph channels may be obtained from a single pair of telegraph wires.

"A further contract provides that the Telephone Company's telephoto system will be available to the Telegraph Companies' patrons for handling facsimile message service between the cities where the Telephone Company operates its system of sending pictures by wire."

# The Rest Room in New Dress

By GRATIA L. PROUTY

*Personnel Department*

THE Women's Rest Room on the 11th floor is located in Section "B"—the oldest part of the building, dating back to 1896-97, and probably completed in its present form before 1900. The room was used originally for blue-printing by the manufacturing department before the days of blue-print machines. From two wide, low windows on the south, tracks ran out on the roof, on which the frames were pushed out into the sun.

The room served a double purpose, however, for it also housed the photographic department. Portraits were taken in the favoring light from the north while the blue-prints were in making on the south.

After the war, when many departments were relocated, the room was released from its former uses, and turned into a rest room for the women. Rugs and big wicker chairs and curtains and cushions changed its aspect completely and made it a comfortable place in which to relax for a little while before the afternoon session. In 1921, the library subscribed to a few magazines for the room.

Out of hours the room has not been idle. Glee club and carol rehearsals have been held there and many a hard fought battle has been decided in the bridge tournaments.

Years of use left their mark on the furnishings, and soot and cinders did their part, till it was decided that the room needed a new dress, and J. G. Motley, Assistant Plant Manager, accordingly took the task in hand this spring. Since the sun pours in through so many windows it was decided to turn the place into a modern sun room. Colorful cretonne hangings, black woodwork and black wicker furniture with bright cushions against a light olive wall, a linoleum floor of cool red tile, and new parchment lampshades with a line of color make a Rest Room that is "decidedly different" and, judging by the increasing use, decidedly pleasing.

*The Rest Room as it appears from near the entrance*

# News Notes

DR. JEWETT addressed the Summer School for Engineering Teachers of the Society for the Promotion of Engineering Education at Pittsburgh on July 18, on the subject of engineering education and its relation to industry.

ON JULY 25, Dr. Jewett addressed the American Bar Association at Seattle on "Fifty Years of Science and Engineering."

### RESEARCH

A. R. KEMP, P. A. LASSELL AND C. L. ERICKSON studied enamel wire manufacture at Hawthorne from July 15 to July 21. While there, Mr. Kemp also investigated problems in connection with submarine telephone cable.

J. E. HARRIS visited Hawthorne in connection with lead cable sheath development.

B. L. CLARKE spent several days in Norfolk, Virginia, inspecting tests in connection with cable corrosion.

A. L. JOHNSRUD lectured on television before the Department of Physics of the University of Minnesota on July 23.

W. G. BREIVOGEL visited Hawthorne in connection with work on handsets.

A. G. JENSEN, who has been engaged in work on transatlantic radio telephony in England, returned on July 16. Mr. Jensen plans to resume his work in England in September.

G. R. YENZER returned August 3 from a three weeks' stay in Hawthorne in connection with the manufacture of condenser transmitters.

HARVEY FLETCHER spoke on "Audition" before the S. P. E. E. Summer School at Cambridge, Massachusetts, on July 25.

J. B. KELLY addressed the summer session of Pennsylvania State College, his alma mater, on August 8. His subject was "Studies in Speech and Hearing with their Application to Social Welfare."

### INSPECTION ENGINEERING

D. S. BENDER has been appointed Field Engineer in the territory of the New Jersey Bell Telephone Company, replacing J. K. Erwin. Mr. Bender, in addition to assuming charge of the Field Engineering work in this territory, will continue as Field Engineer in the territories of the New England Telephone and Telegraph Company and The Southern New England Telephone Company.

A. M. ELLIOTT has been appointed Field Engineer in the territory of the New York Telephone Company, replacing J. K. Erwin in the Manhattan, Bronx-Westchester and Long Island Areas, and R. J. Nossaman in the Up-State Area. Mr. Nossaman will devote his entire attention to supervisory duties in connection with the Field Engineering Force.

J. K. ERWIN has been transferred to the Inspection Development Branch of the Engineer of Manufacture of Western Electric.

J. A. St. Clair has been appointed Field Engineer in the territory of the Pacific Telephone and Telegraph Company, replacing P. B. Almquist.

H. W. Newlund, Field Engineer at St. Louis, visited Fort Worth, Dallas, Denison and Oklahoma City during July in connection with his regular Field Engineering duties.

A. G. Dalton visited Chicago, Omaha, Denver, Los Angeles, San Francisco, Seatle and Cleveland during July and August in connection with Field Engineering work in these cities.

H. G. Eddy, T. Mellors and R. M. Moody attended regular Survey Conferences at Hawthorne during the first part of August.

A. N. Jeffries visited Hawthorne during the latter part of July in connection with audible motion picture work.

W. A. Boyd visited Omaha, Chicago, Indianapolis and Pittsburgh to investigate corrosion of telephone equipment and protective metal finishes.

### Patent

J. G. Roberts visited Chicago in connection with the prosecution of patents. G. M. Campbell, G. H. Heydt and E. V. Griggs visited Washington for the same purpose.

### Systems Development

E. W. Hancock visited step-by-step central offices at Hartford, Trenton, Reading, Altoona, Harrisburg and Scranton during July.

W. J. Lacerte is at Hartford, Connecticut, making tests on service observing equipment.

C. White visited the No. 3 toll boards at Cleveland, Ohio and Utica, New York.

E. P. Bancroft visited Montreal, Smith's Falls and Toronto, Canada, to confer with representatives of the Canadian Pacific Railroad Company on carrier telegraph installations.

H. M. Hagland and V. I. Cruser visited Philadelphia and Boston, respectively, to inspect new 551-A private branch exchanges.

J. G. Ferguson discussed private branch exchanges with Navy Department representatives in Washington.

D. C. Meyer visited Hawthorne and Cleveland during July.

J. H. Sole visited the General Electric Company plant at Pittsfield, Massachusetts from July 25 to 27.

G. A. Benson was in Des Moines, Iowa, for the purpose of discussing the proposed installation of pneumatic tube equipment in the new Des Moines Toll Office with engineers of the Northwestern Bell Telephone Company.

J. R. P. Goller visited the new repeater station power plants on the Washington-Atlanta cable at Greensboro, Durham, Norlina and Warrenton, North Carolina, and at McKenny, Virginia.

V. T. Callahan tested a new 150 horsepower gas engine at Memphis.

### Outside Plant Development

J. M. Hardesty visited clay conduit manufacturing plants at Altman, Ohio, and Brazil, Indiana, and observed the manufacture and installation of concrete conduit in Chicago.

E. M. Honan was in New Haven on July 19 and 20 in connection with the field trial of drop wire attachments.

### Apparatus Development

D. H. Newman has installed for the Life and Casualty Insurance Company of Nashville, Tennessee, the first of the new 105-C radio telephone broadcasting equipments. This equipment includes the crystal control five-kilowatt transmitter. He has also completed the five-kilowatt installation of the University of Florida at Gainesville and visited Birmingham to discuss the technical features of the five-kilowatt station to be established there by the Alabama Polytechnic Institute. The Institute has for two years been operating a 106-A (one-kilowatt) equipment at Auburn, Alabama.

H. S. PRICE is supervising the installation of the fifty-kilowatt broadcasting equipment to be operated by the Crosley Radio Corporation near Cincinnati under the call letters WLW. An unusual feature is the proposal to install, in the same operating quarters, the five-kilowatt equipment of station WSAI and to continue operating the two stations simultaneously.

W. L. TIERNEY has completed the installation of a one-kilowatt broadcasting equipment for Louis Wasner, Inc., of Spokane and made the survey for the one-kilowatt station to be established by the Oregon State Agricultural College at Corvallis, Oregon.

V. F. BOHMAN observed the operation of step-by-step switches in New London, Connecticut on July 12 and 13.

F. J. REDMOND visited Hawthorne during the week of July 23 in connection with the development of a new dial number plate for use on coin collectors installed in telephone booths.

J. N. REYNOLDS AND J. F. HEARN visited the plant of the Precision Die-Casting Company at Syracuse on July 30.

J. R. TOWNSEND visited the United States Naval Academy at Annapolis on July 27 to discuss spring materials in connection with committee activities of the A. S. M. E. The following day he visited the Bureau of Standards in Washington in the matter of flatness measurements on condenser transmitter diaphragms.

R. V. TERRY spent three weeks in Hawthorne assisting in the production of the film recording machine.

### GENERAL STAFF

R. W. KING addressed the Physics Section of the S. P. E. E. Summer School at Cambridge, Massachusetts, on "Physics as a Career in Industry."

W. F. JOHNSON was elected first vice-president of the Purchasing Agents Association of New York at the annual meeting of that organization.