ELL LABORATORIES RECORD

Pedro the Voder makes his bow at the New York World's Fair

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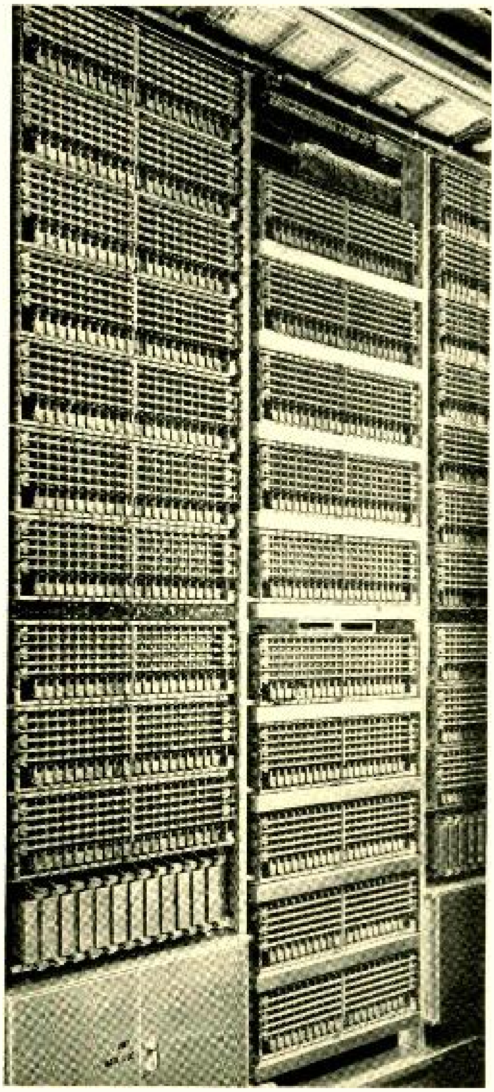


The Crossbar Line-Link Frame

By A. J. BUSCH
Central-Office Switching Development

IN the step-by-step and panel systems each subscriber line is brought to two switching frames. One of these, the line finder, is used when the subscriber is placing a call; the other, generally known as the final frame, is used when a call is being completed to the subscriber. The crossbar system differs radically from these earlier systems in this respect, since with it a subscriber line is connected to only one frame—the line link—which is used for both originating and terminating calls. This line-link frame, like all other major frames in the crossbar system, consists of a group of primary and secondary switches, and each subscriber line is connected to one of the vertical units of one of the primary switches. The vertical units of the secondary switches are divided into two groups of ten each; one group connects to line junctors, which run to incoming link frames, and is used for terminating calls; and the other connects to district junctors which run to district frames and sender links, and is used for originating calls.

The first step the crossbar apparatus must take in establishing a connection is to find the particular line placing the call and then to connect it to an idle district junctor that has access to an idle sender. This work is accomplished by the line-link and sender-link controller circuits, the former of which associates itself with a line when a line relay operates, and remains associated until connected through to a sender. The time required for this operation is so short that only one controller is required for each line-link frame, which may serve from 200 to 700 subscriber lines.

The horizontal multiple connections of the primary and secondary switches of each line-link frame are connected together by line links, and since there are ten horizontal circuits for each crossbar switch, ten line links are available to each subscriber, and 100 line links to the subscribers of each line-link frame. Since a single crossbar switch does not have more than twenty vertical units, this would provide one link for each two subscriber lines, which for ordinary calling rates is more than is needed. Where the calling rate does not warrant so liberal a provision of line links, one or more additional primary bays, referred to as the extension bays, are added, and all are served by the same group of 100 line links. The headpiece of this article shows an actual frame with only a single bay of primary switches. Beneath the primary crossbar switches, under the can covers, are the line relays, which operate when a subscriber places a call. Figure 1 shows an installation where three bays of primary switches are provided. With this arrangement, ten line links serve sixty lines. At the bottom of the bay of secondary switches is a cabinet enclosing the relays of the controller circuit, and just above this cabinet are the multi-contact relays by which this circuit is connected to the crossbar switches.

Subscriber lines connected to the line-link frame are arranged in groups of ten—one or two groups being connected to each primary switch. Where there is an odd number of groups, a crossbar switch with only ten vertical units will be used for the last extension bay. There will be from two to seven of these groups in each row depending on the number of primary bays, and thus from twenty to seventy on a line-link frame, which has ten rows of switches. This is indicated by Figure 2, which shows the ten horizontal rows of primary switches, each with three twenty-unit crossbar switches and one ten-unit switch to provide a maximum of seven groups of ten lines. Any one group of lines may be identified by specifying its horizontal and vertical positions on the line-link

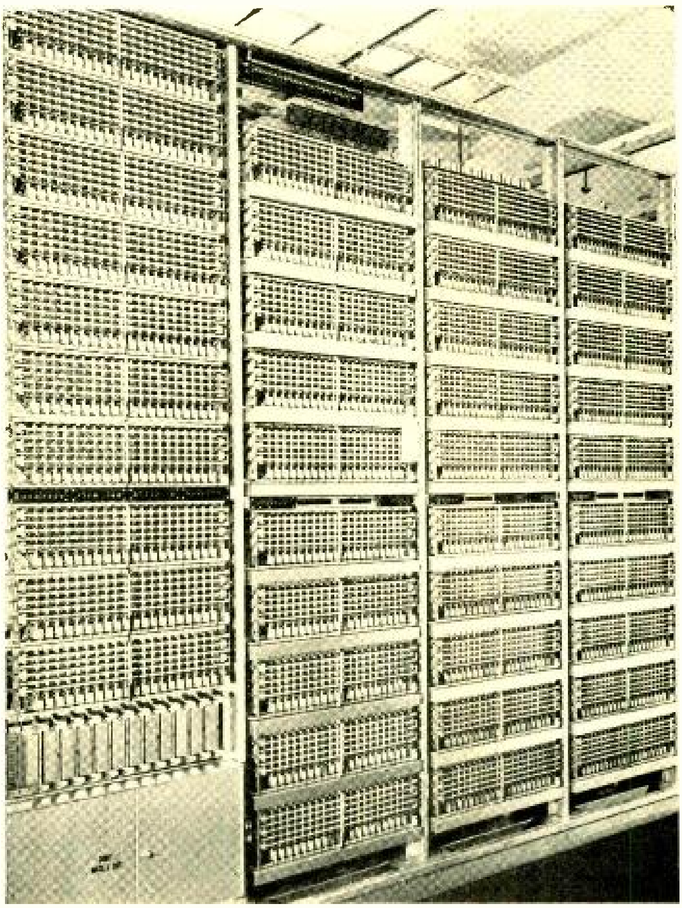


Fig. 1—A line-link bay at the Troy Avenue Office, which employs three bays of primary switches

frame. Thus the group marked G in Figure 2 may be identified as that at the intersection of horizontal group 6 and vertical group 4. By identifying, in addition, one of ten possible vertical positions within a vertical group, a particular line is identified. By providing a relay for each horizontal group, designated from HO to H9, a similar set for each vertical group designated VO to V6, and a set for the positions within a group designated LO to L9, any calling line can be identified by the operation of three relays. The line marked X on the diagram, for example, would be identified by the operation of H6, V4 and L4—the line at the extreme left of each group being numbered O.

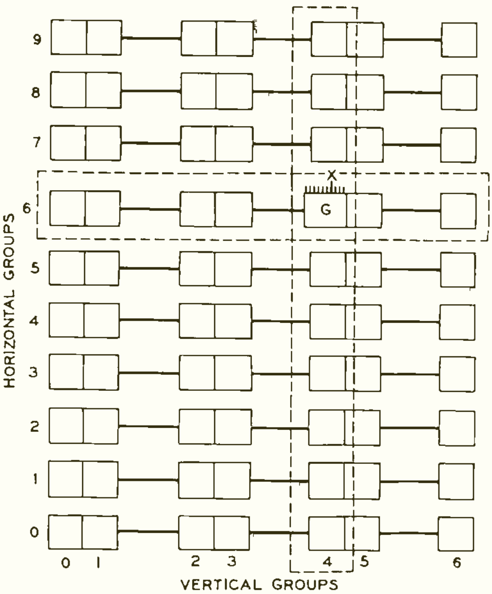


Fig. 2—Any of the seventy possible groups of ten subscriber lines can be identified by specifying the horizontal and vertical groups

Besides the three sets of identifying relays, certain others are required for their proper coördination. Figure 3 shows a simplified schematic of the identifying circuit, and from it the sequence of operation may be followed. At the upper left of the diagram, the possible seven groups in each of the ten rows are indicated by the hold magnets of the first and last line of the first and last vertical groups in the bottom and top horizontal rows, and the corresponding line relays are shown. A line relay, marked L, is associated with each subscriber line, and the operation of one of these relays at once seizes the line-group controller circuit.

Three relays are employed in the identification of each horizontal group, and these are marked HA, HG, and H. There are ten such groups of relays, and each relay has a digit from 0 to 9 following the letter to identify the group. When a subscriber lifts his handset, his line relay operates. This operates HA, and, in turn, HA operates HG. This identifies the horizontal row in which the calling line is located, since a line in any other row would have operated different HA and HG relays. Operation of an HG relay connects the windings of the seven V relays to the leads from the ten groups of line relays in the row that has already been identified—the ten line relays in each group being connected to a common lead. The V relay that corresponds to the group of lines with an operated line relay will operate. The arrival of a second call before the first has been identified is prevented from interfering with the action of the line-group controller by circuit elements not shown.

Each group of lines in each horizontal row has associated with it an LR relay, and when a V relay operates, it—in turn—operates the LR relay of the group containing the calling line. The leads from the contacts of the V relays are multipled to separate contacts of all the HG relays, and thence run to the LR relays of each horizontal row. Since only one HG relay is operated, however, the path to all the LR relays, except in the identified row, are open. Moreover, since only one V relay is operated, only the LR relay in the corresponding vertical group will operate.

The operation of an LR relay, through ten front contacts, closes paths from each of the line relays in its group to the ten LT relays, which are used to identify a particular line within a group. Since only one L relay is operated, however, only the LT relay corresponding to that line will operate.

Most of these relays have contacts or functions other than those shown. The dotted sections of line running to the HA, V, and LT relays indicate additional equipment, required largely to take care of conditions arising when more than one call is placed at

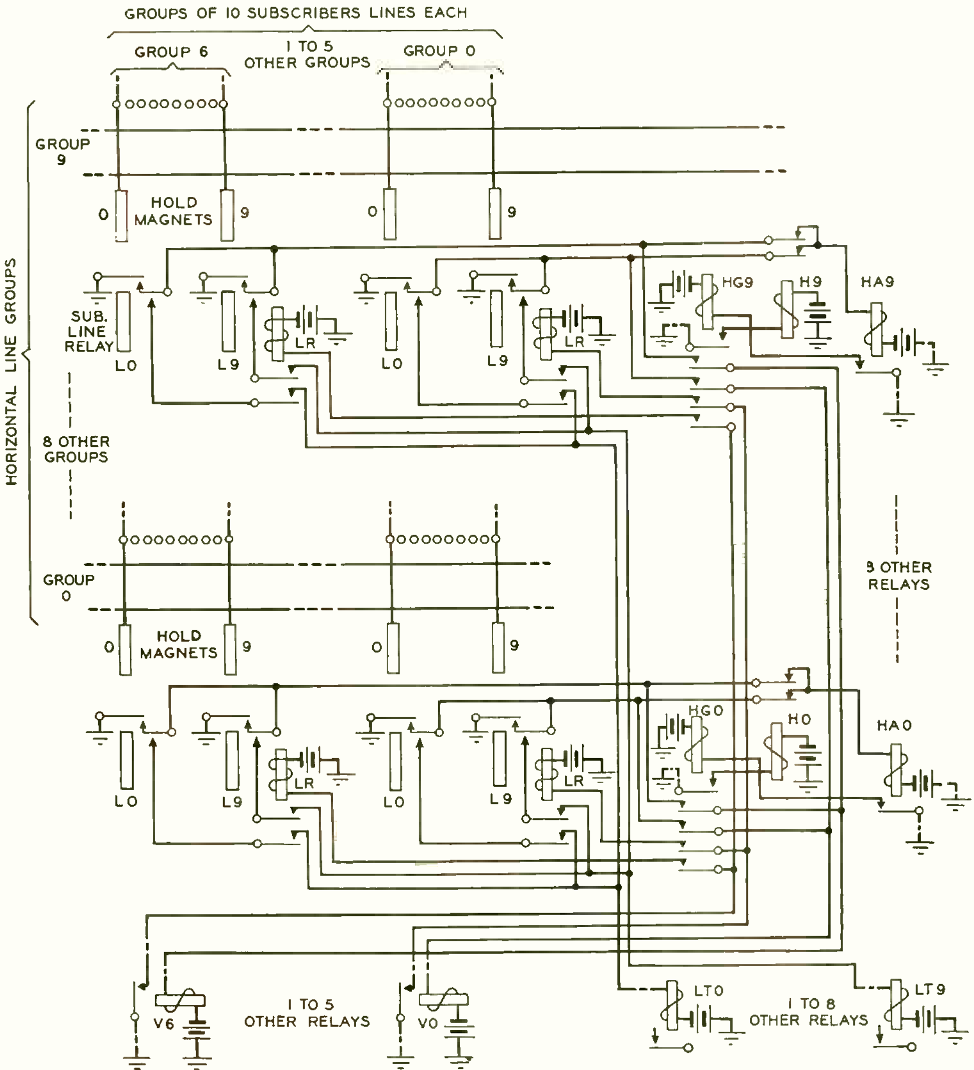


Fig. 3—Simplified schematic indicating the relays involved in line identification

approximately the same time. The H relay, included in each horizontal row in addition to the HA and HG relays, acts through the contacts shown, to isolate the vertical groups so that several V relays cannot remain operated by a single line relay.

As soon as an HG relay has operated, identifying the horizontal row in which the calling line is located,

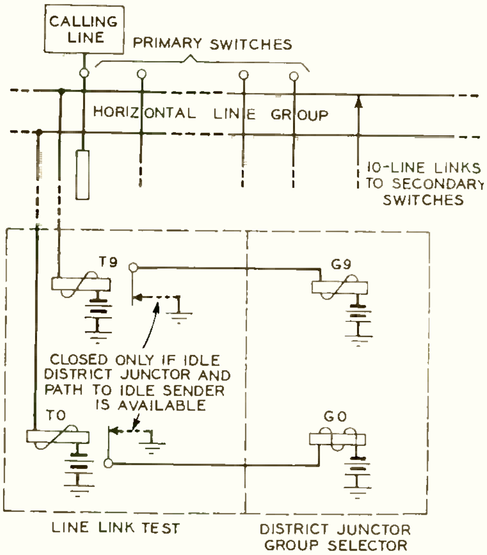


Fig. 4—Idle link identification is made by ten groups of ten pairs of relays

and thus the group of ten line links over one of which the connection will be made, the controller circuit—through another group of relays—starts to look for an idle link that can be connected through to an idle district junctor for which a sender is available. The ten line links from each horizontal row run to different secondary switches, and some of them may be in use for other calls. The first step, therefore, is to eliminate those of the ten line links that are busy. This will determine the line links that are available for the call, and these particular line links, since each goes to a different secondary switch, will designate the groups of district junctors that may be used. Some of these district junctors, however, also may be busy, and others may not have senders or sender links available, and all such junctors must be eliminated from the circuit before the final selection of the path is made.

Line-link selection is made by ten T and ten G relays as indicated in Figure 4. When an HG relay operates, it connects the ten T relays, through contacts on the HG relay not shown in Figure 3, to the ten line links coming from the horizontal row of crossbar switches with which the particular HG relay is associated, and the line links that are busy operate their associated T relays. Operation of a T relay opens the circuit to the corresponding G relay so that it cannot operate; the G relays that ultimately operate indicate the available paths.

Even though a T relay does not operate, indicating thereby that the associated line link is idle, the corresponding G relay may not operate because the circuit connected to its winding through the back contacts of its T relay passes through other apparatus, as indicated by the dotted line. This circuit will not be closed unless there is at least one idle district junctor on the secondary switch to which that line link runs, and unless an idle sender is available for use with the district junctors. Those G relays that do operate thus indicate an idle line link, an idle district junctor, and an available sender. Of these possible paths, the controller circuit selects one. Having made this choice, it operates the select magnets of the primary switch.

At the secondary switch, this line link has access to ten district junctors, one or more of which are idle. They are all served by the same sender-link frame and the same group of senders, however, and the sender-link controller circuit chooses one of the district junctors and also one of the available senders as described in a previous article.* Having made its selection, the sender controller circuit operates the select and hold magnets of the sender-link frame, and the hold magnets on the primary and secondary switches of the line-link frame. It then releases all the select magnets and restores itself to normal. This connects the sender to the calling line and dial tone is sent to the subscriber, who then begins to dial. This entire sequence and concomitancy of relay operations, which has required some two thousand words to outline in the briefest detail, requires only six-tenths of a second to complete.

In this description of the location of a calling line, it has been tacitly assumed that only one call came into the frame during the fraction of a second that is required to connect to it and to release the controller circuit. Even though a number of lines on the frame should place a call at the same instant, however, there would be no confusion or double connections; the calls would be handled, one immediately after the other, following a definite sequence. The rate at which calls come in under any ordinary conditions is not so great as to make the fractional-second wait for the handling of calls ahead of it important.

This sequence handling of calls is secured by the simple device of "chaining" the HA, V, and LT relays as indicated in Figure 5. Suppose, for example, that calls came in simultaneously on a number of horizontal rows. The HA relays of all such rows would operate, but the ground connection that will operate the HG relay is carried in a "chain" through contacts on all the HA relays. If one of the calling lines is in the zero level, HGO will be operated, but the others will not because their ground circuit is open at HAO. Had there been no call in the zero level, the ground lead would have been passed, through a back contact on HAO, to HA1.

A similar "chaining" is applied to the V relays, so that only one LR relay will operate, and to the LT relays so that only one hold magnet in any vertical group will be operated. Having found and connected to one of the calling lines, the controller circuit would start over again and establish a connection to the next.

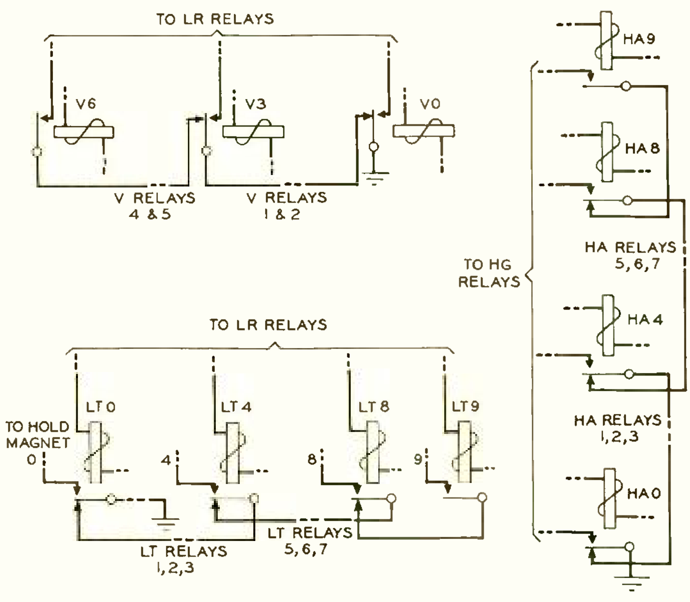
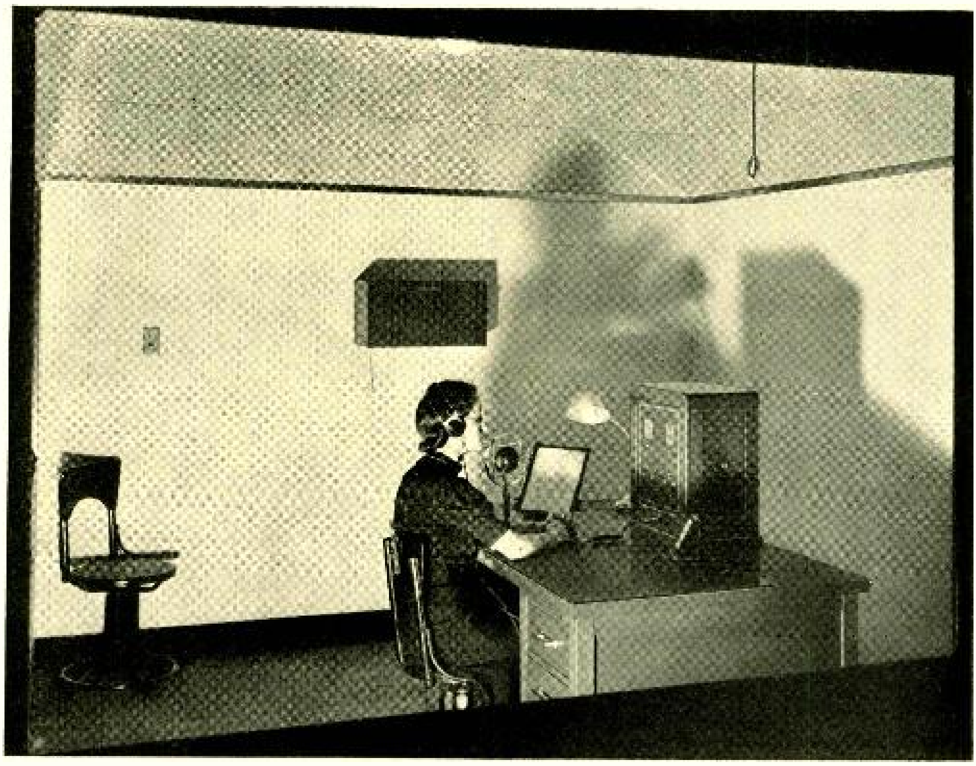


Fig. 5—Typical chaining circuits of the line-link controller

*RECORD, *April*, 1939, *p.* 234.



A Precision Clock for Telephone Time

By R. V. TERRY
Electromechanical Apparatus

THE apparatus employed in time bureaus, which has already been described in the RECORD,* employs an electrically regulated wall clock that makes contacts for sending out the time tones and also for sending out pulses to operate the electric clocks on the turrets in front of the time operator. Both the master clock and the operator's turret clock are provided in duplicate. A new clock has recently been developed by the Laboratories for this service and is now in use at the East Thirtieth Street Office in New York City. It acts both as a master clock and as the operator's clock, and mounts in a turret as shown in the photograph at the head of this article. Its driving power is a synchronous motor which is normally driven by a precision frequency distributed over Bell System circuits, but which may be operated from a regulated commercial supply if desired. The power input is only four watts, well within the output capacity of the 94C amplifier,† which is suitable for use between the clock and the high-precision sixty-cycle supply.

This new clock serves both for time announcements and as the time

*RECORD, *March*, 1931, *p.* 335.

†RECORD, *November*, 1938, *p.* 89.

standard for New York City and the surrounding metropolitan area. It is designed to provide four accurately timed electrical pulses for different circuits. Two of these pulses, each of one-half-second duration and repeating at fifteen-second intervals, are used for the time service. One of them starts at 7½ seconds past the minute, and signals the operator to begin her time announcement. The other, starting on the minute, sends the time tone over the line. The third pulse, also of a half-second duration, is sent every six seconds, starting on the minute, and drives the clocks at the operators' positions. The fourth pulse, of one-second duration, is sent every fifteen minutes starting at fourteen minutes and fifty-nine seconds after the hour, and is used to synchronize the clocks for general use around the offices of the area served by the time system. These are self-winding clocks, and heretofore have been synchronized hourly by a separate source.

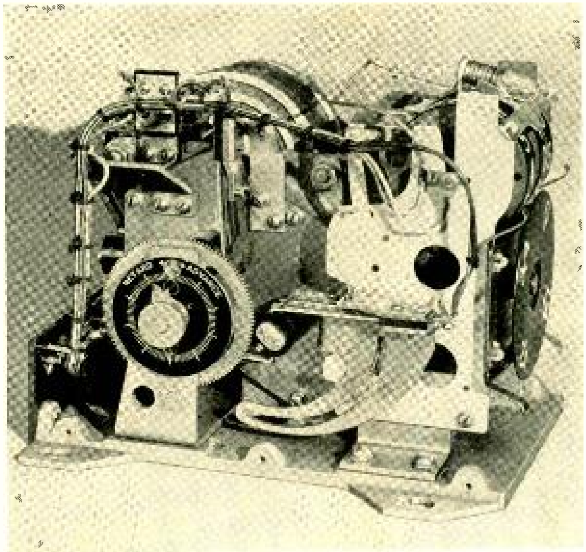


Fig. 2—Side view of time unit showing moveable bracket, at the lower right, for adjusting the duration of the announcing period

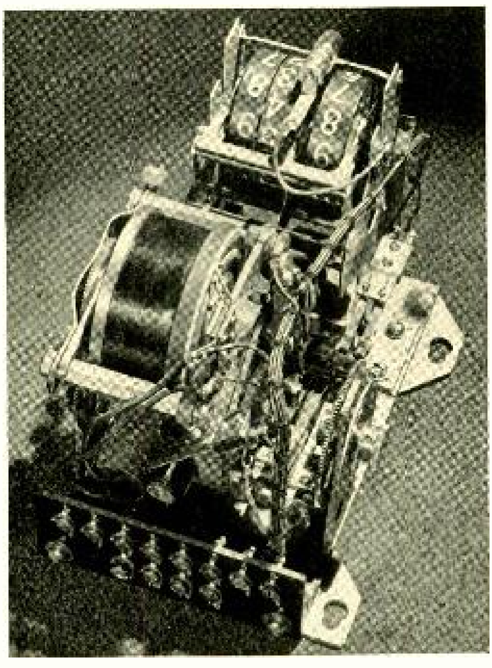


Fig. 1—Time unit with cover removed showing the four timing commutators

One of the disadvantages of the previous time system was that the pulses delivered by the master clock were obtained from cam-operated contacts. It was difficult to maintain the adjustment of the fingers relative to the cams so that the contact would be made at exactly the right moment, and in addition a certain amount of contact chatter could not be entirely eliminated. All of these difficulties are avoided in the new design by the use of commutator-type contacts. There are four of these commutators; and each consists of a cylinder of insulating material in which is set a silver segment, flush with the surface. Pairs of silver fingers ride on each commutator, and the circuit is completed from one finger to the other through the commutator segment. Since there is no up and down motion of the fingers, there is no contact chatter, and nothing to disturb the accurate timing of the pulses.

All of the commutators are driven through a set of gears from the motor, but at different speeds. Two of them, those at the right of Figure 1, are on the same shaft and make four revolutions per minute. The outermost of these two commutators has two pairs of fingers resting on it—one at the bottom and one at the top. The bottom pair sends out the time tone, and the upper pair sends the signal that notifies the operator to begin her announcement. These latter fingers are normally set so that the segment makes contact with them 7½ seconds before it makes with the lower fingers. This interval is usually long enough to give time for the announcement, but this pair of fingers is mounted on an adjustable bracket, evident in Figure 2, so that the interval can be made somewhat shorter or longer if desired.

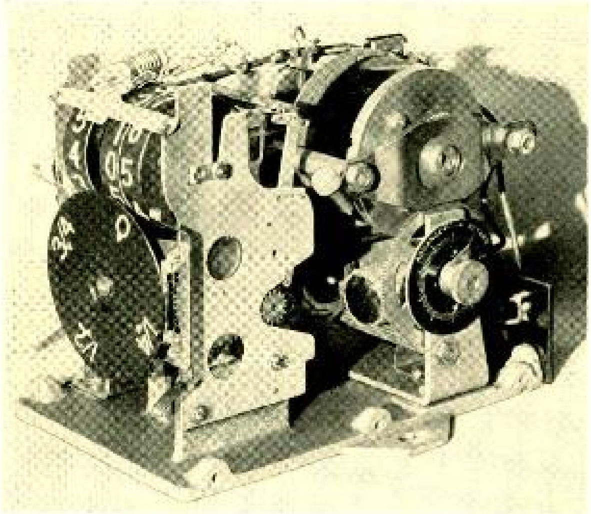


Fig. 4—View of time unit showing cyclometer, at the left, and the adjusting knob and gears for rotating the motor winding, at the right

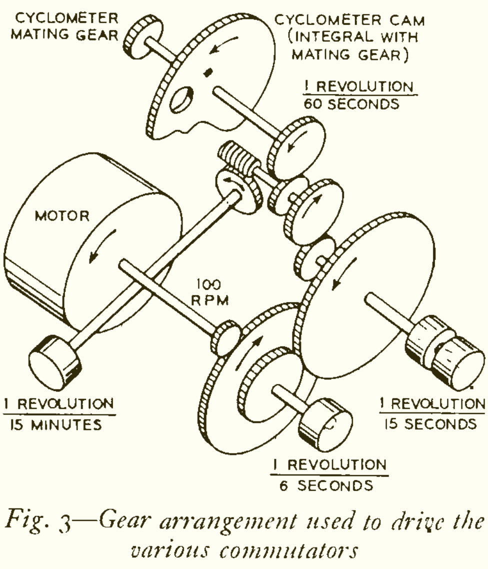


Fig. 3—Gear arrangement used to drive the various commutators

The innermost of the two commutators on this shaft is used with the one at the extreme left in Figure 1, for synchronizing the self-winding clocks in the central-office buildings. This latter commutator makes one revolution in fifteen minutes, and its speed is thus too slow for accurately determining either the duration or time of occurrence of the pulse. The fingers on this commutator are therefore connected in series with those on the inner fifteen-second commutator. The segment on the slow commutator makes contact with its fingers some seconds before the pulse is to be sent out, and remains in contact with them some seconds after it has been sent out. The high-speed commutator regulates both the timing and the duration of the pulse. It will be noticed that its segment is longer than the others as the pulse it sends out is of one-second, instead of a half-second, duration.

The commutator above the fingers of the time-signal commutator makes one revolution every six seconds, and provides the pulses for driving the operators' clocks.

All driving gears, shown diagrammatically in Figure 3, are in the narrow, irregularly shaped housing from which the commutators project. This housing is partially filled with oil, so that the gears are quiet and run under ideal lubrication conditions. The synchronous motor is of a new design with a rotor speed of 100 rpm, and with two windings assembled in the cylindrical drum directly to the left of the housing as shown in Figure 1. A condenser is required to secure the proper phase relationship between the two windings, so that three leads must be carried to the motor. These pass through the three slip-rings and brushes on one side of the motor drum, as may be seen in the illustrations.

Slip-rings are necessary because the drum that carries the motor winding and bearings is arranged to rotate, to provide for adjusting the clock to the correct time. A gear attached to the drum, shown in Figure 4, is driven by another gear, which may be turned by the adjusting knob shown at the right of the illustration. An exactly similar gear and knob is provided at the other side of the mechanism, and is geared to the first one through a shaft running beneath the clock, as shown in Figure 5. This arrangement permits the clock to be adjusted from either side. One revolution of the knob advances or retards the mechanism by one second, and a dial is graduated in hundredths of a second to give precision in setting.

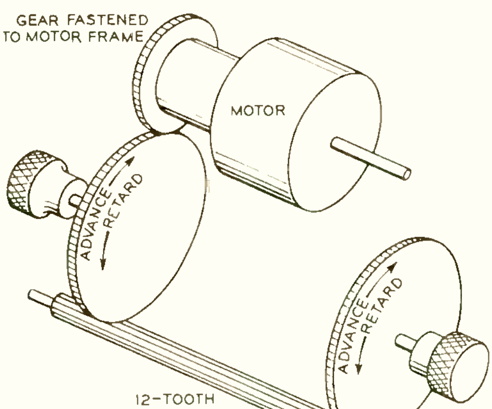


Fig. 5—Gear arrangement for the adjusting drive

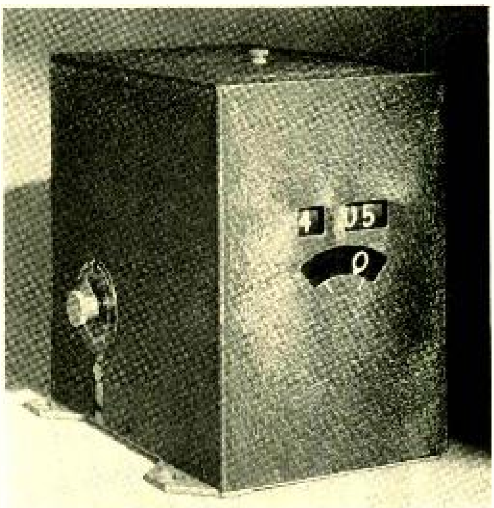
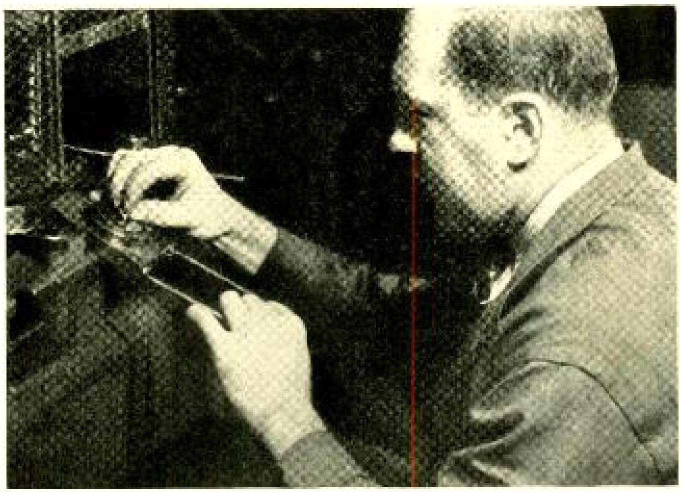


Fig. 6—Front view of time unit

The cyclometer that indicates the time consists of one cylinder for indicating the hour, two similar ones for indicating the minutes, and a disk at right angles to the cylinders for indicating the quarter minutes. This disk is driven continuously by a shaft from the gear box, while the minute and hour cylinders are driven from it by cams. A front view of the unit with cover in place, Figure 6, shows the time indications as seen by the operator. When the quarter-minute arrow is at the white line at the right, the warning tone is sent out, and when it is at the line at the left, the actual time pulse is sent out. The operator thus always has a visual indication of the time remaining in which she must complete her announcement.

Two of these clocks are mounted in the turret, and driving current for each is supplied through a separate channel in the central office. Each is arranged so that in case of failure of its normal supply, it will be automatically switched to the commercial sixty-cycle supply, which will drive the clocks, at possibly somewhat reduced precision, during the period of the emergency. The sixty-cycle commercial supply is also employed to furnish power for the amplifiers associated with the time-announcement system. Should this commercial supply fail while the precision-frequency was still available, the amplifiers will be automatically switched to a battery-driven motor-generator, which will supply the needed 110-volt power. In this way continuous operation of the time-announcement system is assured except under the very unlikely failure of both the precision-frequency and the commercial power supply at the same time.



Extruded Lead Casings for Condensers

By G. R. GOHN
Electromechanical Development

An improved condenser encased in an extruded lead tube has been developed by the Laboratories and is now being manufactured by the Western Electric Company. This form of container will gradually replace in station equipment the familiar rectangular tin can now used. The extrusion of soft metal tubes is not new—tooth-paste and other products are sold in them—but the extrusion of collapsible tubes in forms other than round appears to be rather new and has recently been developed by the Laboratories.

Prior to the adoption of the extrusion method, condenser cans were made by folding up a flat blank of tin plate and soldering three of the bottom edges and a side seam. This method was expensive, until a machine was developed by the Western Electric Company to carry out the operations automatically. The tightness of the soldered joints was also questionable. The seamless extruded can is tight and, while somewhat more expensive than a machine-made soldered container, is superior from an engineering standpoint because it is moisture-proof.

The extrusion process permits the manufacture of seamless, cup-shaped articles with one pair of dies and at a single stroke. This is accomplished by applying sufficient pressure to a relatively massive blank to make the metal flow through a restricted orifice. These blanks may be either hot or cold and both mechanical and hydraulic presses are used. In the extrusion of lead cable sheath and in other operations where steady pressures are employed, hydraulic presses are used. For small collapsible tubes, which are made by impact extrusion, mechanical equipment is preferred because its operating speed is higher and it yields a greater output. The extrusion of lead is carried out at, or not much

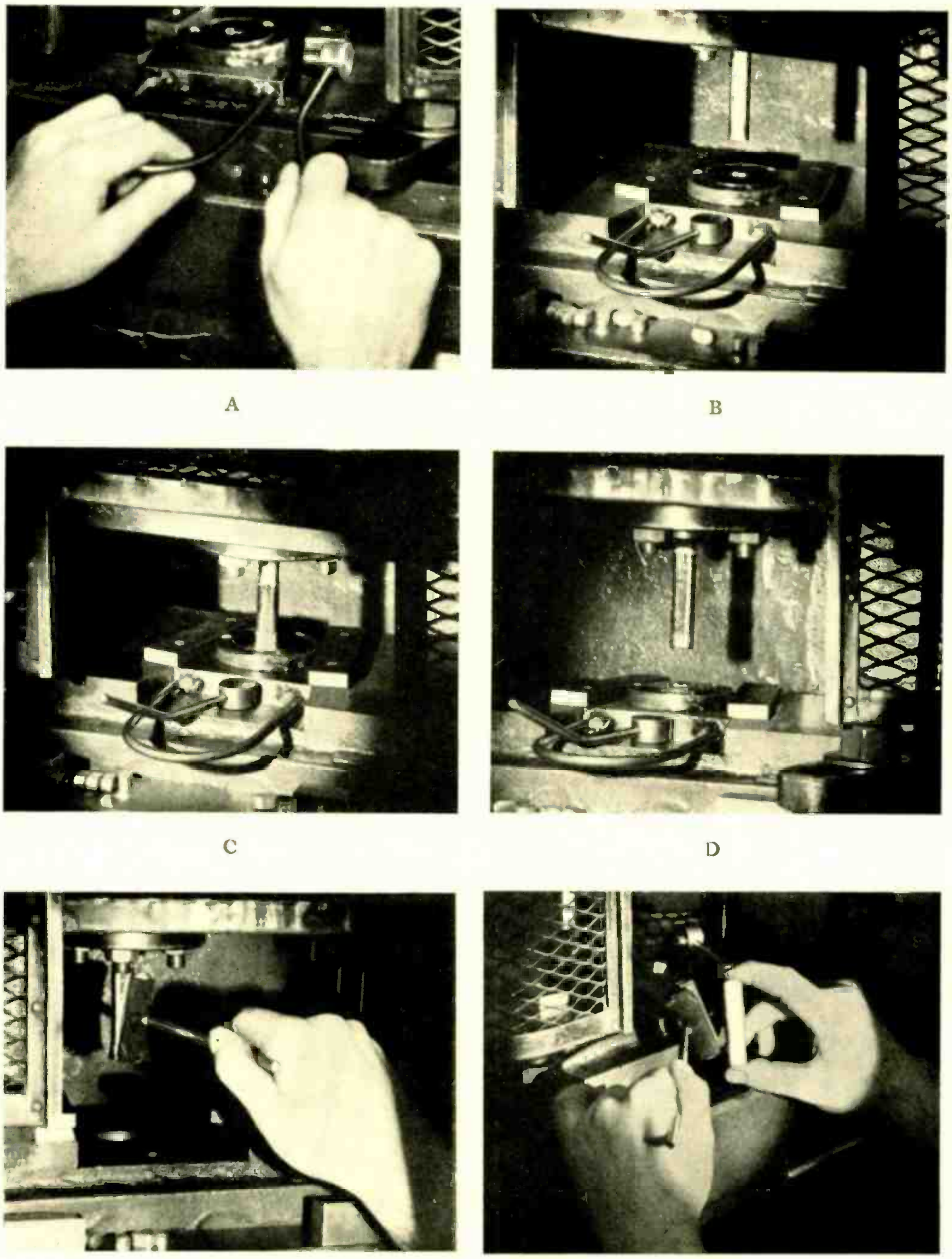


Fig. 1—Experimental equipment for extruding lead casings for condensers, as developed by the Laboratories, is illustrated by this series of photographs. A punch is forced into a die which holds a lead blank. This forces the lead up around the punch to form the casing. The casing is removed from the punch mechanically by a felt finger as shown in E and F, aided by air pressure applied through a poppet valve in the punch

above, room temperature and requires pressures of 40,000 to 60,000 pounds per square inch.

Condenser tubes are extruded by an impact operation on a shaped blank of chemical lead, which has the same cross-section as the finished product. The thickness of this blank has to be sufficient to provide the metal needed to make the bottom and side walls of the can with some excess for trimming to length. The blank is placed in the cavity of a die, which has parallel outer surfaces corresponding in outline and dimensions to the outside of the finished condenser can. The depth of the die is slightly greater than the thickness of the blank. By applying pressure to the blank by a punch shaped like the die, but small enough to allow for the thickness of the walls of the condenser can, the soft metal is forced to flow through the orifice between the punch and the die and forms the side walls of the can. The bottom of the can is formed in the die by restricting the stroke of the press so that the punch cannot touch the die at the bottom of its stroke. On the upstroke the extruded can clings to the punch and has to be removed either by air pressure or mechanical fingers. Cylindrical cans are expanded by air pressure sufficiently to permit ejection from the punch but rectangular or oval-shaped cans like those used for telephone condensers would cling more tightly to the punch if this means of ejection were tried because they would contract along the diagonals of the can. In this case a combination of air pressure and mechanical stripping is used.

During the extrusion operation, the active portion of the punch is at the lower end where the metal flows from the bottom around the sides. Above this active portion the cross-section of the punch is reduced to relieve the flowing lead from internal pressure and to reduce the friction between the can and the punch immediately after extrusion. This reduction is necessary because the extruded can has a tendency to cling to the punch. For the same reason it has been found advisable to aid removal of the can by admitting air to it through a small poppet valve in the bottom of the punch. Opening the valve breaks the

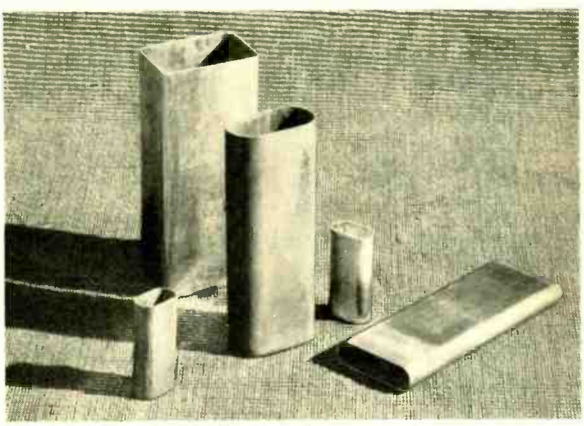


Fig. 2—Collapsible tubes extruded in the Laboratories Shop. The smallest tube on the right is made of aluminum and the other four are lead

vacuum which is formed inside the can when an attempt is made to remove it by force. This operation prevents collapse of the can where mechanical stripping is employed and serves as a means of applying air pressure where the cans are blown off.

When round cans are extruded the flow path from the center of the slug to the outer periphery is uniform in all directions and no particular difficulty is encountered. With oval or rectangular units, however, the flow path is not the same to all parts of the can and very careful tool design is required to insure an equal rate of flow of the metal past all parts of the punch. With this careful adjustment, which is facilitated by the use of liner-pins, no difficulty is encountered in the extrusion of oval or rectangular cans. This has been demonstrated by their successful use in the manufacture of the new condensers.

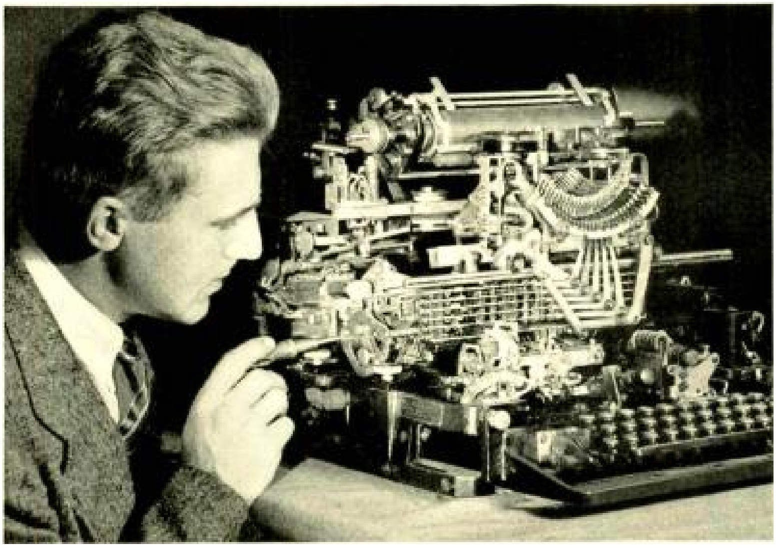
Protective Coatings for Metals

"The chief purpose of this book, admirably accomplished, is to meet the needs of that large body of chemists, engineers, and executives who must decide what methods should be used to protect various metals under the conditions to which they may be subjected in service. Such persons will find in this volume a wealth of information that has resulted from a critical review of the literature and practice in this field. Its authenticity is increased by the fact, noted in the introduction, that appropriate sections of the manuscript were read by over 20 specialists in different branches of this subject.

"The major subjects are: mechanism of corrosion, surface preparation, types and methods of application; coatings of zinc, cadmium, tin, nickel, chromium, copper, lead, aluminum, silver, gold, and platinum metals; and methods of testing metallic coatings. In addition, three chapters are devoted to the composition, application, and evaluation of paint coatings on metals. A final chapter includes oxide and phosphate coatings and vitreous enamels.

"The authors, R. M. Burns and A. E. Schuh, have rendered a great service to science and to industry by their compilation of this fund of knowledge into a clear, readable text."

William Blum, in "Industrial and Engineering Chemistry," April 10, 1939.



Holding-Magnet Selector for Teletypewriters

By W. Y. LANG
Electromechanical Development

WHEN a teletypewriter key is depressed, a signal is sent which includes a start interval, different combinations of five equal "current-on" and "current-off" intervals, and a stop interval. At the receiving end this signal is sorted out by a mechanism which chooses the character called for by setting each of five code bars or code discs in one of two positions, corresponding to the "current-on" and "current-off" condition. In the older teletypewriters used by the Bell System a separate magnet was required to set each code bar. Later the five-magnet arrangement was replaced by another which requires only one magnet with its associated mechanism to set all five code bars. This magnet performs its functions by having the operating current pull up an armature during the "current-on" intervals. A subsequent development modifies this mechanism by driving the armature mechanically against the magnet pole face, once for each of the five equal signal intervals, and for the stop interval. This reduces the pull required of the magnet and permits operating teletypewriters with about one-third of the magnet current formerly used.

In most teletypewriter services it was necessary to provide a line relay at the teletypewriter station, since the proper margin of operation could not be obtained with the teletypewriter magnet operating directly in the line. In a-c areas this necessitated the provision of a rectifier or motor generator set to supply d-c locally for the relay biasing current and for the magnet current. Furthermore, in teletypewriter exchange service large use is made of a line current of 0.02

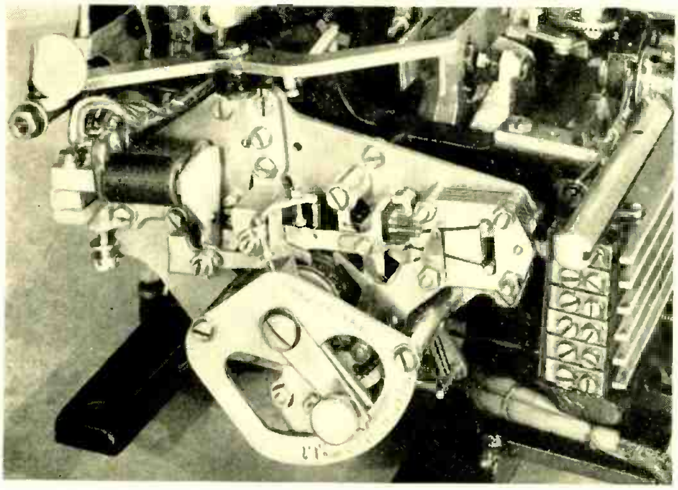


Fig. 1—Holding magnet and selector mechanism of the 15-type teletypewriter

ampere in place of the customary 0.06 ampere, to permit certain desirable switchboard arrangements. This required the use of a more sensitive and more expensive line relay at the teletypewriter station. In searching for means of reducing the cost of station equipment the possibility was noted of eliminating the line relay and rectifier by providing a magnet that could be operated directly in the line either at 0.06 ampere or at 0.02 ampere. Attempts to modify the standard magnet to meet this requirement were unsuccessful because of resistance and inductance limitations. The problem was brought to the attention of the Teletype Corporation whose engineers suggested the adaptation of a new "holding" magnet selector which they had in process of development for a special high-speed teletypewriter. The holding magnet has subsequently superseded the pulling magnet and is being employed quite generally not only with 0.02-ampere circuits but also with 0.06-ampere circuits.

The principle on which the holding magnet operates is the mechanical presenting of the armature to the poles of the magnet at the same time that each of the selecting impulses is received. The mechanical drive mechanism is removed during the continuation of the impulse and leaves the armature held, if current flows through the magnet, or released, if no current flows. A much weaker current is sufficient to hold the armature in the operated position than would be required to pull it from its released position.

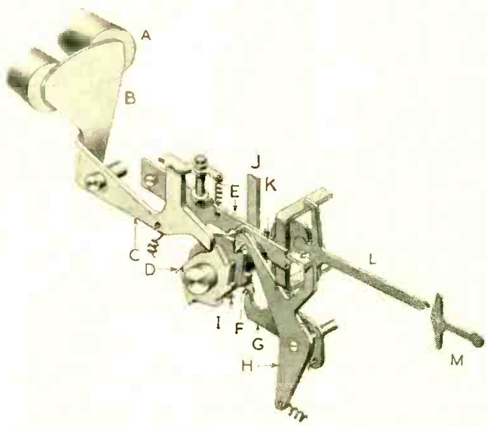


Fig. 2—The selector mechanism. Armature-lever cam (D) *presents the armature* (B) *to the magnet* (A) *for each signal impulse except the start impulse. The locking-lever cam* (I) *holds the selector arm* (E) *in the marking or spacing position. There are five selector-lever cams* (F), *of which one is shown in the illustration; and a clutch cam, not shown, which starts the printing operation. Other parts of the mechanism are the armature lever* (C), *selector lever* (G), *locking lever* (H), *detent stop* (J), *locking wedge* (K), *sword* (L), *and* "T" *lever* (M)

The photograph, Figure 1, and drawing, Figure 2, show the cams which present the armature to the polefaces and the operation of the selector mechanism. On one end of the main shaft an assembly of cams is driven by a motor through a friction clutch. The first cam of the assembly, the armature-lever cam, presents the armature to the cores for each impulse except the starting impulse. The second, or locking-lever cam, holds the selector arm in the "marking" or "spacing" position. The third to seventh are selector-lever cams which operate selector levers 1 to 5 respectively, and the eighth, or clutch cam, trips the main-clutch lever.

When the teletypewriter is ready to receive, a steady current flows in the line and the selector-cam assembly is held from rotating by a latching mechanism. On the arrival of a signal combination, the first impulse—current off—deënergizes the magnet, trips the latching mechanism, and allows the cam assembly to rotate. The armature lever rises on a peak of its cam and moves the armature against the magnet. If current is on—a "marking" impulse—the armature holds, and the spring which connects the armature lever to the selector arm pulls the selector arm up to its marking position.* If current is not on—a "spacing" impulse—the armature releases when the armature lever drops off its cam peak and the selector arm returns to the spacing position. This is the condition illustrated in Figure 2. When the selector cam has rotated to release the armature lever the locking lever drops in an indent in its cam and holds the selector arm in position.

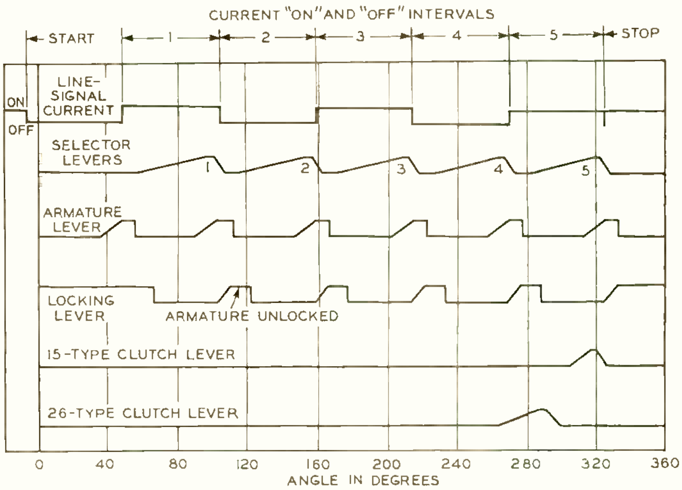


Fig. 3—Timing of the cams of the selector-cam assembly. The relationship between the line signal and the operation of the several cams can be varied by repositioning the range-finder arm of the mechanism

Selector lever 1 then rises on its cam peak and presents the forked extension of the selector sword to the two lateral extensions of the selector arm. If the selector arm is locked in the spacing position the lower extension of the selector arm blocks the lower fork of the sword and raises its point. On the other hand if the selector is locked in the marking position, the upper member of the fork is blocked and the sword point moves downward. The selector lever then drops into an indent in its cam and thrusts the sword outward into engagement with one arm of a "T" lever. The "T" lever rotates in turn and positions the code bar directly or

*This spring allows the armature to be presented before the selector arm has been released by the locking lever.

through linkages such as vanes or bell cranks. On receipt of impulses 2, 3, 4 and 5, the same cycle of operations is carried through. Shortly after selector lever 5 starts to rise on its cam peak, the clutch throw-out lever

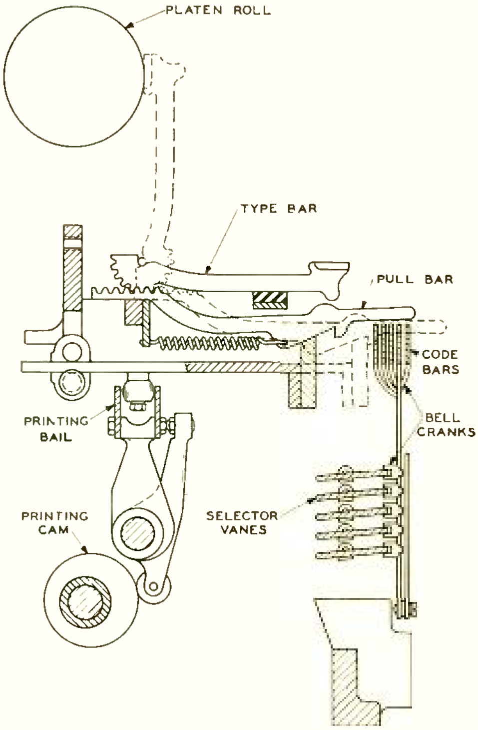


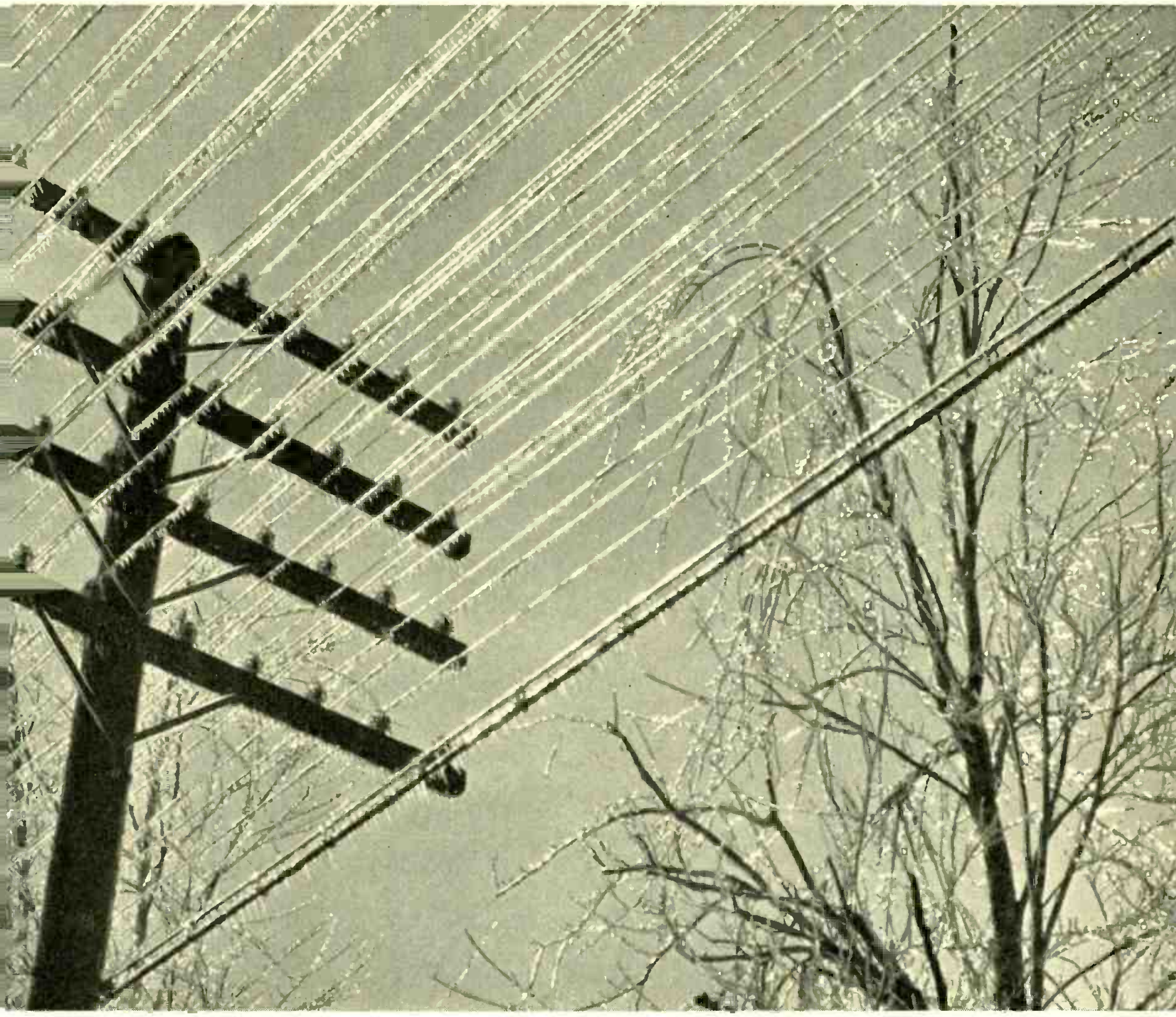
Fig. 4—Printing action of the 15-type teletypewriter. When the code bars have been positioned by a code signal one of the pull bars drops into a line-up of slots in the code bars. A projection on the pull bar then catches the lever connected to the printing bail as it advances. This raises the type bar and prints the character

is tripped, thereby allowing the main clutch to engage and drive cams associated with it to perform the printing or function operation.

Immediately before the stop pulse is received the armature-lever cam presents the armature to the magnet which is then energized and holds the armature. The latching mechanism engages the stop arm of the selector-cam assembly and prevents it from further rotation. The angles through which the individual cams of the selector-cam assembly have rotated when they operate are shown in Figure 3.

Teletypewriters must be capable of typing correctly not only from signals of correct length, but also from distorted signals, in which the "current-on" pulses are lengthened or shortened at either beginning or end. Furthermore, the teletypewriter must have no objectionable effect on the operation of the central-office repeater to which it is connected. As first tried, the holding magnet sent back to the central office an induced impulse large enough to affect the repeaters. This condition was remedied by using a non-inductive shunt around the magnet, but this shunt magnified the difficulties of meeting receiving margin requirements, that is of correctly recording distorted signals. The gradual decay of the releasing current and the consequent tendency to variations in releasing time resulted in degradation of receiving margins and proved to be the principal problem in this development. Changes in mechanical design and refinements in manufacture provided a satisfactory solution of these difficulties.

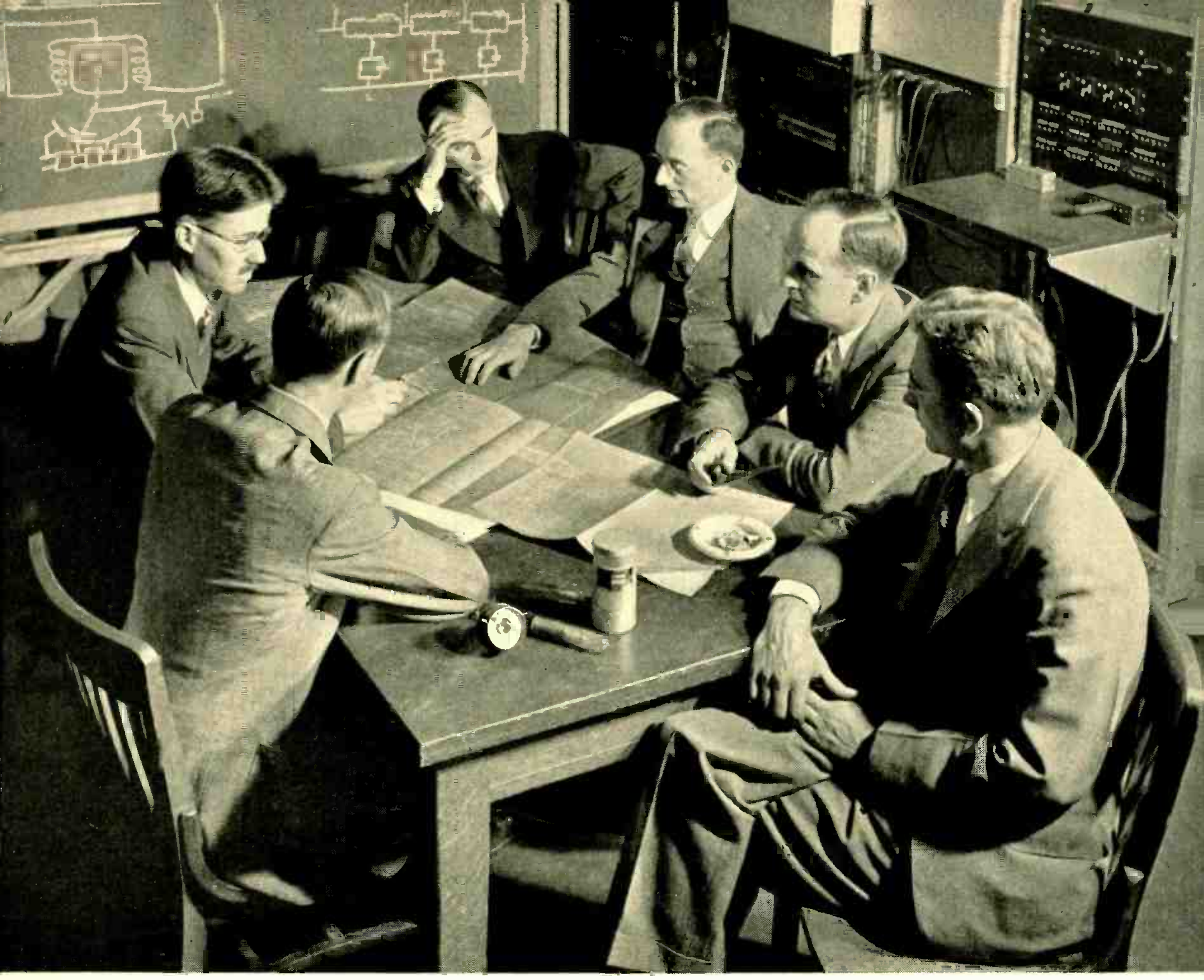
The holding magnet has been adopted not only for the 15-type teletypewriter, but also for the regenerative repeater and for the 26-type teletypewriter. It is somewhat more expensive than the pulling magnet, but it does away with the line relay and rectifier in most installations. The saving from these two items considerably exceeds the additional cost of the holding magnet, which thus provides a substantial reduction in the average cost of subscribers' equipment for teletypewriter stations.



The Story of the 2B Regulator

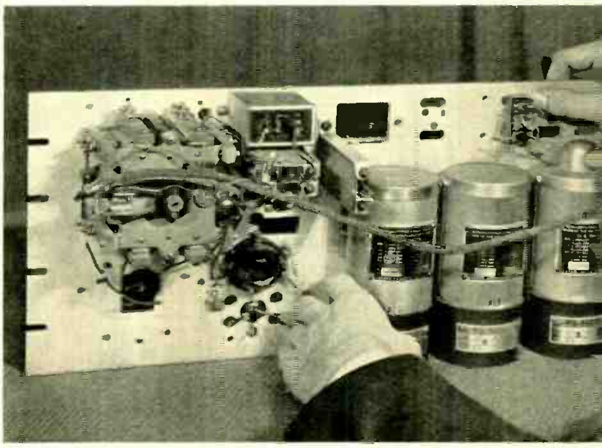
AN illustration of organized engineering in the Bell Laboratories is the development of the 2B Regulator, a device which automatically compensates the effect of changing weather on high-frequency open-wire telephone circuits. Sometimes such a useful new device is an isolated invention; sometimes it is a commercial application of knowledge gained in pure research; and sometimes it is an unforeseen by-product of engineering directed toward quite a different end. But most frequently, as in the case of the 2B Regulator, it is the logically developed solution of a specific problem.

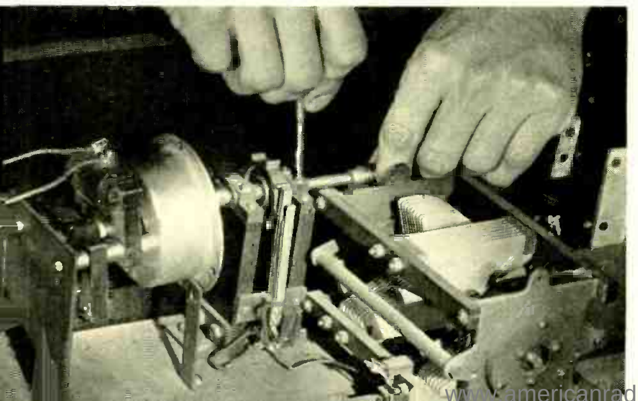
A statement of one spectacular phase of the problem is the photograph of a sleet storm; a better statement, perhaps, would be a curve of attenuation during such a storm. Since weather changes constantly and causes wide variations in line losses, a means is required to regulate repeater gains so that the transmission level is reasonably constant.



Development of the 2B Regulator was undertaken in connection with the recent redesign of the type-C carrier system. The regulator was to be—and is—so designed that it can be used with the old equipment as well as with the new. Promising methods of attack upon the problem were discussed in design conferences and explored by individual engineers. In the conference group are B. A. Fairweather, D. B. Penick, and D. M. Terry of the Toll Systems Development group; W. R. Lundry of the Apparatus Development Department; J. W. Beyer, supervisor of the Toll Systems group which carried on the development; and F. R. Dickenson of the Equipment Development group, all of whom contributed in one way or another to the development of the regulator. At his desk is D. M. Terry, who had direct charge of the design of the equipment.

Ideas incorporated by design engineers in rough pencil sketches and notations are organized by a draftsman into schematics, wiring diagrams, and assemblies, all of which are likely to change from time to time as the ideas are developed. Development models are built: sometimes they are "breadboard" models built by the engineers in their laboratories, and sometimes they are finished units carefully constructed in the Engineering Shop. Often several widely different methods of operation are tested before the final design is established.





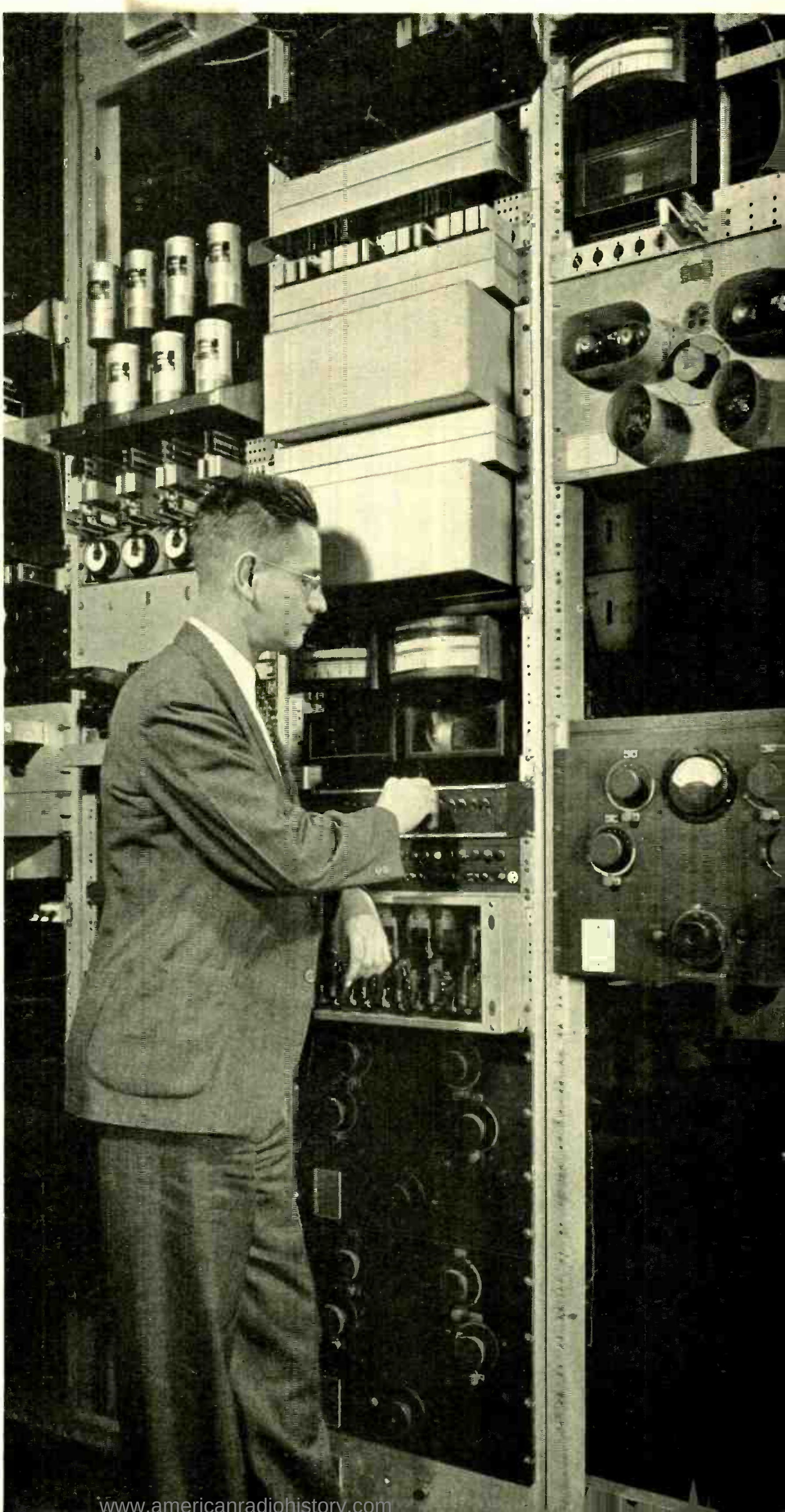
These two models, representing different stages in engineering the 2B Regulator, were built in the Shop. "Breadboard" models were built, but have not survived. As soon as such a model has served its purpose, it generally is disassembled and the apparatus used in a new circuit.

The 2B Regulator, shown at the right, occupies but nine inches of space on a standard relay rack. An entire C5 carrier terminal, including the regulator, is mounted on one bay, as shown below.

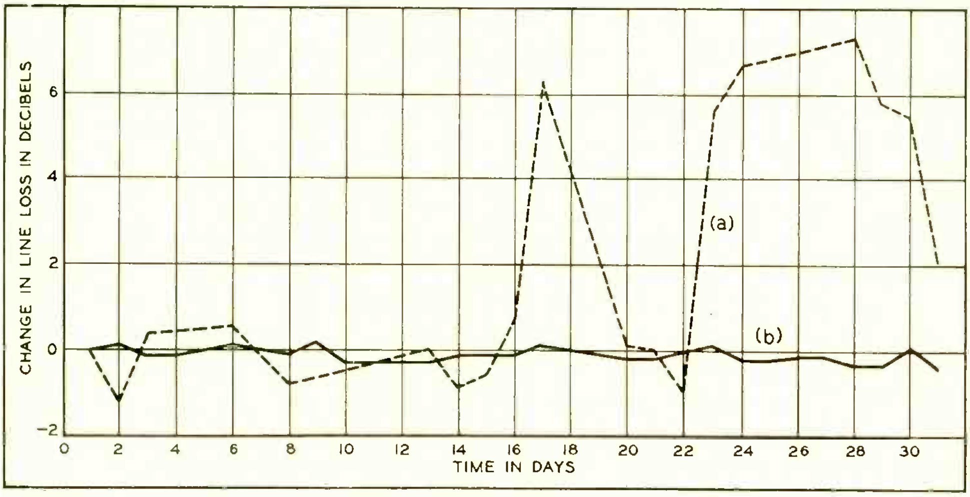
Type-C carrier systems compri
six channels—three in each directi
—in the band from ten to thirty kil
cycles. Attenuation is different at ea
frequency, and is affected to a differe
degree by changing weather. Th
regulator includes a continuously va
able artificial line with a frequenc
attenuation slope similar to that
the real line, and an equalizer who
characteristic is the reverse of the li
slope. In lining up a system the art
ficial line is adjusted so that when
is added to the real line the slope
the combination neutralizes that
the equalizer, leaving the overall tran
mission essentially uniform at all fr
quencies. Then as the loss and slo
of the real line change, the artifici
line is made to change in the revers
direction, leaving the overall tran
mission still uniform.

The artificial line is controlled by
motor to which current is supplie
through a relay. The relay is co
trolled by a pilot frequency picke
off the line by a selective filter an
rectified; when the attenuation of th
pilot frequency changes by more tha
0.5 db in either direction the regulato
circuit is closed and the artificial lin
is adjusted to compensate the chang
A second relay, also controlled by th
pilot frequency, actuates an alar
when very large changes in attenua
tion occur—as when the line is opene
or short-circuited.

Regulating equipment for the older type-C carrier systems required an entire bay—space equivalent to that occupied by a complete C5 terminal. The remaining equipment of the older systems occupied two and a half more bays.



2B Regulators are assembled and wired at the Kearny works of the Western Electric Company. The characteristic curves below show (a) variation in line attenuation at a pilot frequency over one repeater section of a C5 carrier system; (b) the same when corrected by the 2B Regulator.



The 17B Oscillator

By W. J. MEANS
Electrical Measurements and Design

WHERE a testing frequency is to be varied over a wide range, an oscillator of the heterodyne type is generally recognized as the most convenient to use. Not only does it permit the frequency to be set by a single control, but its output-frequency characteristic may readily be made substantially flat. The reasons for this are apparent on a little consideration. The frequency of a single vacuum-tube oscillator varies with the square root of the capacitance of the tuning condenser, and thus to secure a frequency range of 100 to 1, for example, the capacity would have to be changed over a range of 10,000 to 1. Since condensers always have appreciable minimum capacitance, the maximum value becomes too high to be readily secured in a single air condenser. In addition a single coil cannot cover such a wide frequency range, so that besides using several condensers, there must be a number of coils to cover different sections of the frequency range. Moreover the output of an oscillator inherently varies with frequency; only over a comparatively narrow range does it remain substantially constant. Where a wide frequency range is required from a single oscillator, the output cannot be held constant.

In a heterodyne oscillator, the outputs of two separate oscillators, one fixed in frequency and one variable, are passed through a modulator, and the difference frequency is selected as the oscillator output. To secure a frequency range from 1 to 100 kc, for example, it would be possible to employ one oscillator with a fixed frequency of 500 kc and one whose frequency is variable from 400 to 500 kc. The difference frequency can then be varied from 0 to 100 kc by varying the adjustable oscillator from 400 to 500 kc—a range of only twenty per cent of the top frequency. Over this comparatively narrow range, a single condenser and single coil can be used, and by careful design the output can be made substantially flat.

In connection with the types J and K broad-band carrier systems, it was necessary to develop an oscillator to cover the range from 1 to 150 kc, accurate to 25 cycles, and with an output that would be essentially flat with frequency. The heterodyne principle was therefore employed, and the oscillator, which is now available, is known as the 17B. It is a-c operated with an output adjustable from 1 to 1000 milliwatts. Besides being used in conjunction with the installation of the broad-band systems, it will also be used as an operating tool in terminal offices, and is finding wide use in the shop and in the laboratory as well. The circuit development was facilitated by earlier work done on an experimental oscillator for laboratory use already described in the RECORD for October, 1935. The larger range and different use of the 17B oscillator, however, has required a number of modifications and refinements of the earlier design.

Since the oscillator is intended primarily for central-office use, it is mounted on a standard nineteen-inch panel suitable for fastening to a relay rack, where it will occupy about twenty-eight inches of vertical space. Its appearance may be seen in the photograph at the head of this article, and its circuit is indicated by Figure 1. The outputs of the two component oscillators, one with a fixed frequency of 650 kc, and the other with a frequency adjustable from 500 to 650 kc, are fed to a balanced vacuum-tube modulator, thence through a low-pass filter, which discriminates against the component fundamental frequencies and also against the higher modulation products, and then to the output amplifier. A balanced volume-control potentiometer gives the required output adjustment, and a double-impedance output transformer gives output impedances of either 135 or 600 ohms. To minimize the effect of variations of the a-c supply voltage, a regulated plate supply* is provided, and ballast lamps are inserted in the filament circuits.

The heart of any heterodyne oscillator is its main tuning condenser. To meet the precision requirements, the condenser had to be capable of being reset to within at least 1/20000 of full-scale capacitance and a scale had to be provided with three thousand 50-cycle divisions. Since the mid-position between two closely spaced lines can readily be judged by the eye, this permits reading to the 25-cycle precision requirement. The condenser chosen is a special worm-driven precision air condenser with a ball-

*RECORD, *May*, 1937, *p.* 298.

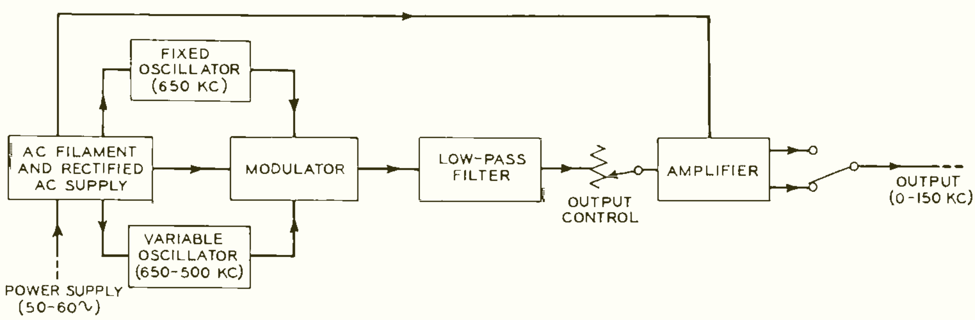


Fig. 1—*Block schematic for the* 17B *oscillator* bearing rotor. Considerable development work in coöperation with the supplier was necessary to secure the characteristics needed. The 180-degree plates are shaped to yield an approximately straight-line frequency calibration. To reduce the backlash to an amount that can be tolerated, a clock spring is mounted on the rotor shaft to place a definite torque on the rotor at all times. This torque throws the worm wheel against the worm, and forces its teeth to engage on the same side regardless of the direction of rotation.

Since these oscillators are to be employed in central offices, where the temperature may vary as much as twenty degrees either way from a mean temperature in the neighborhood of seventy-five degrees Fahrenheit, it was necessary to make it reasonably insensitive to temperature changes. This is not a simple matter, since with a condenser having a temperature coefficient of capacitance of fifteen parts in a million per degree Fahrenheit (which is better than average), a twenty-degree temperature rise would account for a forty-five-cycle change in frequency at the high end of the scale.

If a condenser were made of the same metal throughout, its temperature coefficient of capacitance might be expected to be about the same as the linear coefficient of expansion, since the capacitance is proportional to the area of the plates divided by the distance between them, and the plate area increases by twice the temperature coefficient while the spacing between plates varies in direct proportion to the coefficient. In practice the coefficient is generally larger than this relationship would indicate, however, because of distortion of the structure due to differential expansion between metal parts and between metal parts and insulating materials.

In the condenser used with the 17B oscillator, all the structural parts, including the cast frame, the rotor shaft, the stator support rods, and all spacers, are made of the same aluminum alloy. The rotor plates, however, are alternately aluminum alloy and invar, so that the total area of the plates tends to vary by the same relative amount as the change in separation. In addition, the amount of insulation has been reduced as much as possible, and the type used has a much lower coefficient than materials commonly used. Tests on a number of condensers indicate that the overall temperature coefficient of capacitance is under three parts in a million per deg. F.

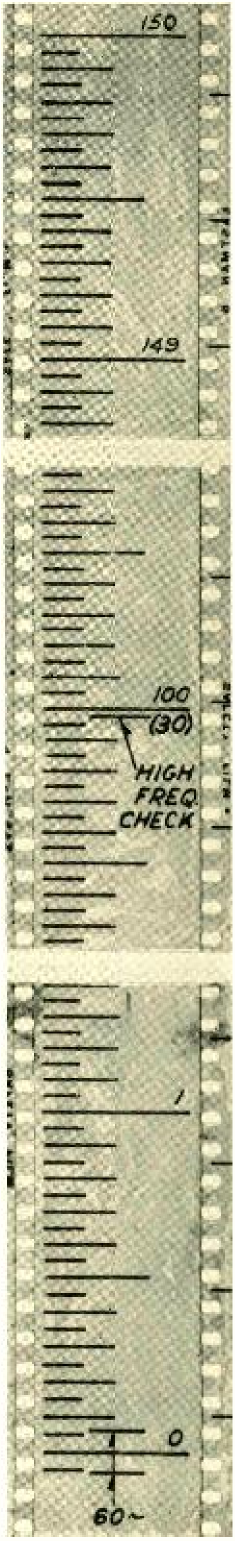


Fig. 2—Sample of 35-mm film used for the frequency scale

Most heterodyne oscillators have been equipped with dials on the main condenser shaft, and the required scale is marked around the periphery of the dial. For this oscillator, however, a dial at least eight feet in diameter would have been required to secure sufficient length of scale on the periphery of the dial.

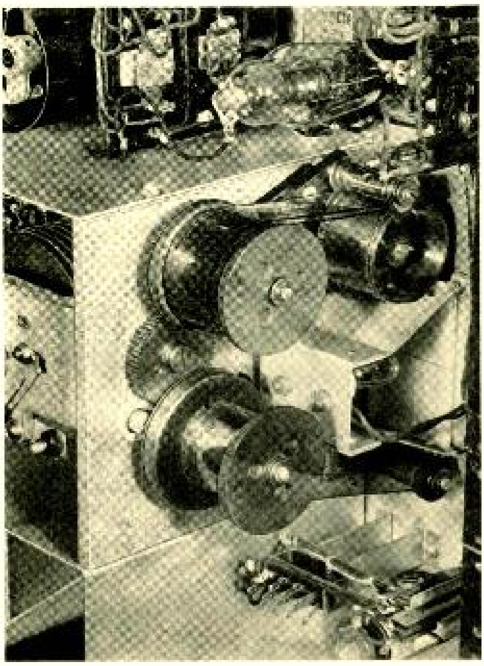


Fig. 3—Film and sprocket arrangement for the 17B oscillator scale

To obtain the equivalent scale length in a small space, the oscillator is provided with a 25-foot length of 35-mm moving picture film which engages with a sprocket on the worm shaft of the main tuning condenser. The scale appears on this film, which is illuminated from behind through an opal diffusing glass. Typical sections from several different parts of the scale are shown in Figure 2. The marking is in kilocycles except for the sixty-cycle marks at the low end of the scale. It will be noted that there are two of these sixty-cycle points. This is because an output frequency of sixty cycles may be obtained when the "variable" oscillator is either sixty cycles above or sixty cycles below the "fixed" oscillator frequency. Both points must be located during the low-frequency check and adjustment, which is described later. From 60 to 130 kc the film is marked at each kc point with a complementary scale in parentheses, the markings indicating the frequencies that must be modulated against the oscillator output to obtain a sum of 130 kc. These figures are provided to facilitate measurements of pilot and carrier frequency levels in the type-K carrier-telephone system.

The frequency is set by bringing a division on the film in alignment with two hair lines, one on the opal glass behind it and one on the glass window through which it is read. As may be seen from Figure 3, the film is stored on two spools connected together by spur gears in such a way that as film is drawn from one spool it winds up on the other. One spool is connected to its driving gear through a clock spring to maintain tension on the film regardless of the varying diameter of the film on the two spools.

A factor of great importance in designing a heterodyne oscillator is to hold the frequencies of the component oscillators within the required precision limits regardless of changes in ambient temperature. A change in frequency of either oscillator has considerable leverage on the output frequency. A change of the fixed oscillator of 0.01 per cent, for example, would affect the output frequency by sixty-five cycles, which is more than twice the allowable tolerance. If not carefully avoided, changes of this magnitude could readily occur since both the capacitances and inductances of the tuned circuit might easily have temperature coefficients of fifteen parts in a million per degree Fahrenheit, and with coefficients of this size a temperature change of seven degrees Fahrenheit would produce a sixty-five-cycle change.

Some natural compensation occurs since the temperatures of the two oscillators tend to rise simultaneously, so that both oscillators tend to change in frequency in the same direction at the same time, and the change in the difference frequency is reduced. Drift is further reduced by securing coils and condensers of small temperature coefficients, and by designing them so that one is positive and the other negative. In the present oscillator the coils have a positive coefficient of under six parts in a million, and the condensers have a negative coefficient of the same order. In addition the condensers for the two component oscillators are matched in pairs so that the differential drift is less than five parts in a million.

To correct for residual drift and ageing of the components, adjustments are provided for making the output frequency agree with the oscillator scale at two points, sixty cycles and 100 kc. At sixty cycles, the frequency of the fixed oscillator may be changed by a trimmer condenser so that its frequency is just sixty cycles above that of the adjustable oscillator. At 100 kc, the capacitance of each oscillator is changed the same amount by a single screwdriver adjustment, but since at this frequency there is more capacitance in the variable oscillator circuit, this adjustment affects the two oscillators unequally, and thus may be used to vary their difference frequency and to bring it into exact agreement with the oscillator scale. Since this adjustment changes the capacitance of both oscillators by the same amount, it has negligible effect at sixty cycles.

The low-frequency point is determined by beating the output against the sixty-cycle power supply frequency through a small synchronizing lamp. For the high-frequency check, a 100-kc crystal is incorporated in the oscillator. When this is connected across the grids of the amplifier

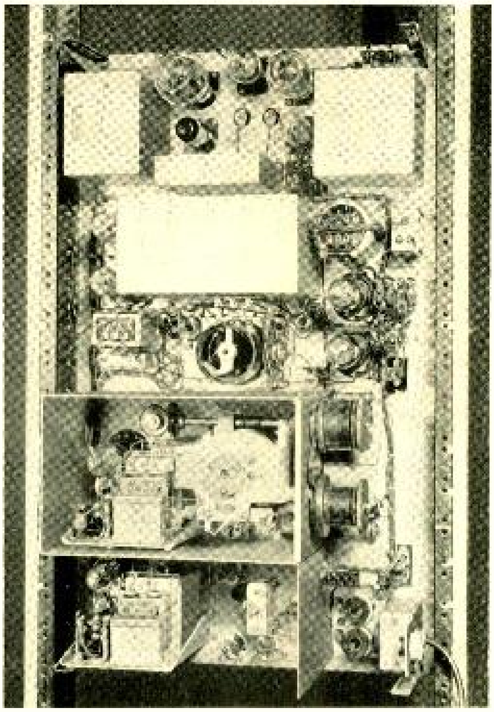


Fig. 4—Rear view of 17B oscillator

stage, it resonates when the oscillator frequency is 100 kc, and a low-resistance shunt is formed that drops the output and extinguishes the synchronizing lamp connected in the output circuit. Keys are provided on the front of the panel for making tests.

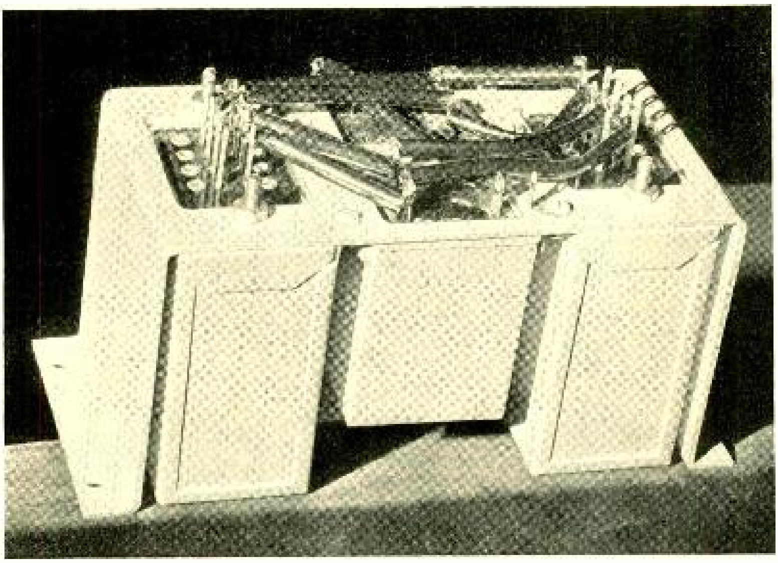
In arranging the apparatus on the panel, care has been taken to place the component oscillators where they will not be subjected to unnecessary heating. As may be seen in Figure 4, they are placed in separate compartments at the lower left. The fixed oscillator is the lower one, and the variable oscillator, with the air condenser, is immediately above it. At the right of the latter are the two spools carrying the calibrated film. Immediately above are the modulator, amplifier, low-pass filter, and output transformer. The 100-kc crystal is at the upper right of this section. The upper section of the panel carries the power supply with its regulator and ballast lamps. The greatest amount of heat is generated in this upper section, and is readily carried away by convection. The next greatest amount of heat arises in the modulator and amplifier section immediately below it. This leaves the two oscillators where they are essentially unaffected by heat from the power apparatus.

The oscillator frequency is controlled by the combined knob and crank at the right in the photograph at the head of this article. Since the film scale moves rather rapidly by the window, and is difficult to read while in motion, a coarse frequency calibration is provided by the dial just at the left of the control crank, which is mounted on the main tuning condenser shaft. The dial at the bottom of the panel provides a frequency change of ± 50 cycles, which is sometimes useful in making tests on crystal filters. The only other controls are a volume control, near the center of the panel, and keys for setting up the low- and high-frequency calibrating conditions, and for selecting the desired output impedance, which may be either 135 or 600 ohms.

The oscillator may be operated from either a fifty- or sixty-cycle supply at any voltage from 105 to 125 volts. The output frequency characteristic is flat to within about 1 db from 3 to 150 kc. Over this range the total harmonics and other spurious frequencies are 37 db below the fundamental for the outputs that are below 100 milliwatts and at least 27 db down for higher outputs.

Elliott Cresson Medals

have been awarded by The Franklin Institute to George A. Campbell and John R. Carson. Dr. Campbell receives his award "in consideration of his life-long study of the theory of electric circuits, resulting in notable contributions to the science that underlies telephony and in inventions of fundamental importance in the art." Dr. Carson receives his "in consideration of outstanding contributions to the art of electrical communications." The awards will be made at the Medal Day exercises of the Institute on May 17.



A Longitudinal-Noise Filter for the Type-K Carrier System

By P. W. ROUNDS
Transmission Networks Development

To a considerable extent, the type-K carrier system will be applied to pairs in existing voice-frequency cables, and it is very common for such cables to connect at various points along their route to open-wire branch lines running to offices off the route of the main cable. As pointed out in a previous article,* high-frequency disturbances are readily picked up by open-wire lines, and if they were allowed to enter the main toll cable, they would ultimately appear as objectionable noise on the carrier pairs. Such noise currents pass over the open-wire lines "longitudinally," flowing over all four lines of a phantom group in the same direction, and thence to ground through the wire-to-ground capacitance of the cable. It was decided, therefore, to insert filters in these branch lines, which would highly attenuate the longitudinal currents in the branch circuits without seriously increasing the loss in the voice paths.

The filter designed is arranged as shown schematically in Figure 1. One filter is provided for each phantom group of the open-wire line, and each consists of two four-winding coils with a condenser connected between each wire and ground. The coil windings are poled so that currents traveling from odd to even-numbered terminals tend to produce flux in the same direction in the cores. The coils thus present their full impedance to longitudinal currents, and minimum impedance to currents flowing in the side or phantom circuits. Currents flowing equally in the four wires from left to right, in other words, encounter

*Record, *March*, 1939, *p.* 206.

maximum inductance because they all tend to increase the flux in the core, while currents flowing down one wire of pair 1 and back the other, or down both wires of pair 1 and back both wires of pair 2 encounter a minimum

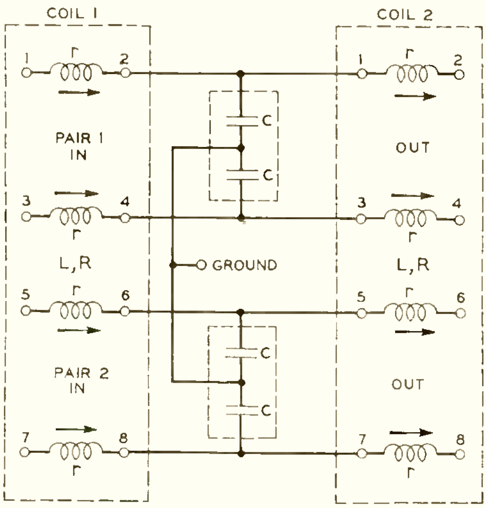


Fig. 1—Schematic diagram of the 81A *noise filter*

inductance because they produce fluxes that oppose each other in the core of the filter.

The coils, developed by S. G. Hale, are made by twisting four insulated wires together spirally, and then winding this conductor cord over a toroidal core of chrome-permalloy tape. This gives a well-balanced winding that minimizes crosstalk between the component circuits. The high permeability of the core permits a large inductance, L, to be obtained with relatively few turns, so that the resistance of the winding to currents in the voice paths, *r*, is kept low, while the high core loss at carrier frequencies furnishes a high effective resistance, R, to the longitudinal currents that produce a net flux in the core.

As a result of these conditions, the filter acts as a different type of network for the three types of circuits—the longitudinal circuit, the phantom circuit, and the side circuit. These are indicated schematically in Figure 2. In the upper diagram, representing the longitudinal circuit, the upper side of the circuit represents the four wires in parallel, and the inductance is the combined inductance of the four windings of each coil. The lower side of the circuit represents the ground return, and the capacitance, since it results from four condensers in parallel, is equal to four times the capacitance of one condenser. The resistances shown represent the parallel resistance of the four windings, which

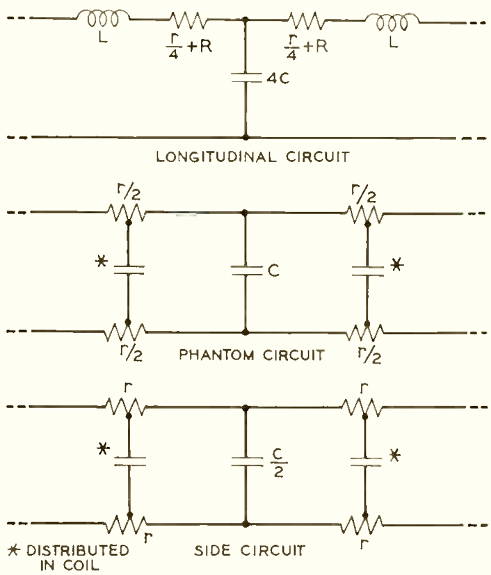


Fig. 2—Equivalent networks for longitudinal circuit, above; phantom circuit, center; and side circuit, below

is relatively small, plus the core losses, which are relatively high.

In the middle diagram, representing the phantom circuit, each side of the circuit stands for the two wires of a pair. There is practically no inductance in the circuit because the flux tended to be caused by pair 1 is balanced by that tended to be caused by pair 2. Moreover, since there is no flux there is no core loss, so that the resistance shown is only that of two windings in parallel. In addition the capacitance is only one-quarter that of the longitudinal circuit — two strings of two condensers in series giving a net overall capacitance equal to that of one condenser alone.

The side-circuit schematic is similar to that of the phantom circuit, except that the resistance is slightly higher—consisting of that of one winding instead of two windings in parallel—and the capacitance is lower because it consists of two condensers in series. Both of these latter schematics are essentially the same as a length of cable, consisting of series resistance and shunt capacitance, and the loss they produce is about equal to 1000 feet of 19-gauge toll cable. The effect of the filters on the voice circuits, therefore, is only about the same as that of an added thousand feet of cable. To the longitudinal currents, however, the action is that of a filter because of the combination of reactance and capacitance, and the longitudinal loss characteristic measured between fixed resistances is as shown

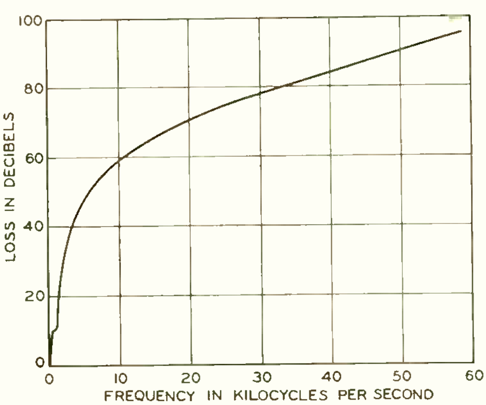


Fig. 3—Longitudinal insertion loss characteristic of a typical filter as measured between fixed resistances

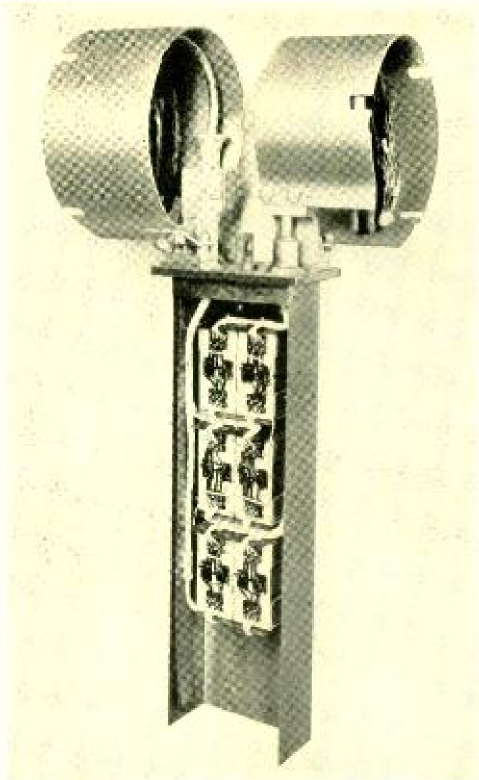


Fig. 4—Partially assembled loading coil case potting six 81A filters

in Figure 3. At 12 kc, the lowest type-K frequency, the loss is over 60 db, and it rises to nearly 100 db at the upper frequency of 60 kc.

The actual suppression realized in practice is less than these values chiefly for two reasons. In the first place, the impedances of the circuits are not pure resistances and are not all of the same value, so that the terminations of the filters in service are not the same as used for the laboratory measurements. Moreover, the carrier-frequency disturbing currents induced in the four wires of a phantom group are not exactly equal, and thus there is a component of the induced current that is not longitudinal. The suppression that is obtained, however, is high enough to reduce the noise from open-wire branch lines to acceptable values.

The filters are assembled as shown in the photograph at the head of this article. Each coil is mounted in a separate sealed container, and the four condensers are in two containers mounted between the other two. From two to thirty of such units are mounted in a sealed case arranged for mounting on poles or in manholes. These cases, designed by J. R. Bardsley, are similar to loading-coil cases, and are hermetically sealed to retain the dried gas that is applied under pressure to toll cables. A partially assembled case of one type is shown in Figure 4. Because of the high-voltage surges sometimes encountered on open-wire lines, and of the inaccessibility of the filters for maintenance purposes, the component parts and wiring have been designed for high dielectric strength. Such precautions help to insure a continued satisfactory performance in reducing the longitudinal noise that may arise from branch lines of open-wire circuits.

Vitamin B_1 and Scientific Endeavor

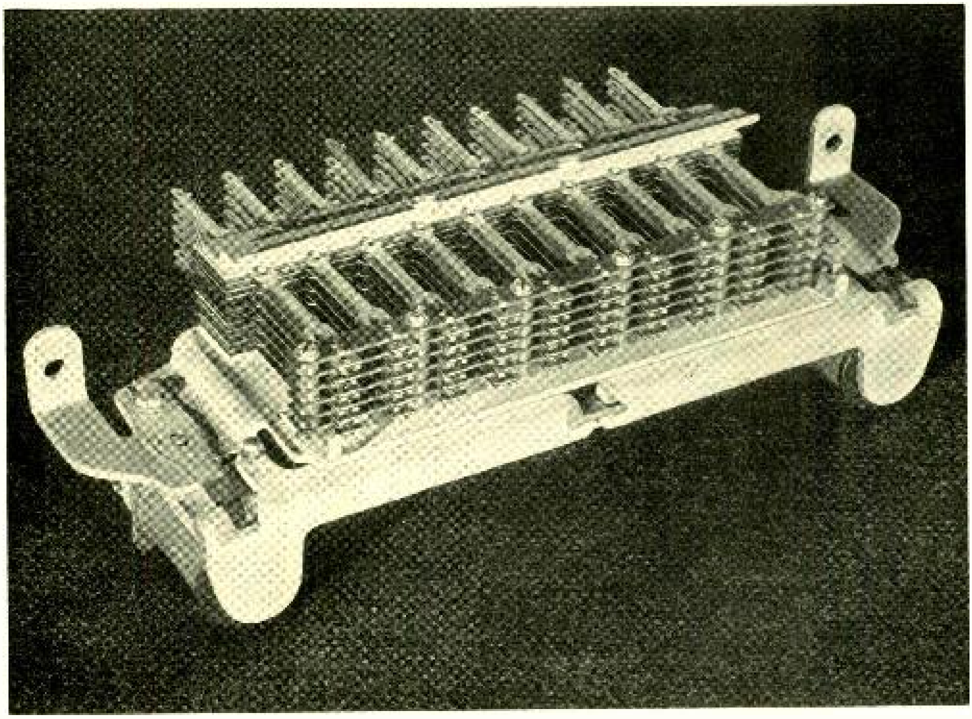
In the March 25 issue of "Nature," R. A. Peters, Whitley Professor of Biochemistry in Oxford University, discussed the recent book "Vitamin B_1 *and Its Uses in Medicine" by R. R. Williams and Tom D. Spies, M.D. Dr. Peters, who is the foremost British authority on Vitamin* B_1*, said in part:*

"The tale which is told by the authors is viewed in the first instance as a problem in practical medicine and in the construction of diets which may be needed to save from the consequences of vitamin B_1 *deficiency even in its milder forms. A particularly valuable feature of the work is the inclusion of the tables of the vitamin* B_1 *content of foods; these will form a basis for future research. This section of the work should be read by all those who are responsible for the maintenance of the health of the community, as well as being a guide in practical medicine.*

"The more medical part forms eight out of the twenty-nine chapters, the latter two-thirds of the book being devoted to the chemical nature and mode of action (biochemical and physiological) of this vitamin.

"The tale of the various functions of thiamin in nature, its need for the growth of micro-organisms, and of the work which has led to the present idea of the intimate connection with carbohydrate metabolism is well told, with due caution and criticism and not without pointers for the future.

"The reviewer has nothing but praise for this work as a whole, for the knowledge which it displays, for its fair judicial outlook, and for its production."



The Multi-Contact Relay

By BRUCE FREILE
Electromechanical Apparatus

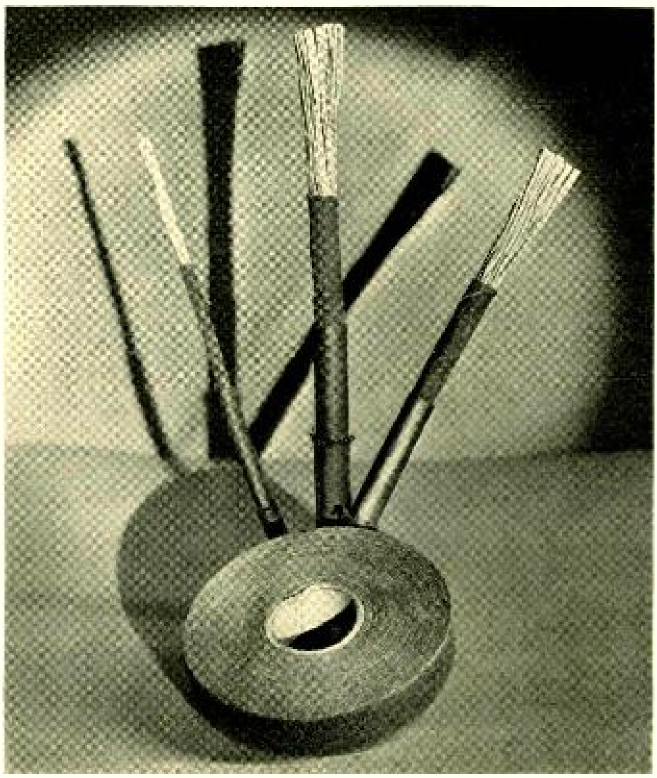
ONE of the interesting features of the crossbar system is the extensive use of common controller circuits. Among the more important of these are the markers and senders and the line-link and sender-link controller circuits. For each call these circuits must be connected to one of their switching units for a very brief interval—usually only a fraction of a second. During this interval, however, a large number of paths must be closed between the controller circuits and the switching unit. As part of the development of the crossbar system, therefore, it was necessary to develop a relay capable of closing a very large number of contacts. The multi-contact relay shown in the photograph at the head of this article was the result.

The relay employs two coils and two armatures, each of which operates half the contacts. The contact springs are arranged in ten pile-ups and each may have as many as six pairs of springs—giving a total of sixty contacts per relay. The complete structure, however, may be used as two independent relays, each with 15, 20, 25, or 30 contact springs, or—by connecting the coils in parallel—as a single relay with double the capacity in contact springs.

The contacts of these relays, as with the U and Y types, are all double.

The end of the moving spring is forked, each tyne carrying a contact, and the fixed spring carries two corresponding contacts. These latter springs have punched holes behind the contacts through which pass small insulating studs that operate the springs. These studs are fastened to the moving springs and are moved by the armature when the relay operates.

These relays are mounted vertically, so that dirt particles do not tend to lodge on the contacts. Tight-fitting can covers, not shown in the photograph, slip over the spring pile-up section, leaving the magnets and armatures exposed. Soldering terminals for the contacts project from the rear, and are arranged—like those of the crossbar switch—so that a straight length of bare wire can be used to connect together the terminals that are to be multipled. Because of the large number of operations the relays must make, careful attention has been given to the mechanical design in order to prevent excessive wear of rubbing surfaces in the relays.



An improved cable for inside wiring which has better moisture-resisting characteristics than similar cable now in use is shown here. The improvement results from the addition of a thermoplastic jacket between the core of the cable and the braid. This jacket makes unnecessary a cord under the braid to aid in stripping; and it permits the cable to be made with a smooth surface and more pleasing appearance.

Contributors to this Issue

A. J. Busch joined the Laboratories in 1922 immediately upon receiving the E.E. degree (cum laude) from the Polytechnic Institute of Brooklyn. After completing the student course, he was engaged in laboratory testing and analysis of both manual and panel telephone circuits for two years. An equal period was spent in designing manual circuits and from 1926 to 1933 he engaged in the design of panel selector circuits. Since 1933, he has designed circuits for the crossbar system.

P. W. Rounds received the degree of A.B. from Harvard University, 1929, and then joined the Transmission Networks Department of the Laboratories. Since then he has been engaged chiefly in the design of equalizers and networks that are used in program and voice-frequency toll circuits.

W. J. Means graduated from the Harvard Engineering School in 1923 after a course in Mechanical Engineering and soon thereafter joined the Western Electric Company at Hawthorne. After two years of manufacturing cost reduction and similar work, he transferred to the Apparatus Development Department of the Laboratories, where he engaged in laboratory development and mechanical design work. Since that time he has worked principally on vacuum tube oscillators, portable testing apparatus, recording meters, and ringing interrupters.

A. J. Busch

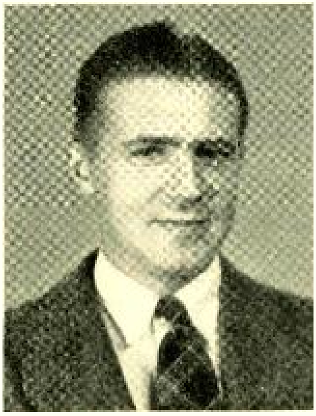
After Bruce Freile graduated from Stevens in 1909 with the M.E. degree, he worked for the Crocker-Wheeler Company. He then came to West Street to take charge of the physical division of the shops laboratory and later headed the chemical and check inspection work. When manufacturing activities removed to Hawthorne he left the company but returned in 1914

P. W. Rounds

W. J. Means

Bruce Freile

G. R. Gohn



W. Y. Lang

R. V. Terry

to design dial apparatus with the Engineering Department and was associated with the work on pulse machines, reciprocating bar type of interrupters, number-checking units and other apparatus. Shortly after the Western Electric Company undertook the manufacture of step-by-step apparatus in 1926, Mr. Freile was placed in charge of a group handling the general engineering of this apparatus. For the past five years he has been supervising the development of crossbar switches, multiple-registration equipment, and the multi-contact relays widely used in the crossbar system.

G. R. Gohn was graduated from Otterbein College with an A.B. degree in 1926. He took graduate work at Ohio State University and at Columbia University where he received a B.S. in Engineering in 1929 and that of Metallurgical Engineer the following June. He then joined the Materials group at the Laboratories to engage in studies of non-ferrous sheet metals, die castings and spring design. In 1932 he spent five months in the Engineer of Manufacture Department of the Western Electric Company. On returning to the Laboratories he continued his general work on metallic materials as well as special studies of fatigue and forming characteristics of spring materials.

W. Y. Lang joined the Laboratories as a Technical Assistant in the design drafting department in 1920. He took the course for technical assistants and afterwards attended City College and Columbia University. From 1922 to 1923 he was with the specifications department and from 1923 to 1927 in the Precision Apparatus Laboratory. Since 1927 he has been a member of the Technical Staff and has been concerned with design work on printing telegraph apparatus.

R. V. Terry joined the Technical Staff of the Laboratories in 1922, after extensive engineering experience with the General Electric Company, Thomas A. Edison, and other manufacturing concerns. He associated first with the Commercial Products Development Department where he took part in the development of public-address, sound, picture, and picture-transmission systems, and of television apparatus and certain features of the transatlantic radio telephone. In 1935 he transferred to Electromechanical Telephone Apparatus development, where he has since been occupied with timing systems and special service clocks.