# BELL LABORATORIES RECORD

*Checking the calibration of a compression testing machine in the Materials Laboratory*

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# Dial Offices for Small Communities

By F. T. MEYER
*Equipment Development*

THE adaptation of improved telephone equipment to the smaller communities, especially those more or less isolated from the larger operating centers, has been greatly facilitated by the development of a new dial office of the step-by-step type. How one of these offices appears to the layman was recently described by W. P. Helm in the World's Work: "When one enters one sees only columns of odd machinery, like metal filing cases, that rise in tiers from the floor to the ceiling. Busy little discs run over the surface of those tiers, darting about at high speed, while here and there a light flashes on and snaps off. One hears a purring made up of many rapid click-click-clicks as the metal discs come in sudden, gentle contact with other metal. Once a day perhaps, an inspector drops in to see if everything moves smoothly. He stays a few minutes, closes the door behind him, and goes away. Through this deserted little building there filters night and day the entire telephone conversation of the little city. The metal panels and discs make the connections and do all the work."

For these small offices step-by-step operation was found best fitted to combine low operating cost with a high grade of service. The equipment, arranged for operation without the constant attention of a maintenance man, is of such a nature as to afford a uniform grade of service twenty-four hours a day.

This new office has been coded No. 360-A and may be used in many communities now served by small manual boards either of the magneto or common-battery type. With a capacity of about 500 lines, it may be economically used in localities with as few as 100. Local calls are dialed and switched in the usual manner but all outside calls, or calls to special service operators such as Information, Toll, and Assistance, are passed to a nearby or master office where they are handled manually. This master office also serves as a maintenance headquarters where all alarms, warning of irregularities at the unattended office, are indicated. In some cases maintenance headquarters and special service operators may be located in different nearby offices.

The "columns of odd machinery, like metal filing cases," that Mr. Helm referred to are of course the step-by-step line finders, selectors, and connectors which have already been described in the Record*. The "busy little discs" are the wipers that move up and rotate around the various levels of trunks and lines. Since the usual capacity of a No. 360-A dial office is less than 500 lines, only three digits need be dialed except for ten-party lines where an additional digit is necessary to set up the proper ringing code. In establishing a connection through the mechanical train only a line finder, one selector, and a connector are required. All three types of switches may be mounted on a single frame.

These switch frames are of the universal type used with the No. 701 PBX, ** and mount switches on both sides. The frames because of their compact construction are easily transported. They are of very moderate height — approximately seven feet — and are self-supporting, thus greatly simplifying their installation in almost any kind of a building. Their portability, of course, simplifies installation work, particularly where a later change in location is necessitated. The relays and equipment required for the line, trunk and alarm circuits are mounted on separate racks of construction similar to that of the switch frames. Instead of using both a main and an intermediate distributing frame, a combined distributing frame is employed which unites the functions of both.

The alarm equipment furnished with these offices is somewhat unusual. It is this equipment that discovers those irregularities requiring the attention of a maintenance man, and transmits the alarms to the nearby maintenance headquarters. All irregularities found are classified mechanically into two groups: those requiring the immediate attention of a maintenance man, and those of a minor nature which may be

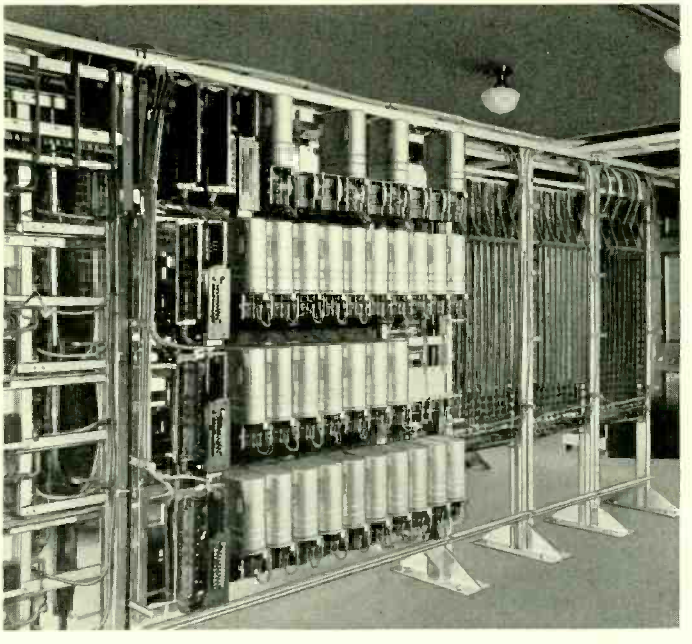


*Fig. 1 — Typical switch frame construction for 360-A office. Line finders are at the top and selectors and connectors are on the three lower shelves*

* Bell Laboratories Record, *Feb.*, 1929, *p.* 236; *Dec.*, 1926, *p.* 174.

** Bell Laboratories Record, *Sept.*, 1929, *p.* 36.

rectified at some more convenient time.

These small offices usually require but very few trunks to the master office, which because of their length are generally expensive. When maintenance headquarters and special service operators are located in the same mas-

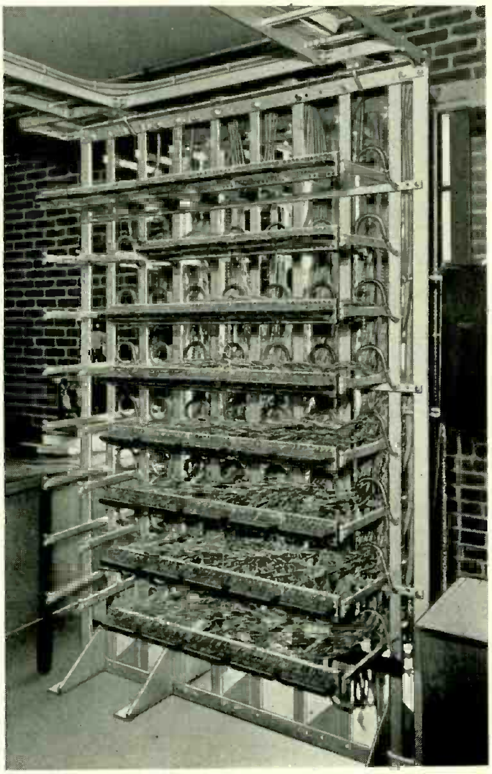


*Fig. 2—Office side of combined distributing frame used with 360-A unattended offices for small communities*

ter office, greater trunk efficiency is obtained by using a single group of trunks for both maintenance and operating purposes. To make this possible the alarm equipment at the small office is provided with a relatively simple selecting device which, when an equipment irregularity arises, seizes one of the trunks to the master office and signals the operator there in the same way as though the local subscriber had dialed the special service operator. When the operator answers she receives a distinct tone which serves as the maintenance alarm signal. Two different tones are used; one indicating the presence of a relatively important and the other an unimportant condition. An auxiliary feature is a provision that enables a maintenance man at the master office or at maintenance headquarters to dial a particular number at the unattended office and to verify the nature of any irregularities reported. When the connection has been established, he will receive a tone indicating the class of irregularity which exists, and thus be able to check the original report or to determine whether the condition has cleared itself. Periodic inspections of the offices are, of course, regularly made for cleaning, testing, and adjusting the apparatus.

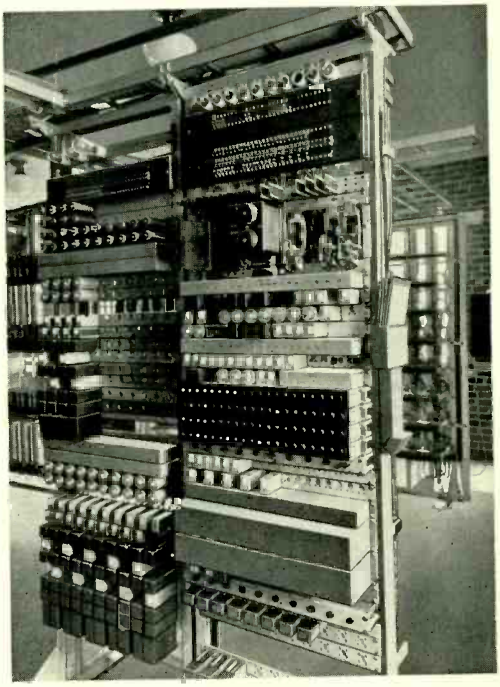


*Fig. 3—Two bays of relay racks in a 360-A dial office*

Two types of ringing machines are available and their selection is determined entirely by the local operating requirements. One is a small panel-mounted unit arranged for intermittent operation. It is thrown into operation only when a receiver is off the hook. The other, arranged to furnish ringing for four-party full selective lines, is designed for continuous operation only.

All subscribers, with the exception of ten-party lines, are assigned distinctive terminal numbers: an arrangement referred to as terminal-per-station service. Four-party semi-selective service may be provided, however, with the same equipment. For ten-party lines an extra digit is dialed to select the proper ringing code, and the ten-party connectors differ from the regular connectors in embodying a rotary switch to provide this service.

In general the same classes of service are available as in regular central offices, except that no message rate or prepayment coin box service is provided. Coin box lines are operated on a post-payment basis, the operator requesting the deposit of the coin after the connection has been established. These lines are assigned terminal numbers and may receive calls in the same manner as other subscribers. Calls originating at pay stations, however, are carried through special switches which act as selecting or concentrating devices for routing these calls over trunks to the master office where they are handled by the operators there. With the exception of pay stations, subscribers are provided with dial instruments, and other subscribers or the various special service operators are dialed in the usual manner. The subscriber may be unaware that the office in his community is unattended.

*Fig. 4—An automatic power plant is included in the equipment for the 360-A unattended office*

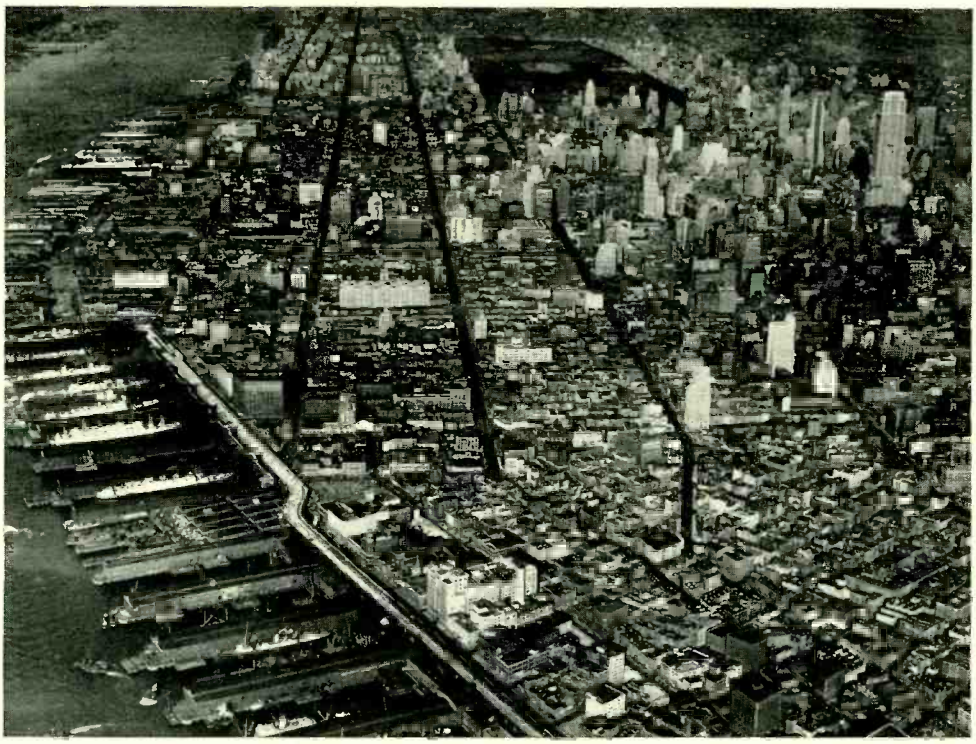
For communities of much more than 500 lines, the economic value of the No. 360-A equipment rapidly diminishes. To meet the requirements of the larger communities a new office, which will be coded No. 350-A, is being developed. This larger office employs equipment essentially the same as used for regular step-by-step offices,* and is available in two sizes, one using frames nine feet high and the other with the standard eleven-foot six-inch frame used in regular central offices.

For offices below 100 lines, two small units are being developed and

* Bell Laboratories Record, *Sept.*, 1927, *p.* 7.

will be coded No. 370-A and No. 370-B with respective capacities of ninety and forty lines.

Both the No. 370 and No. 350 equipments, like the No. 360-A, are arranged for operation without the constant attendance of a maintenance man. With the completion of the new developments there will be available for field use a selection of improved telephone equipment with a wide range of application and flexibility.



Fairchild Aerial Photo Service

*In the central foreground, the light-colored group of buildings is Bell Laboratories. In the upper center is Central Park; and at the upper right, the Empire State Building*

# Recording Contour Gauge

By E. C. ERICKSON
*Telephone Apparatus Development*

THE faithfulness with which a telephone transmitter converts sound into equivalent electrical waves depends to a large extent on the design and action of the diaphragm. Proper performance requires that it be both accurately constructed and so mounted that the voice vibrations are correctly transmitted to the mass of carbon granules where the conversion to electrical waves is accomplished. The diaphragm for the handset transmitter has three seating surfaces which are employed to position it accurately between the mouth of the cavity containing the carbon granules and the supporting frame. Irregularities of these surfaces in either parallelism, flatness, or in the separation of their planes, affects the operation of the transmitter. To determine how much variation might be allowed in these characteristics without appreciably affecting the quality of transmission, and thus to determine proper manufacturing tolerances, it was necessary, as part of the development work, to measure a large number of diaphragms very accurately, assemble them in handsets, and then compare the quality of transmission with the variations in the diaphragms.

*Fig. 1—Cross section of handset transmitter showing the position occupied by the diaphragm*

The handset diaphragm may be seen in Figure 1, but the relative positions of the three seating surfaces are more clearly indicated on the schematic diagram of Figure 2. Measurements taken must determine variations in flatness and parallelism of these three surfaces, and also the distance between their planes. Punched from duralumin sheets only three thousandths of an inch thick, the diaphragms are exceedingly delicate and care must be taken so that the measuring device will not itself cause distortion by bending them.

These variations were determined where only a few samples were concerned by taking point-by-point micrometer measurements around the diaphragm. A special measuring pointer with a very light measuring pressure was employed. Not only was this method dependent on the personal equations of the tester, but the time required was considerable. Nearly a day was necessary to secure measurements on an adequate number of points around the three seating surfaces of a single diaphragm. For a man to measure the requisite number of diaphragms in this manner would have required a number of years so that it was necessary to develop a measuring device which, with the same or greater accuracy, would be capable of much more rapid measurements than the hand method.

As finally perfected, the apparatus is shown photographically in Figure 3 and diagramatically in Figure 4. The diaphragm rests on the rotating table of a small jig, shown in greater detail in Figure 5. One end of each of three pivoted feelers rests on the diaphragm along a radial line. Two of them rest on two of the actual seating surfaces while the third rests on the back of the third surface. Since variations in thickness of the metal of the diaphragm are very minor, no appreciable error was introduced by this arrangement. The other end of each feeler carries a wire a thousandth of an inch in diameter and the ends of the feelers are bent so that the three wires lie one above another in the focal plane of a light projector.

Shadows of the tips of the three wires are projected onto three prisms, each of which refracts the shadow of one wire down through a cylindrical

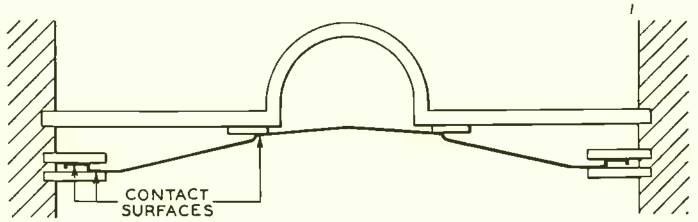



*Fig. 2—Schematic diagram indicating the positions of the three seating surfaces of the diaphragm*

lens to a photographic recorder. The cylindrical lens is ruled with lines one-eighth inch apart which form ordinate lines on a strip of photographic paper which, carried by an electric motor, passes through the light field below the lens and then through developing and fixing baths. A belt attached to the recording mechanism also drives the table carrying the diaphragm.

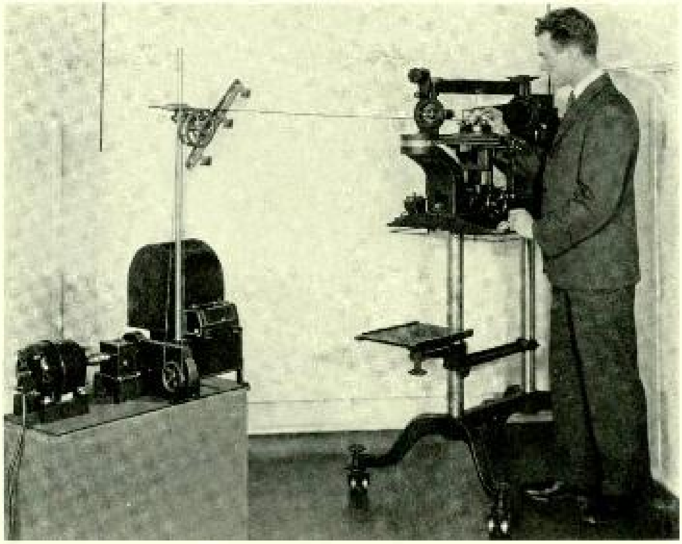


*Fig. 3—R. O. Sloan with the apparatus for measuring irregularities in diaphragm seating surfaces*

As the diaphragm is rotated each of the feelers moves up or down as the surface deviates from a plane. The travel of the wire pointers on the ends of the feelers is recorded on the photographic tape and forms a permanent record of the variations in the diaphragm. The magnification of the vertical motion of the levers is exactly 125 so that one-eighth inch on the paper—the spacing of the ruled lines—is equivalent to one thousandth of an inch on the diaphragm.

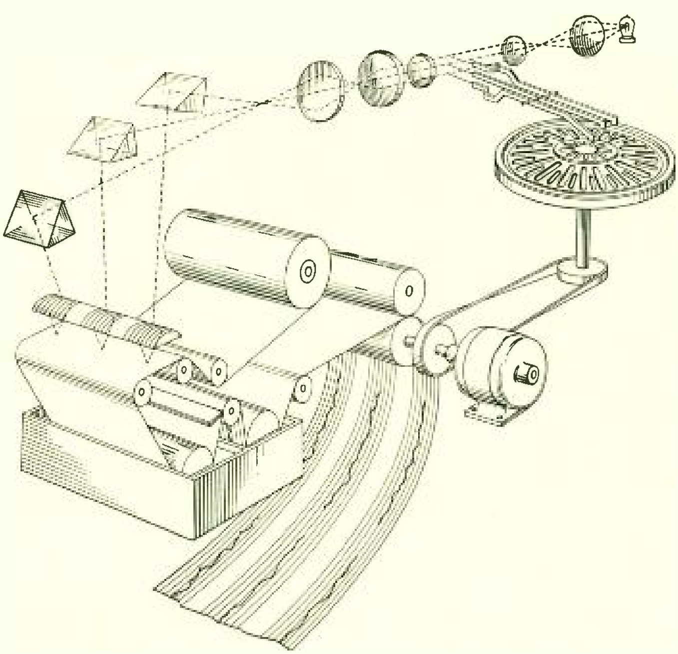


*Fig. 4—Diagrammatic sketch showing essential elements of measuring apparatus*

Two typical records are given in Figure 6. One shows a fairly good diaphragm and the other a poor one. From such sets of curves considerable information may be obtained. If the surfaces were perfectly flat and parallel, the traces on the paper would be straight and also parallel. The amount they

*Fig. 5—Small fingers ride on the diaphragm while it is rotated*

deviate from straightness is directly measurable since each horizontal ordinate corresponds to a thousandth of an inch. The interplanar distance between any of the seating surfaces may also be obtained in thousandths of an inch by a proper calibration of the chart.

In addition to these principal measurements, it is also possible to see the type of distortion existing in the diaphragm. One line fairly straight, for example, and another varying unevenly—with jagged breaks—shows that that particular surface is rough while the diaphragm as a whole is undistorted. A similar wavy characteristic of all three lines, on the other hand, indicates a warp of the diaphragm as a whole.

With this rapid method of measurement it was possible to obtain curves of 10,000 diaphragms in one week. An electrically operated mechanism was devised which on pressing a foot switch raised the three feelers so that a new diaphragm could be inserted, and at the same time connected a resistance in the circuit of the driving motor to slow down its speed. This arrangement cut down the amount of photographic paper between successive diaphragm records.

Although this apparatus was developed primarily for measuring the ring seating surfaces of diaphragms of handset transmitters, it is rapidly finding other uses. It may be employed to measure distance of separation, flatness, and parallelism between all sorts of ring surfaces or for studying the accuracy of concentric bearings or shafts. Also it will serve to determine the contour of miscellaneous parts such as machine screws. The large optical magnification allows very small deviations of the measured surface to be easily determined.

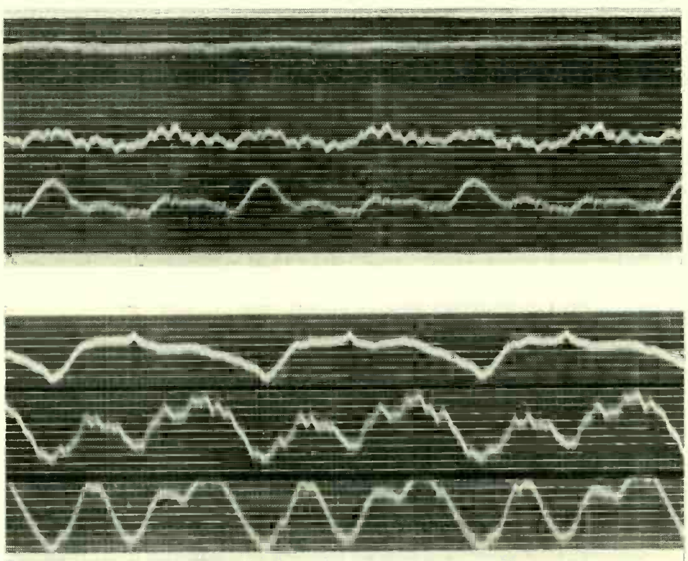
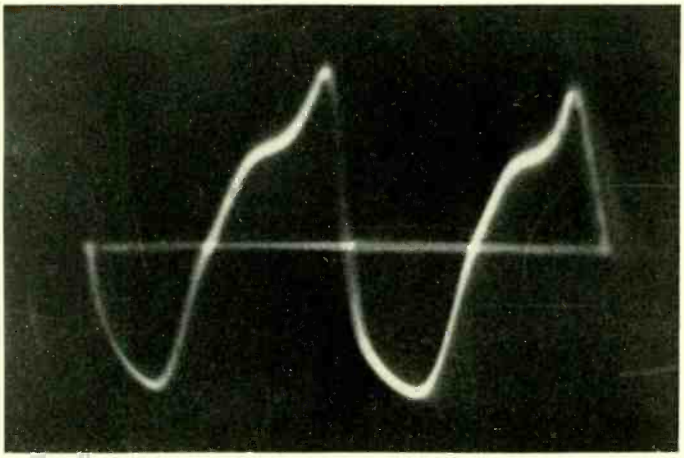


*Fig. 6—Photographic record of two diaphragms. The upper is a fair average diaphragm and the lower a poor one*



# A Linear Time Axis for a Cathode-Ray Oscillograph

By A. L. SAMUEL
*Vacuum Tube Development*

WITH an oscillograph of the commonly used vibrating type, the time scale is obtained by moving a sensitized strip of paper across the vibrating light beam at a constant speed. Under these conditions the time axis is said to be linear since the distance in the direction of the paper between any two points on a curve traced on it is directly proportional to the elapsed time. With the cathode-ray oscillograph, on the other hand, the only moving element is the stream of electrons. If a uniform time axis is desired some arrangement must be provided to move the beam across the distance separating one of the pair of vanes at a constant speed.

To study the wave shape of some alternating voltage, for example, the voltage would be impressed across the plates *x* and *y* of the cathode-ray tube indicated in Figure 1. The electron stream would then move up and down as the voltage passed through its cycle of values. This action by itself would give only a vertical straight line on the front of the tube. To spread this line out into a time-voltage curve, the electron stream must be moved horizontally across the tube at a constant rate. When this is done the number of complete cycles seen on the front of the tube will depend on the relation of the frequency of the voltage depicted to the time of the horizontal motion, and to procure a stationary curve the electron stream must be made to superimpose successive groups of cycles. This is accomplished by causing the electron stream, after it has traced one group of cycles by a steady motion from left to right, to return rapidly to the left side again and start tracing another group. There is thus a double motion of the electron stream: an up and down motion in synchronism with the voltage variations being studied and a back and forth motion which is relatively slow but at constant speed from left to right followed by a very rapid return motion from right to left.

The frequency of this second motion must be some even multiple of the frequency of the exciting wave so that the various recurring sections of curve will be accurately superimposed

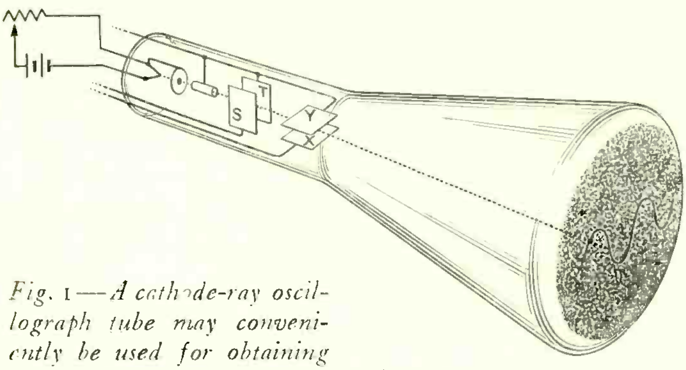



*Fig. 1—A cathode-ray oscillograph tube may conveniently be used for obtaining stationary images of recurring phenomena at voice frequencies by using one of the pair of plates to supply a linear time axis*

on one another. The actual motion of the electron stream for such a curve would be as indicated on Figure 2. If the frequency of the voltage curves shown in these illustrations were 1000 cycles per second, that of the sweep circuit, the circuit providing the time axis, would be 500 since while the voltage curve goes through two cycles the sweep circuit moves through one. The essential requirements of such a sweep circuit are that its frequency be exactly an even multiple of the frequency to be measured, that the time of motion from left to right be large compared to that from right to left, and that the motion from left to right be a linear function of time.

Until recently it has been customary to obtain the requisite action of the sweep circuit by employing a cold-cathode discharge tube in conjunction with a condenser which is slowly charged through either a resistance or a thermionic tube. The charging of the condenser produces a steady rise in voltage that slowly sweeps the electron stream across the cathode-ray tube, and the discharge of the cold-cathode tube, when the voltage across it reaches some definite value, by immediately discharging the condenser, rapidly sweeps the stream back to the starting point.

The arrangement when the condenser is charged through a resistance is shown in Figure 3. When the battery circuit is first closed the voltage across the condenser, and thus across the cold-cathode discharge tube, is zero; but it steadily rises as the condenser charges through the resistance, and when it reaches the sparking voltage of the tube the condenser rapidly discharges through the tube until the extinction voltage is reached, when another cycle starts. By connecting the tube terminals across the plates *ST* of the cathode-ray tube the timing horizontal movement of the electron stream is obtained. The

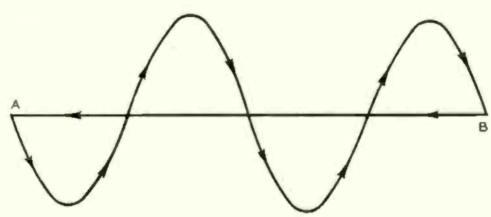



*Fig. 2—A sweep circuit moves the electron stream across the tube at a constant speed and then rapidly returns it to the starting point*

objectionable features of this circuit have been the inconveniently high sparking voltage required; and the erratic, unreproducible, and uncontrollable characteristics of the tube.

To avoid these difficulties the Laboratories recently developed a sweep circuit employing a three-element gas-filled tube of the hot-cathode type. The slight increase in the complexity of the circuit, due to the hot cathode and the grid, is more than compensated by the constant characteristics and lower operating voltage of the hot-cathode tube, and by additional control which is possible by means of the grid. With the three-element tube the striking potential is no longer uncontrollable but depends on the potential applied to the grid. This additional controlling element makes it possible to control the frequency of the sweeps more accurately and to maintain a constant relationship between it and the frequency of the phenomenon which is being measured.

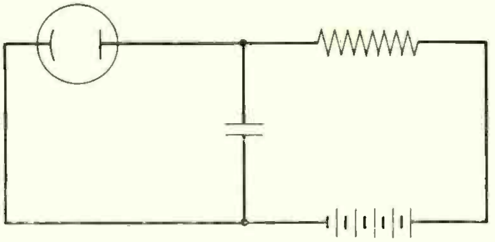


*Fig. 3—A cold-cathode tube in conjunction with a condenser, charged through a resistance or a thermionic tube, has been commonly employed for sweep circuits in the past*

Although many forms of gas-filled tubes may be used for the purpose, that employed in the apparatus described below is the Western Electric No. 269-A tube, the characteristics of which are given in Figure 4. The breakdown voltage of this tube depends on both anode and grid voltage, and when it is reached current at once flows, and the voltage across the tube drops to the extinction potential which is about twenty volts. Whether or not the discharge is extinguished, however, depends on whether the anode potential is maintained at twenty volts or allowed to drop below it. If it drops below and remains below for a short but definite interval, which is a characteristic of the tube, the discharge will cease.

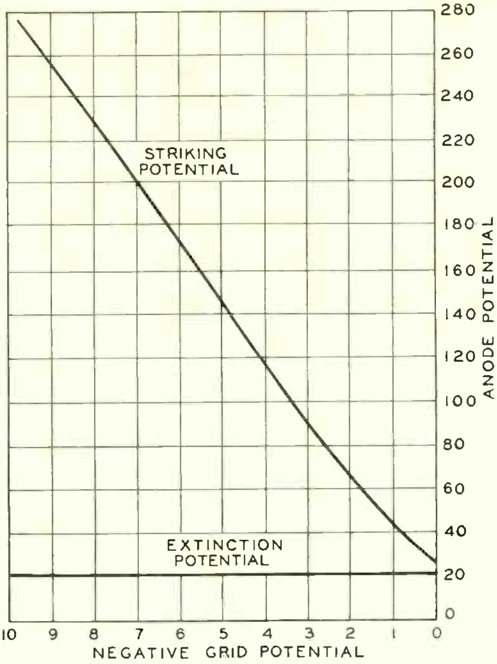



*Fig. 4—Characteristics of the 269-A tube as it is used in sweep circuits*

A simple form of sweep circuit, using the three-element tube and arranged to charge the timing condenser through a resistance, is shown in Figure 5, and a graphic representation of the sweep cycle in Figure 6. During the period $T$ the condenser is charging and the beam of the cathode-ray tube will be swept across the tube at a nearly constant rate. When the striking potential is reached the voltage

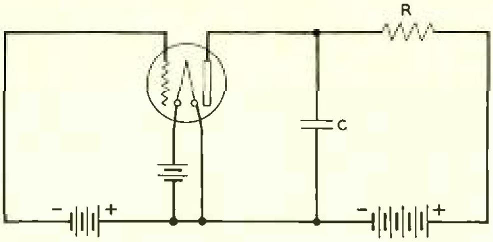



*Fig. 5—The employment of a three-element, hot-cathode tube adds a second element of control in the grid*

immediately drops to the extinguishing potential and, with proper circuit conditions, will go below it where, after a definite but very short interval, *t*, the discharge will cease and a new cycle will be begun. The interval *t* thus represents the rapid return stroke of the electron stream of the cathode-ray tube.

The frequency of the sweep stroke is the reciprocal of the sum of *T* and *t*. The charging time of the condenser *T* may be varied by changing the values of the resistance, the capacity of the condenser, or the battery and grid voltages, so that the frequency of the sweep may be adjusted to any value from a very few cycles per second up to an upper limit of about 10,000 for the tube under discussion. The upper limit of frequency is determined by the time, *t*, which is a characteristic of the tube. As a rule the condenser capacity will be of the order of 0.1 microfarad and the resistance, in general, should be above 100,000 ohms. The connections of the sweep circuit to the cathode-ray tube are shown in Figure 7.

The rate at which the condenser charges is independent of grid voltage but the time, *T*, during which it charges is not, since this time is controlled by the striking potential which in turn is affected by the grid voltage.

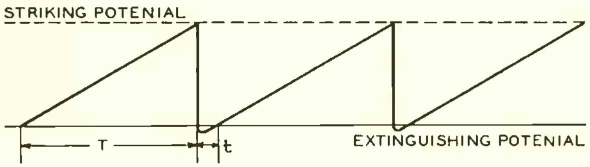



*Fig. 6—During the period T the condenser is charged, which slowly moves the cathode stream across the face of the tube, and during t, it is rapidly returned to the starting point*

This fact makes it possible to use the grid circuit to synchronize the sweep cycle accurately with the frequency being observed. By coupling to the grid circuit, as indicated in Figure 7, an alternating potential in phase with the input circuit being measured, it is possible to shorten or lengthen the charging period, *T*, so as to bring the instant of striking always at a given phase of the input wave. The normal characteristics of the tube, and values of the parameters will make the period *T* approximately correct

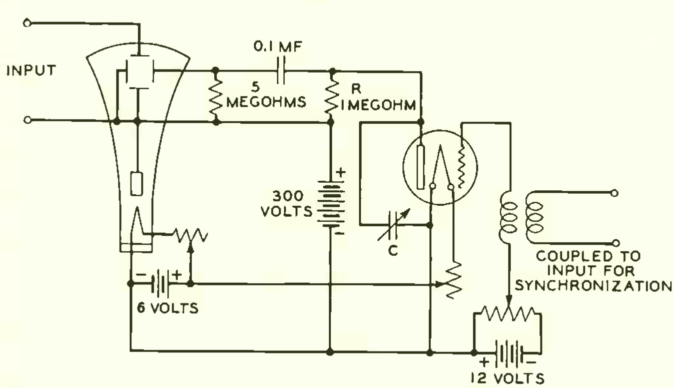



*Fig. 7—An alternating potential coupled to the grid circuit furnishes an accurate method of synchronizing the sweep circuit to the input circuit*

but the superposition on the grid potential of a small voltage which depends on the phase of the input circuit will suffice to cause the return sweep to occur always at the same point of the input wave.

The charging of a condenser through a resistance is an exponential function of time which over a short section of the earlier part of the charging period is very nearly a linear function of time. This simple method of charging through a resistance is adequate for the majority of purposes where the time axis need not be very accurately linear. When more exactly linear characteristics are required the resistance is replaced by a two-element thermionic tube, as mentioned, which gives the desired linearity of time.

Equipment of this type employed in Bell Telephone Laboratories is shown in use in Figure 8. This apparatus is a self-contained unit with all controls brought to a panel on the front. Visual observations may be made as shown in the photograph, or photograph films may be used and a permanent record made. The apparatus has found valuable employment for studies in the audible frequency range wherever the need for an accurately linear time axis is paramount.

*Fig. 8—C. A. Kotterman making an observation on the apparatus developed for uses within Bell Telephone Laboratories*

# "—And the Operator Will Answer"*

By R. C. DAVIS
*Local Systems Development*

On lifting the receiver, a dial subscriber finds himself in communication with a mechanical servant of matchless attentiveness and obedience. Nor does this servant take offense when, wishing human aid, the subscriber dials "Operator". The mechanism is aware that there are services which demand an intelligence typically human; and in many instances it will itself refer the subscriber to an operator, if he does not ask for one. In each dial office, therefore, there are operators to supplement the mechanism, sitting at a comparatively small manual switchboard known as the DSA (dial system "A") board.


A subscriber often wishes to make a call to a station which he cannot dial directly. At times he merely wishes assistance in placing a call which his dial could normally complete, or to report a service irregularity. Occasionally he must request assistance from the operator in sending police, fire apparatus, or an ambulance when emergency prevents him from remaining at the telephone. The cases in which a subscriber may wish the aid of an operator are diverse and vary with locale. The first two mentioned are of universal occurrence, however, and account for the greater part of the need for human assistance. In all these circumstances the subscriber will dial "zero" and receive a trunk to the DSA board where an operator will answer.

When a subscriber requests an operator to place an out-of-town call, she will do one of two things. If the call is to a nearby point, as from a city to one of its suburbs, she will connect the subscriber with the distant office, either directly or through the intermediary of a tandem office, supervise the call, and record its details on a ticket for billing purposes or collect the prescribed coins at a coin box. If the DSA operator finds that the subscriber's call is of the sort she cannot complete, she will connect the subscriber, and pass the details of his call, to the toll office, where a toll operator will complete, supervise and record the call.

If a subscriber has repeatedly dialed a station and has received a busy signal or no answer, he may dial the operator, feeling that she may be able to obtain the station. At his request she will herself call the station. Even though she too is unable to complete the connection, he is often better satisfied if the operator verifies what

*Introductory pages of a telephone directory.

the mechanism has told him. Her greater familiarity with the system will often enable her to correct some misunderstanding of the subscriber's which has led to his making the "assistance call".

When a subscriber moves so that he must be assigned a new number, his old line is for some time not reassigned but connected to a trunk leading to the DSA board. If this old number is called an operator will answer on the trunk, ask what number was called, consult her records, and give the caller the subscriber's new number. The operator also provides this "intercepting service" on lines temporarily out of order.

A subscriber on a party line, wishing to call a fellow party whom he cannot dial himself, will give the operator the number of the station and tell her that it is connected to his line. She will ask him to hang up and will dial the party herself. On then removing his receiver, the subscriber can converse with the called party when he answers.

In dial offices where the panel system is used, senders* store the subscriber's dial pulses and control the action of the selectors. If the subscriber dials improperly, or a line becomes grounded or short-circuited, the sender may be stuck. If a subscriber were connected to the sender, his call would be delayed as long as the office remained unadvised of the sender's condition. The sender is accordingly designed so that, if not freed in a predetermined time, it automatically informs the operator. Immediately she answers on a trunk asking the subscriber to hang up and dial again. She will then attempt to free the sender in trouble; failing in that, she will report the trouble to the maintenance force.

Here and there in dial offices, operators furnish numerous other services. There are areas where rural lines terminate at a dial office, and calls from subscribers dialing the rural numbers or a rural code are completed by the operator. In some panel dial installations there is apparatus which times each call from a coin-box station, collects the coin near the end

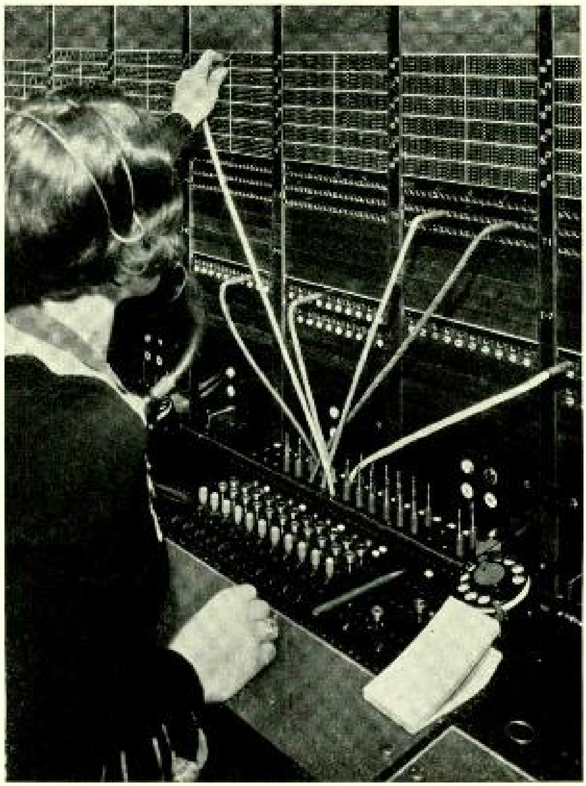


*Fig. 1—A typical special-service position in a panel central office has special-service cords, jacks to incoming and outgoing trunks, and (above) a multiple of number-checking test-terminals*

*Bell Laboratories Record, *December, 1928, p.* 143.

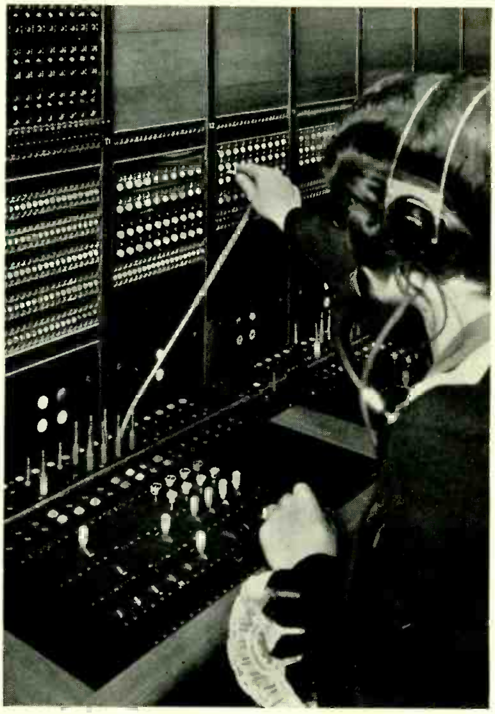


*Fig. 2—Typical sender-monitor position for a panel central office, showing intercepting cords, sender-monitor jacks, and jacks to permanent signal holding trunks and to lines temporarily in trouble*

of the initial period, and later informs the operator that another coin should be collected. The operator then requests the caller to deposit an additional coin and monitors to ensure that he does so.

It is obvious from this summary of some of her duties that the function of the DSA operator is varied and interesting. She is called upon from moment to moment to perform quite diverse services, which are all rather complicated, since the dial mechanism handles the simpler functions of the office. The DSA switchboard itself, therefore, is so arranged as to simplify her task as much as possible.

In general the board is not unlike any other manually operated switchboard. Instead of with the usual subscribers' jacks, however, the face of the board is equipped with jacks and lamps for answering on the various trunks terminating at the switchboard. On the face, outgoing trunk jacks are also to be found, for completing calls from the incoming trunks. The keyshelf of each position is equipped with double-ended cords and their associated lamps, ringing and listening keys, and a dial or a ten-button keyset.

As far as possible the different types of call are brought in over different trunks, grouped so as to indicate to the operator the type of service she will be expected to perform on answering. Thus over one group of trunks come the calls of subscribers who have dialed "zero". Calls in which for some reason the sender has become stuck arrive either on a "permanent signal holding" line or, if district selections had started before the sender was stuck, on a "sender-supervisory" line. Calls to or from rural lines, from coin stations where overtime charges are required, and from toll offices, all arrive over special trunk groups of their own. In answering most of these calls the operator uses her regular "special-service cords", but intercepting calls and sender-monitor work she handles with "intercepting cords".

In the continuing development of dial systems, of course, some of the functions now performed by the DSA operator may some day be done mechanically, but it can readily be seen that there are classes of service where the intelligence of an operator may never be replaced by a machine.

# Repeaters for Two-Wire Toll Circuits

By R. L. CASE
*Toll Systems Development*

TELEPHONE repeaters are the foundations on which the present extensive system of long distance telephony is built. Although without them it is possible to talk over considerable distances by employing large conductors and heavily loaded lines, overall economy favors the use of repeaters and less expensive lines even over distances of a few score of miles. Vacuum tubes, which are universally used as the amplifying elements of repeaters, are one-way devices; gain is obtained for only one direction of transmission. As a result it is necessary either to use a four-wire circuit with one pair of conductors carrying the conversation in one direction and the other pair conveying the return conversation, or with two-wire toll lines to employ a circuit at repeater stations which, while permitting conversations proceeding in either direction to be amplified, prevents the amplified output from affecting the input of the repeater. Were it not for such a provision, any impulse received at the repeater would produce a "singing" condition which would make communication impossible.

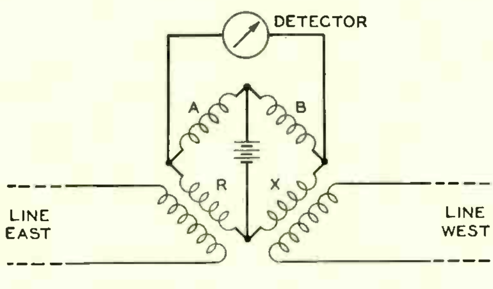



*Fig. 1—Two-wire repeaters employ a bridge circuit to prevent the amplified output from affecting the input circuit*

This circuit, a modification of those used earlier for telegraph repeaters, is based on the principle of the Wheatstone bridge. The similarity of principle is brought out by Figure 1. Here the detector represents functionally the repeater input, and the battery, the repeater output. It is assumed that the two are associated so that the battery circuit is closed only when the detector is actuated. Arms R and X are coupled to the lines east and west respectively. A signal coming from the east disturbs the balance of the bridge and actuates the detector. This in turn closes the battery

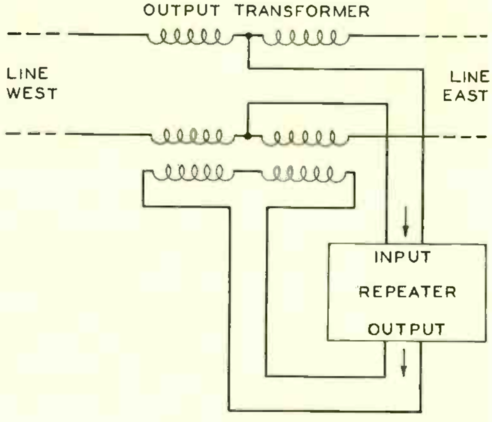



*Fig. 2—The 21-type repeater employs but a single amplifying element and is limited in its use by the requirement that the lines in opposite directions must balance each other*

circuit which, through the coupling of X, sends on a similar but stronger signal west and returns a like signal to the line east through the coupling R. Because of the balanced bridge connection, however, the battery impulse has no effect on the repeater itself.

The adaptation of this circuit used with telephone repeaters may employ either one or two amplifiers. In the former case the repeater is referred to as of the 21 type, where the 2 stands for amplification in two directions, and the 1 for one amplifying element. When two amplifiers are employed, the repeater is of the 22 type: providing amplification in two directions by two amplifying elements.

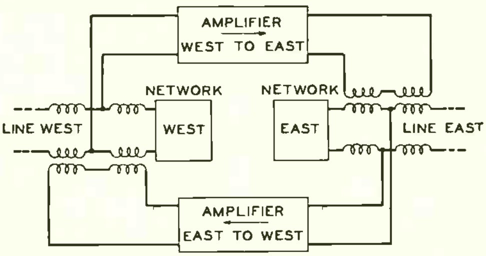



*Fig. 3—Employment of balancing networks and two amplifying elements results in the broader applicability of the 22-type repeater*

The circuit arrangement for the 21 type is indicated in Figure 2, where the particular transformer arrangement is known as a hybrid coil. The lines in the two directions must have approximately similar impedance characteristics in order that the bridge circuit may be in balance. Conversation proceeding in either direction enters the input of the repeater element and an equal amplified output is transmitted in both directions. That returned to the speaker serves no useful purpose, but that transmitted on to the listener is many times the received energy in value and is the useful amplified transmission. This arrangement is not adapted to lines requiring more than one repeater in tandem because, owing to the appreciable time of transmission over lines long enough to require more than one repeater, the energy transmitted back to the speaker would arrive late enough to become an objectionable echo. Because of this fact and the requirement that the lines on the two sides of the repeater station must balance each other, the 21-type repeater has had only a limited use.

The 22-type repeater, now generally used, employs what is essentially two of the 21-type circuits. The input of one amplifier is connected to the hybrid coil of the line east, which is balanced by an east network instead of by the line west. This network is designed to have impedance characteristics like those of the line it balances. The output of this amplifier is connected to the hybrid coil of the line west as shown in Figure 3. The amplified output energy is divided in two as with the 21-type repeater. Half of it flows west as the amplified transmission and the other half, instead of being returned to the line east as an echo, is dissipated in the west network.

Repeaters were first extensively used for the transcontinental line of 1915, but have been considerably im-

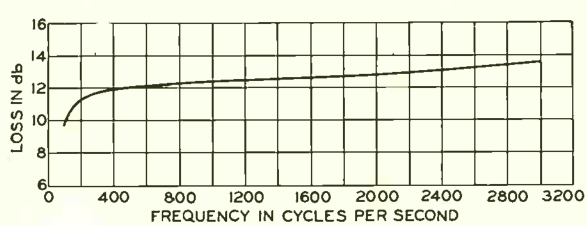



*Fig. 4—Loss-frequency characteristics of a 50-mile section of 16 gauge H-44-25 loaded cable circuit*

proved since that time.* A few years ago, the 22-type repeater was redesigned with the object of taking advantage of many years of experience and the impedance. Although the loss per mile at any one frequency varies for different types of lines, it is alike for all in increasing with frequency.

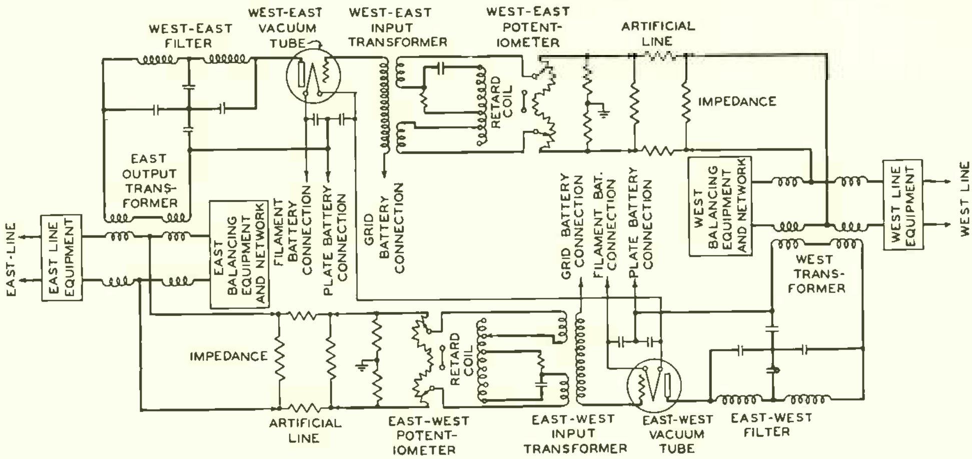



*Fig. 5—A simplified schematic diagram of the 22-A-1 repeater*

and of all recent developments, and of making a single design serve for all lines. The chief characteristics of a line that affect the repeater design are the variation of loss with frequency, The loss-frequency characteristic of a fifty-mile section of one type of loaded cable circuit is given in Figure 4. By designing a repeater, in which increase in gain with increase in frequency was adjustable, it was possible to make a single repeater satisfactory in this respect for any line.

The impedance differences between the various types of line were taken care of by designing the repeater to have an impedance of six hundred ohms, and then by using a repeating coil of proper ratio between the line and the repeater.

The repeater so designed, known as the 22-A-1, is shown in simplified schematic form in Figure 5. On the upper part of Figure 6 is given a typical gain-frequency characteristic for the repeater and associated equipment arranged for the cable circuit of Figure 4, and on the lower part for the com-

** A full discussion of the theory and practice of repeaters was presented before a joint meeting of the A.I.E.E. and the I.R.E. in 1919 by Bancroft Gherardi and Frank B. Jewett.*

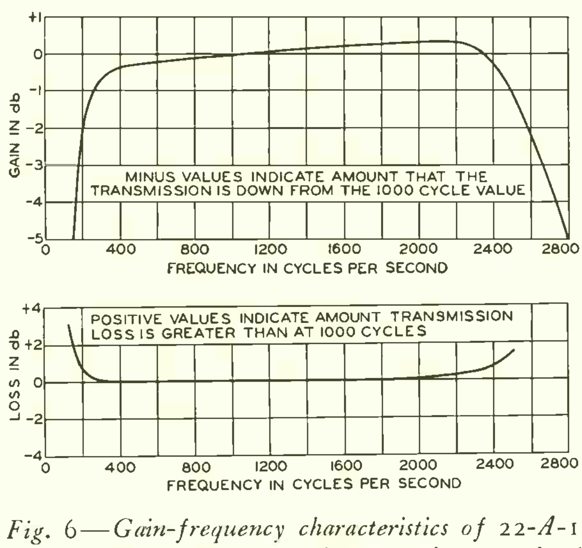



*Fig. 6—Gain-frequency characteristics of 22-A-1 repeater and associated equipment, above, and of repeater and 50-mile cable section, below*

bination of the repeater and a fifty-mile cable section. It will be noticed that the overall characteristic is practically flat over the voice range.

Maximum gain is 19.5 db, but by means of a slide-wire potentiometer and resistance pads of fixed loss, the actual gain may be adjusted to fit the losses of the lines for which the repeater is designed to operate. To compensate for differences in transmission characteristics of various lines, equalizers are connected in series with the input transformers. A resistance and capacitance in parallel provide the desired characteristics at low frequencies and a retard coil, adjustable in three-millihenry steps, gives the necessary adjustment at the higher frequencies. Filters are used to introduce a large loss at frequencies beyond the useful range so as to reduce the range of frequencies at which the network must balance the line.

The repeater is designed to operate with any of the three standard ringing frequencies of 20, 135, or 1000 cycles but the arrangements are not indicated on Figure 5. For either 20 or 135 cycle signaling, connections to a ringer are made between the bridge points of the hybrid transformers and the potentiometers. Since signals at 1000 cycles fall within the voice range they are transmitted by the repeater itself and so require no special provisions. The ringing equipment may or may not be mounted in the same bay as the repeaters.

To make the repeater readily adaptable to various types of line circuits, the filter, balancing network, and signaling apparatus were designed as separate units so as to be easily changed. The repeater proper, therefore, consists of only the input and output transformers, the potentiometers, the tubes, and the equalizing apparatus. It is arranged on a seven-inch panel as shown in Figure 7. The blank space on the left front of the panel provides room for the two filters. Three covers are provided: one for the rear, a front cover for the potentiometer, and another front cover for the rest of the equipment except the tubes. Three battery voltages are required. The two filaments, connected in series, are supplied by a twenty-four-volt battery, the grids by a nine-volt battery, while the plates require 130 volts. A typical bay layout of repeaters is shown in Figure 8.

The effectiveness of the hybrid coil

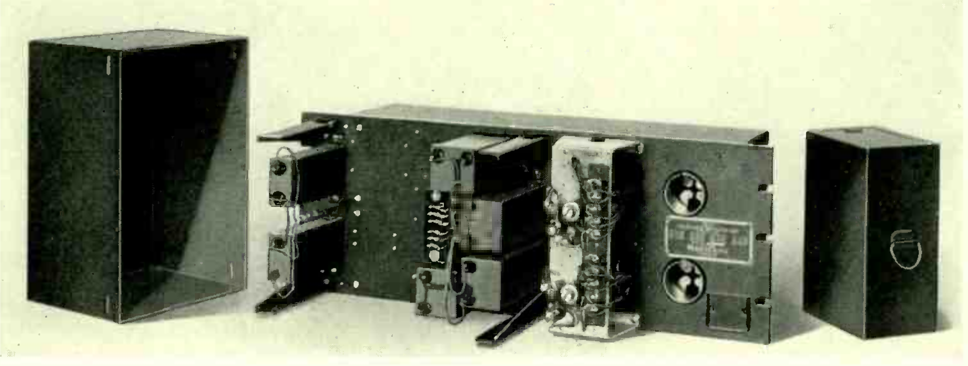


*Fig. 7—A single repeater unit is mounted on a seven-inch panel suitable for use with standard frames*

*Fig. 8—A typical line of repeater bays*

in preventing the output of one amplifier of a repeater from feeding the input of the other, as has already been pointed out, depends on the exactness with which the network balances the line. The term "line," in the broad sense used here, includes not only the open-wire or cable conductors but the equipment connected to the line at the repeater station. Such a typical line circuit at an intermediate repeater station is shown in Figure 9. To obtain the high degree of balance required, the network is composed of separate units, each arranged to balance one part of the line circuit, and these units are connected in the same order as is the equipment in the line. The arrangement for the network used to balance the line circuit of Figure 9 is shown in Figure 10. These two illustrations represent open-wire circuits but the arrangement for cables would be the same except that the absence of carrier would make unnecessary the use of carrier filters and their balancing networks.

Spacing between repeaters on toll circuits depends on a number of factors among which are the interference from power circuits, cross-talk from other communication circuits, and the degree to which balance may be obtained. Considering these fac-

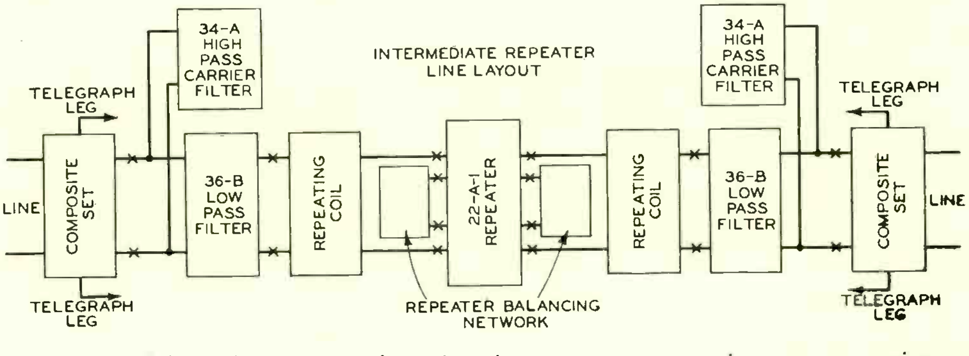



*Fig. 9—Schematic representation of equipment at an open-wire repeater station*

tors, a spacing of fifty miles between cable repeaters and of from 150 to 275 miles for open-wire repeaters is common practice. Certain deviations occur since it is generally desirable to locate repeater stations in or near some town.

As the length of a repeatered circuit is increased, the distortion due to imperfect balances between the networks and lines becomes greater so that in practice the length of two-wire toll circuits is limited. At the present time, two-wire cable circuits are not usually designed to operate over distances greater than 250 miles although open-wire lines may be of much greater length. For cable distances longer than 250 miles, four-wire circuits are generally used. With the large expansion of toll facilities, however, particularly of new cable circuits, the demand for 22-A-1 repeaters rose to about 20,000 in 1929.

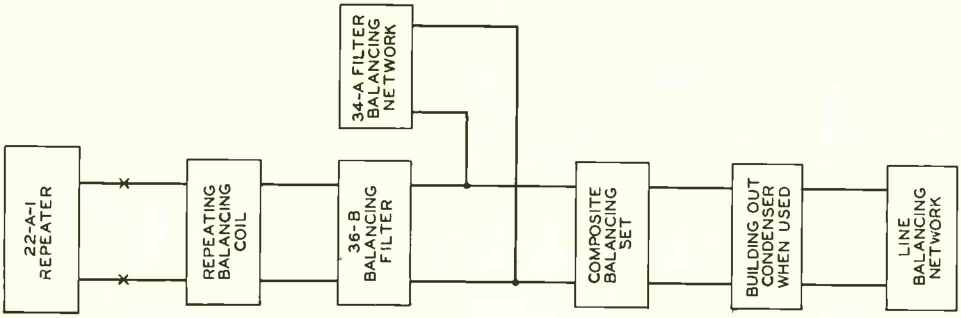



*Fig. 10—Layout of balancing network for intermediate repeater. Separate units are provided to correspond to each part of the line equipment*

# Measuring the Frequencies of Radio Signals

By A. A. ROETKEN
*Radio Research*

A NECESSARY accompaniment of linking together telephone systems by radio has been the extension into the radio field of the high standards of reliability customary in wired telephony. In all radio communication one of the gravest hazards to reliability is the interference of one station with another due to variations in their carrier frequencies. As a first step toward eliminating such interference, it is necessary to provide a means for accurately measuring the interfering frequencies.

The methods of measuring frequencies used in recent years are based on relating an unknown frequency to an appropriate multiple of a known standard frequency. In such a multiple, any error in the standard is multiplied in absolute value. Thus the absolute error of the measurement, in cycles per second, is proportional to the frequency. Methods of measurement sufficiently accurate at comparatively low frequencies may, therefore, be quite inaccurate at the high frequencies used in the short-wave telephone links.

To decide the feasibility of apparatus for readily measuring high frequencies with great accuracy, a device was developed which has been constructed and installed at Holmdel for prolonged test. It is capable of measuring frequencies in the range of five million to thirty million cycles with an accuracy of better than three parts in one million. Avoiding the need of unusual operative skill and permitting rapid determinations, the apparatus asks only simple mechanical manipulation, at the conclusion of which it displays the desired frequency value as a number in a bank of switchboard lamps.

The fundamental principle of the system is that of combining the frequency to be measured with a known frequency of such a value as to produce a beat frequency whose value has one less digit than that of the original frequency. This beat frequency is then beaten with a second known frequency to produce a beat frequency whose value has two less digits than the original frequency. In theory this beating process could be carried to a point where the final beat was so small as to be negligible. In fact, however, the process is repeated only until the beat frequency obtained is low enough to be measured with high precision by comparison with an electric oscillator.

As an illustration, suppose a frequency of 25,462,375 cycles were to be measured. If this were beaten with 20,000,000 cycles, a beat frequency of 5,462,375 cycles would be obtained. This in turn could be beaten with 5,000,000 cycles to produce a beat frequency of 462,375 cycles. These operations could be continued in successive stages to any point desired. The value of the original frequency would then be obtained by adding the list of known frequencies which had been inserted.

A device operating in precisely this manner is not entirely practical, and consequently the device has been built on a somewhat modified plan. The beat frequencies admitted in any stage are limited to those with values whose first digit is 5, 6, 7, 8 or 9; the value of each known frequency is made an integer followed by zeros. This scheme in no way limits the frequencies which can be measured, but merely makes necessary the occasional use of a known frequency the first digit of whose value is one greater than that of the unknown frequency with which it is beaten. Thus the beat frequency of 5,462,375 cycles of the above illustration must be beaten with 6,000,000 cycles in order that the value of the resulting beat frequency will have 5, 6, 7, 8 or 9 as its first digit. Using this arrangement, it is not possible to obtain the value of the unknown frequency by simple additions; a series of additions and subtractions must be performed. These computations are, however, accomplished automatically by an indicator, actuated by the tuning dials and displaying the value of the measured frequency immediately upon completion of the mechanical operations of measurement.

In Figure 1 the scheme of measurement appears in block form. All known frequencies are exact multiples or submultiples of a reference standard of 1,000,000 cycles generated by a quartz crystal oscillator of high precision and stability. Multiples are generated by means of harmonic generators, and submultiples by controlled multivibrators. This equipment is indicated on the left side of Figure 1. Each unit produces six known standard frequencies, except the higher of the two harmonic generators, which produces 10, 20, and 30 million cycles.

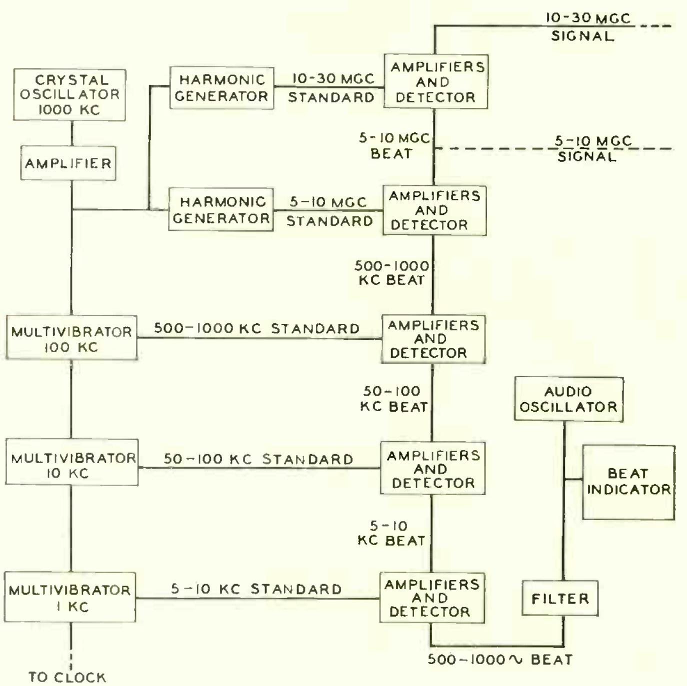



*Fig. 1—By beating an incoming radio signal down in successive known steps, its frequency can be accurately determined with an audio-frequency oscillator*

For each harmonic generator and multivibrator there is a corresponding amplifier-detector, equipped with an input filter passing only frequencies whose values begin with 5, 6, 7, 8 or 9 followed by the proper number of digits, one less for each successive stage. It is the function of each amplifier-detector stage to beat the required known frequency with the signal or beat frequency from the preceding stage. Since for any given signal or beat frequency there is available at each stage only one standard frequency which will produce a frequency which the filter in the succeeding stage will pass, the appearance of a current in the succeeding stage, on a trial of the available standards, indicates which to use. The final stage produces a beat frequency between 500 and 1000 cycles, which is measured by the zero-beat method against a calibrated low-frequency oscillator.

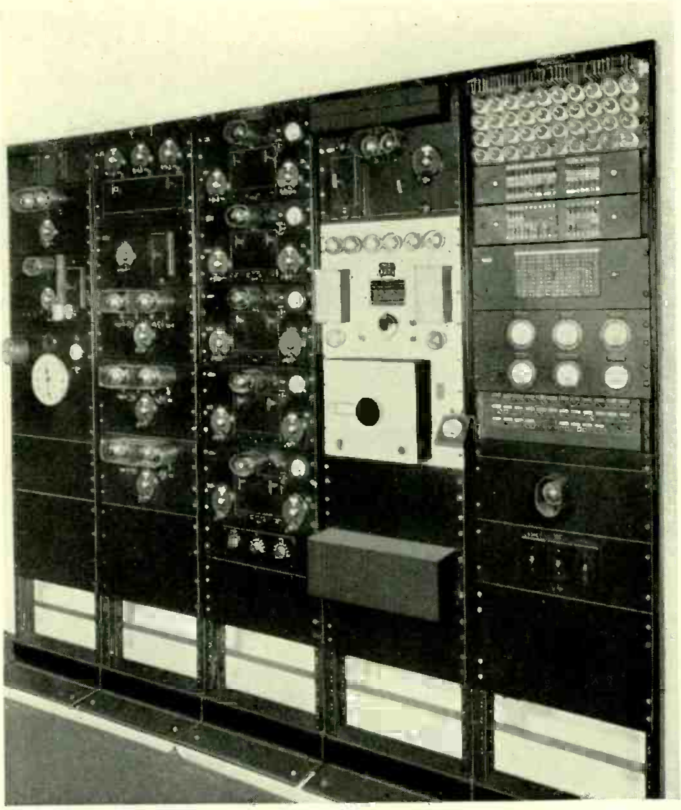


*Fig. 2—An embodiment of the radio frequency measuring system is in operation at Holmdel*

The precision of measurement is largely dependent upon errors contributed by the two standards: the quartz oscillator and the low-frequency oscillator. The greater error is contributed by the quartz oscillator, whose frequency may vary slightly about a mean. This variation is a maximum of ± 1/3 cycle about an average of 1,000,000 cycles for temperature variations. The error resulting from this variation is proportional to the frequency being measured. The error contributed by the low-frequency oscillator is determined by the absolute accuracy of the oscillator calibration, and the degree of precision to which this calibration can be read. A maximum error of 2-1/2 cycles is possible for this particular oscillator, an error independent of the frequency being measured. An additional variation of one part in a million in the quartz frequency standard has been allowed for battery and barometric changes. Summing these possible errors, the overall accuracy of measurements of frequencies within the range of 5 to 30 million cycles is within 0.00015%+3 cycles.

Since the precision of measurement obtainable depends not only on the constancy of the quartz-crystal oscillator but on its absolute accuracy, means are provided for checking its frequency. A synchronous clock which keeps accurate time when supplied with 1000 cycles is driven by 1000-cycle power obtained from the last multivibrator. This clock can be checked against time signals to within

0.05 second. Thus the frequency of the oscillator can be checked over a period of time very precisely.

The frequency-measuring equipment is mounted upon five seven-foot relay racks, as shown in Figure 2. The standard oscillator, harmonic generators, multivibrators and clock are mounted on the two bays at the left. Power is supplied to these circuits independently from the remainder of the equipment, in order that the standard equipment may operate continuously, since the rate of the clock furnishes the calibration of the quartz oscillator. The center bay supports the five amplifier-detector units, with which frequency measurements are made. The fourth bay contains relays for the thermostats and the automatic indicator, a high-frequency comparison oscillator, a modified 13-A oscillator for the measurement of the final three-digit beat frequency, and an output filter. The fifth bay is primarily a power-supply bay, supporting protective devices, filament resistors and power-metering circuits by means of which all plate, shield and filament currents are metered. The lamp bank of the automatic indicator is also located on this bay.

In making the measurements, the operator moves a tuning dial in the first amplifier-detector circuit to give a maximum deflection of the detector-plate meter in that circuit. He then tries beating the signal with one after another of the standard frequencies available at that stage, and picks the frequency which gives a deflection of the detector-plate meter in the succeeding stage. He next passes to the tuning dial of this second stage and proceeds as before. His last adjustment is to set the low-frequency oscillator to a value which gives an indication of zero beat on a beat-indicator meter. He then sets three dials at the bottom of the center bay to the number indicated by the low-frequency oscillator, and operates a switch, lighting lamps which show the value of the frequency to the last digit.

25,462,375
20,000,000
5,462,375
6,000,000
537,625
600,000
62,375
70,000
7,625
7,000
625

# Automatic Testing Equipment for Trunk Circuits

By E. R. LUNDIUS
*Local Systems Development*

SATISFACTORY completion of a manual call does not depend entirely on manual operations. In the subscriber's cord circuit, used to connect a calling subscriber to an outgoing trunk, and in the trunk circuit itself are certain relays which must operate promptly and correctly. In particular there is the tripping relay which must disconnect ringing when the called subscriber answers, and the supervisory relays which, by lamp signals to the operator, indicate when a called subscriber answers or hangs up, or when one of the subscribers wishes to attract the operator's attention. Some of the requirements placed on these relays are rather severe. The various duties required of the tripping relay have already been described in the RECORD*. Those of the supervisory relays are no less important, and the obstacles in the way of their correct performance are often great because of the varying trunk conditions with which the relays have to operate and the rapid "flashing" of the switchhook they are frequently required to follow.

To make sure that these relays are functioning properly they are frequently tested, and since there are large numbers of them in each central office, their testing is a task of considerable magnitude. To simplify and quicken the procedure automatic circuits have recently been developed which operate the relays under conditions more severe than are ordinarily met in service. Whether the relays operate satisfactorily or not will be indicated to the testing operator, and steps are taken to have adjustments made when necessary.

The locations of these relays in a typical established connection are shown in the simplified diagram of Figure 1. The answering supervisory AS relay is under control of the switchhook of the calling subscriber. The calling supervisory CS relay is operated by the trunk supervisory TS relay at the called office, which in turn is controlled by the called subscriber. Contacts on the AS and CS relays control supervisory lamp signals, the lamps being extinguished or lighted depending upon the operated or unoperated position of the relays.

Requirements placed on the operation of the CS relay are more severe than those of the AS. Not only must it operate over a long trunk but the duration of the pulses it receives are shortened because of the time of operation and release of TS, which intervenes between it and the switchhook. Both CS and TS must be able to follow the interruptions of the busy signal which are 60 or 120 per minute, as well as the flashing of the

* *February*, 1931, *p.* 288.

switchhook. Supervisory relay TS, under the worst circuit conditions, must thus be able to follow 120 interruptions per minute with the proper relative values of the open and closed period of its contacts to transmit impulses which, attenuated by the trunk, are still adequate to operate and release supervisory relay CS. The tripping relay, on the other hand, must not operate on the highest ringing voltage and smallest allowable impedance in the circuit to the subscribers station, but it must operate when the subscriber answers even with the lowest ringing voltage and highest impedance in the circuit.

The automatic testing equipment recently developed places tests on both the trip and the TS supervisory relays in the trunk to determine that they act properly under these most adverse conditions, and at the calling office measures the pulses received over the trunk from the TS relay. From the magnitude and duration of these received pulses the circuit can determine whether the CS supervisory relay would be properly actuated under all service conditions. The equipment is in two parts: one terminated in jacks at the "A" or calling board and the other in jacks at the trunk or receiving board. That associated with the trunk board is known as the automatic test line and consists of a selector switch, for controlling the sequence of the various steps of the test, and about sixty control relays. At the "A" board the equipment is known as the outgoing-trunk test circuit and has the necessary apparatus to receive and record the pulses sent back over the trunk by the TS relay while it is under

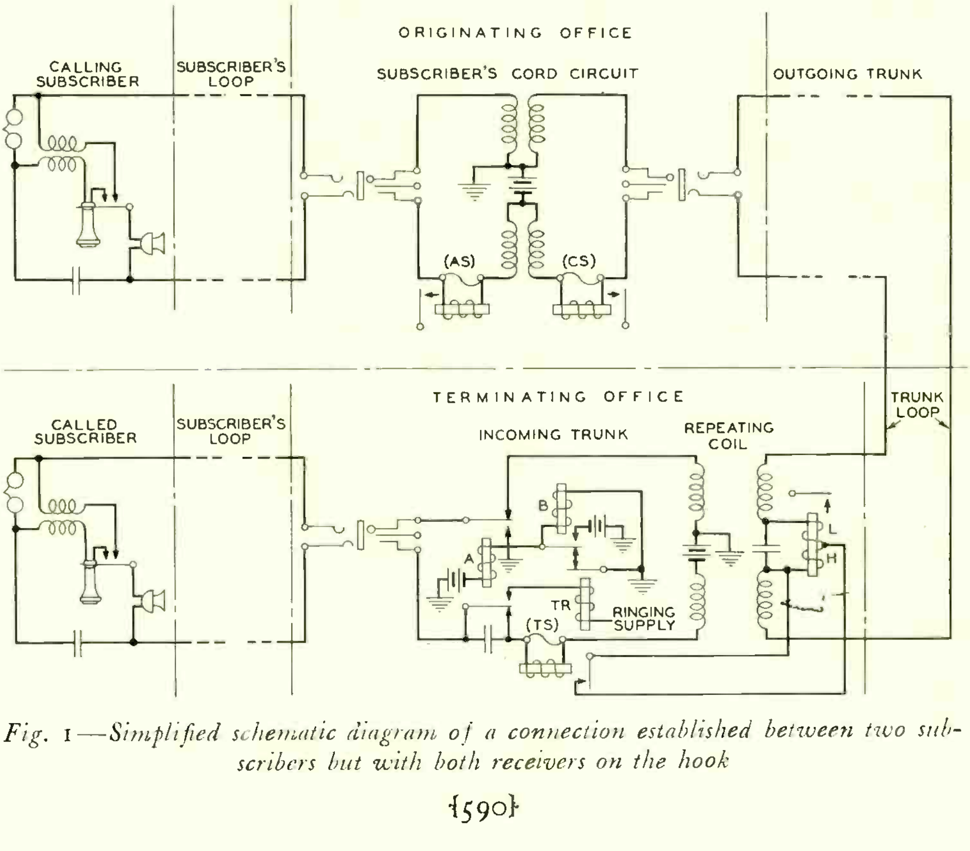



*Fig. 1—Simplified schematic diagram of a connection established between two subscribers but with both receivers on the hook*

test. The general arrangement during test is indicated in Figure 2.

The outgoing-trunk test circuit is multipled to jacks at the various positions of the "A" board. Each appearance consists of two jacks. One is connected to the outgoing trunk to be tested by a patching cord and into the other the operator or meter man plugs the answering end of a cord circuit so that she may talk to the answering operator at the "B" board, and listen to the signals received after the test has started. The automatic test line appears throughout the subscriber's multiple at the trunk board and thus has a line number as any subscriber would have. After the test operator has plugged the patching cord into an outgoing trunk, she receives the order tone from a position at the trunk board and then passes the number of the automatic test line to the trunk operator who completes the connection with one of her cords.

After this test connection has been established the start relay operates and in turn actuates the test control relays. These move the selector switch from the normal to the first test terminal, and ringing is applied which is heard by the test operator at the "A" board. The selector is then moved to the pre-trip test which applies to the trip-relay circuit a non-operate test condition to insure that the relay will not operate under the minimum line-circuit impedance. The tripping relay, if functioning properly, should not operate under these conditions, and if it does, an interrupted tone is returned to the test operator to indicate failure. If the trip relay does not operate, the selector is automatically advanced to the trip test.

In this position a resistance is connected to the trip relay which represents a subscriber's loop circuit of maxi-

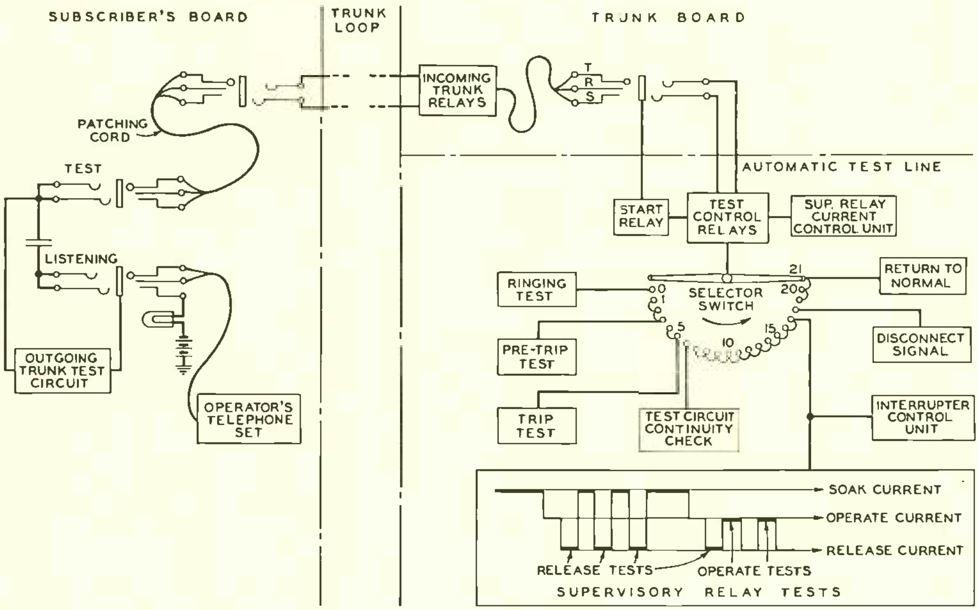



*Fig. 2—In using the automatic testing equipment the outgoing trunk test circuit takes the place of the subscriber's cord circuit, and the automatic test line takes the place of the called subscriber's line*

mum impedance when the receiver is off the hook. The relay should now trip, and if it does not, failure is indicated by the continuation of the ringing induction. Proper action of the relay, however, will disconnect ringing and move the selector to the next position, which imposes a continuity test on the circuit.

This test insures that everything is in order and readiness for the tests of the supervisory relay. Among other things the current control unit, by means of a voltmeter relay, will measure the potential of the central office battery and introduce into the test circuits proper resistances for the tests of the supervisory relays. The values of the resistances inserted will depend on the battery voltage found to exist, and may be changed to correspond to one-volt variations in battery potential. Should this change from 24 to 25 volts, for example, or from 24 to 23, occur between tests the circuit will automatically adjust the resistance accordingly. During the procedure of a single test, however, no change in resistance is made.

As the selector advances through the various steps of the supervisory-relay test a series of three values of current is applied to the relay in a definite sequence and at a rate of 120 per minute. The three values of current are known as "soak", which approximates the maximum current the relay woud carry under operating conditions; "operate", which is the minimum current on which the relay should operate; and "release", which is the maximum current on which the relay should release.

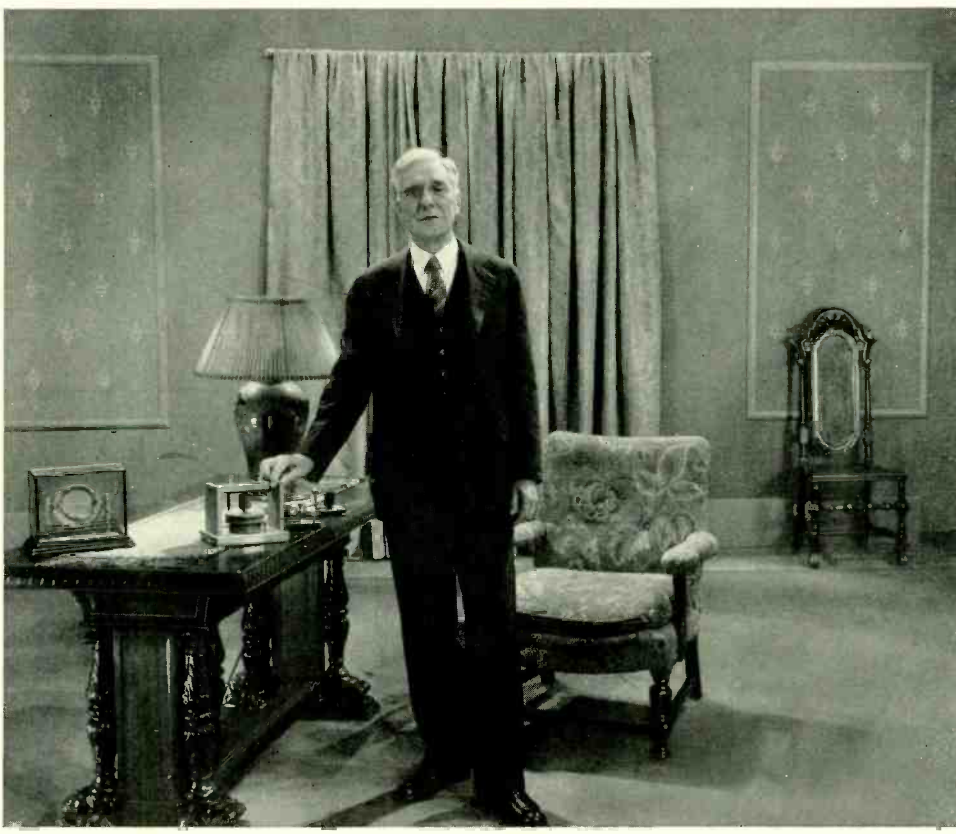
First the "soak" current is applied, followed by operate and release. This represents a gradual dropping off in current from maximum to minimum, and represents the worst release condition. It is followed by two cycles of "soak and release" currents; then by another cycle of soak, operate and release; and finally by two cycles of operate and release. The last two cycles test the capability of the relay to meet its operating requirements. These six tests result in the transmission of an equal number of make and break impulses over the trunk loop to the Outgoing Trunk Test Circuit where they are registered on pulse-counting relays. Upon completion of the last pulse, a lamp will light as a signal to the test operator that the trunk has satisfactorily passed the test. On failure of the supervisory relay no lamp will light. The automatic test line sends out an audible signal to indicate that all tests are completed.

With this newly developed equipment, therefore, a single operator or maintenance man at an "A" board can test all the outgoing trunks in that office in a very short time. The test proceeds automatically and with maximum speed. Between tests there is required only the removal of one end of a patching cord from the trunk just tested and its insertion in the next.

# NEWS AND PICTURES

*of the*

# MONTH



*Thomas A. Watson, in the Laboratories' sound-picture studio, makes a record of his story of the telephone's invention*

# General News Items

## Edgar S. Bloom Celebrates Thirty-fifth Anniversary

On July 6, Edgar S. Bloom, President of the Western Electric Company and a member of the Board of Directors of the Laboratories, completed his thirty-fifth year in the Bell System.

*Edgar S. Bloom*

Mr. Bloom has had a varied and extensive telephone career in these thirty-five years of service. He was in the Traffic and Engineering Departments of the New York Telephone Company for twelve years and then became General Plant Superintendent of the Pacific Telephone and Telegraph Company. He gained wide experience in engineering construction, plant operation, and in commercial and executive fields as a member of several of the Associated Companies in the middle and southwest. He was Chairman of the Board of Directors of the Indiana Bell Telephone Company and the Ohio Bell Telephone Company, and Vice-President of the Illinois Bell Telephone Company previous to being named Vice-President of the American Telephone and Telegraph Company in 1922.

On August 3, 1926, Mr. Bloom was elected President of the Western Electric Company and on August 26 of the same year was elected to the Laboratories' Board of Directors.

## Watson in Sound Film Tells of Telephone's Invention

On June 30 Thomas A. Watson was at the Laboratories to make a sound picture in which he described his experiments with Alexander Graham Bell that led to the invention of the telephone. To illustrate his talk he used replicas of Bell's harmonic telegraph transmitter and receiver and the first telephone, the original wire over which the first articulate sentence was transmitted by electricity, and replicas of other instruments used in their early experiments. The instruments were borrowed from our Historical Museum. The originals were constructed by Mr. Watson from plans outlined by Professor Bell.

In recounting the telephone's invention Mr. Watson told of their experiments on the harmonic telegraph in which steel springs of different pitches were utilized. Bell at this time spoke to Watson of his hopes for devising a telephone, or "speaking telegraph", as he often referred to it. The principle of transmitting spoken words over a wire by impressing the vibrations of the voice on an electric current was conceived by Bell long before the actual invention of the telephone, Mr. Watson stated.

While working on the harmonic telegraph Bell was accustomed to tune each receiving instrument by holding it to his ear. On June 2, 1875, he rushed excitedly into the room where Watson was snapping a transmitter spring and announced that he had not only heard the pitch but the overtones of the spring transmitted over the wire. Bell then was confident that if the pitch and overtones of a spring could be heard, the voice might likewise be transmitted. The next day the first telephone was constructed and for the first time speech sounds were transmitted over wire.

They continued their experiments for nearly a year longer, and although Watson now and then could recognize words spoken by Bell over the wire, the results were not as successful as they hoped for. A new wide-mouthed transmitter operated with battery was constructed and Bell, when the new device was placed in readiness for the first trials, accidently spilled a container of acidulated water. "Mr. Watson, come here, I want you," he shouted excitedly.

Mr. Watson hurried to Professor Bell and announced he heard his words, which were picked up by the wide-mouthed transmitter. They constituted the first complete and intelligible sentence to be transmitted over the telephone.

The sound picture was made for purposes of historical record. W. C. Langdon, historical librarian of the American Telephone and Telegraph Company, accompanied Mr. Watson and Carlyle Ellis, also of the American Telephone and Telegraph Company, directed the picture. F. L. Hunt was in charge of the photography and sound recording in which he was assisted by the Laboratory staff.

### Laboratories Men Recipients of Degrees in Brooklyn

At the Commencement exercises for Brooklyn Polytechnic Institute, June 17, degrees were conferred on three Laboratories members. L. E. Abbott of the Apparatus Development Department was awarded the degree of M.S. in M.E.; E. E. Wright of the Research Department, B.S. in Chem.; and R. B. Hearn of the Systems Development Department received an E.E. degree.

### Testing Machines Exhibited

At the invitation of the American Society for Testing Materials, the Bell System occupied two spaces in the scientific section of the exhibition at the Society's convention at the Hotel Stevens, Chicago, late in June. In one of the spaces, Western Electric showed several instruments developed at Hawthorne, notably the reed gauge for precision measurements.

The Laboratories' exhibit, in charge of G. R. Gohn and C. H. Marshall, included an instrument for checking parallelism of diaphragm surfaces; a fatigue tester for sheet metals; a cold-flow machine for testing insulation, and a filament-wire extensometer.

## Acoustic Engineers Conduct Cathedral Survey

*C. F. Eyring using reverberation meter for acoustic tests in St. Patrick's Cathedral*

For the past several weeks members of the Acoustics group of the Sound Picture Laboratory have been making an acoustical survey of Saint Patrick's Cathedral, New York City. The data compiled consist of reverberation time measurements, studies of the sound intensity distribution, noise survey and articulation tests. An interesting procedure in the reverberation time measurements involved the use of the great organ of the Cathedral as a source of tone, extending the range of the measurements to 32 cycles. The work has been undertaken by C. F. Eyring and F. A. Goss of the Special Products Development group of the Apparatus Development Department.

Members of the public speaking classes of New York University were employed as observers in conducting the articulation tests. They were scattered throughout the Cathedral in small groups and listened to the words spoken to determine acoustic qualities. Cooperating in the articulation tests from the Laboratories, were: F. L. Hunt, W. A. MacNair, R. L. Hanson, R. D. Gibson and D. W. Shirley of the Sound Picture Laboratory; W. A. Munson, D. W. Wheeler, A. R. Soffel and C. M. Kopf of the Research Department; and C. R. McConnell of the Commercial Relations group. The acoustical survey of the Cathedral is being made at the request of Western Electric.

## Improved Program Circuits Now Under Test

Improved open-wire circuits for program transmission between Chicago and San Francisco are now undergoing trial installation. The circuits remain on a voice-frequency basis but by means of improved apparatus will transmit a considerably wider band of frequencies as well as a wider range of volumes. To make room for the wider band to be transmitted requires removal from service of a carrier telephone channel on the same wires which would otherwise overlap in frequency. Careful conditioning tests of the new apparatus at the various repeater stations will be necessary. Extensive overall measurements and observations will also be required.

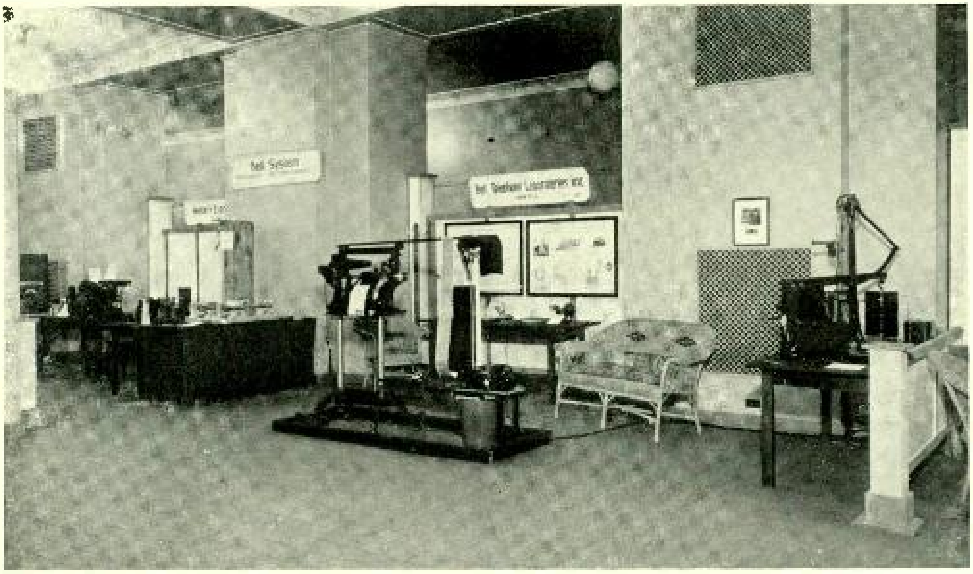
A conference attended by representatives of the Long Lines Department, Pacific Telephone and Telegraph Company, the general departments of the American Telephone and Telegraph Company and the Laboratories, was held in Chicago to organize the testing and cutting into service of the new apparatus. C. W. Green, J. A. Krecek, A. H. Shuper, C. F. White, A. E. Bachelet, and C. E. Schissler were the Laboratories representatives. Following the conference, Mr. Bachelet went to Crockett, California, and Mr. Schissler to Terre Haute, Indiana, to conduct tests. They will spend several months at these and other points along the route of the circuits. Tests of the new apparatus were also conducted by C. F. White and J. A. Krecek at Rawlins, Wyoming.

### Administration

Mr. Charlesworth attended the Summer Convention of the American Institute of Electrical Engineers, held at Asheville, North Carolina.

R. L. Jones was twenty years a member of the Bell System on July 31.

H. D. Arnold is a representative of the Acoustical Society of America on the Board of Managers of the newly formed American Institute of Physics.




*The Laboratories' exhibit for the A.S.T.M., with the diaphragm tester in the center*

# Departmental News

## Apparatus Development Special Products

O. M. Glunt, Assistant Director of Apparatus Development in charge of Special Products, completed twenty-five years with Western Electric and the Laboratories on July 17.

Mr. Glunt gained extensive experience on the design of telephone apparatus during his early years with the Western Electric Company and in the development of submarine-detection devices, fire-control equipment and similar work for the government during the war period. Immediately afterward he was given charge of engineering and installation work on public address systems, and in 1923 the development work on radio. The scope of the Laboratories' work in both of these fields expanded rapidly. In 1927 the work on by-products was augmented by the development of sound pictures which was included under Mr. Glunt's supervision. During the past few years his supervision has contributed notably to the development of such diverse fields as radio for broadcasting and airplane use, sound pictures, power-line carrier telephony, and train dispatching.

*O. M. Glunt*

Mr. Glunt, who is a graduate of Ohio State University in the class of 1906, took the Western Electric student course. As an incident of that course he worked at Chicago on the machining and assembly of apparatus parts, switchboard assembly and later switchboard and substation installation. He came to the Engineering Department in New York in 1911 and until the war period worked on the design of central office apparatus and mechanical repeaters.

Since the inception of the Record Mr. Glunt has been a member of its editorial board. He has been President of Bell Laboratories Club and is a member of the executive committee of the Edward J. Hall Chapter, Telephone Pioneers of America. In addition he is a fellow of the Acoustical Society of America, and a member of the Board of Editors and Chairman of the Papers Committee of the Society of Motion Picture Engineers.

H. C. Curl visited the Navy Bureau of Engineering in Washington to discuss problems concerning general naval announcing systems.

W. Herriott and J. Crabtree attended the convention of the Society of Motion Picture Engineers at Hollywood, where a paper *Directional*

*Effects in Sound Film Processing* was presented by Mr. Crabtree. They also discussed engineering problems with representatives of the West Coast E.R.P.I. and various sound picture studios during their visit.

F. L. Hunt addressed a meeting of the Edward J. Hall Chapter, Telephone Pioneers of America, held June 25 in the Auditorium, on recent developments in sound pictures. The talk was followed by the showing of several sound films.

*Some Acoustical Problems of Sound Picture Engineering* were discussed in a paper presented by W. A. MacNair at the Chicago convention of the Institute of Radio Engineers.

C. F. Boeck attended the annual convention of the American Institute of Electrical Engineers held at Asheville, North Carolina. He also visited Toronto to inspect recent improvements made in train telephone equipment on the Canadian National Railways.

## Radio Development

Before the Institute of Radio Engineers at their annual convention in Chicago, G. D. Gillett presented a paper entitled, *Some Developments in Common Frequency Broadcasting.* He then visited Davenport, Iowa, to observe the operation of the Western Electric common-frequency broadcasting equipment installed at station WOC of the Central Broadcasting Company.

The installation of a 1-kw. radio-telephone broadcasting equipment and associated speech-input equipment for station WLIT owned by Lit Brothers of Philadelphia, was supervised by W. P. Fisher and O. W. Towner. While in Philadelphia Mr. Fisher also inspected broadcasting station WIP owned by Gimbel Brothers.

B. R. Cole and H. E. J. Smith at Asbury Park directed the installation of a 1-kw. radio-telephone broadcasting equipment and associated speech-input equipment for station WCAP, owned by Radio Industries Broadcast Company.

The application of scientific principles to radio-receiver development was discussed by C. B. Aiken in a recent talk before the physics students at Princeton University.

J. E. Tarr supervised the installation of a specially-designed speech-input equipment for station WEEI, owned by the Edison Electric Illuminating Company of Boston.

A demonstration of the new radio-telephone equipment designed for itinerant flyers was given for Mr. W. L. Smith, Chief Engineer of the National Air Transport, Inc., during a flight in the Laboratories' Fairchild airplane from Newark to Chicago. F. C. McMullin of the Western Electric Company accompanied Mr. Smith on this trip. A. R. Brooks piloted the plane while D. B. McKey made the demonstration.

O. W. Towner visited Huntington, West Virginia, to supervise the installation of a 1-kw. radio-telephone broadcasting equipment and associated speech-input equipment for WSAZ, Inc., and to inspect station WOBU, owned by the Charleston Radio Broadcasting Company. He also inspected the station of the Durham Life Insurance Company, WPTF, at Raleigh.

The summons of death came on two occasions during recent weeks to members of the Radio Development group. On June 21, J. O. Gargan died while on a visit to relatives in Schenectady. On July 2 F. S. Bernhard succumbed at Caldwell, New Jersey, following an operation for appendicitis.

Mr. Gargan's service with the Western Electric Company and Laboratories dated from 1914. He was in charge of mechanical design in the Radio Development Department.

In the design and criticism of apparatus construction, his ability was highly developed. He was responsible for the mechanical design of all radio transmitters, receivers, and field measuring sets produced by the Radio Development department; for the design of radio-telephone apparatus—for broadcasting, aircraft, Coast Guard and other uses. At the time of the war he was engaged on the development of radio apparatus for the Signal Corps. During this period he was sent to assist Thomas A. Edison when the noted inventor, engaged on war work, appealed to the Western Electric Company for a mechanical engineer to aid him in his activities.

*J. O. Gargan*

Mr. Bernhard came to the Laboratories in 1916 and left in 1917 for military service. At the time of his death he was a reserve officer in the United States Army Air Corps. He was associated with the development program for airplane radio-telephony since its inception and was stationed for an extended period at Hadley Field in charge of the installation and testing of equipment used in the Laboratories' planes. Previous to this work he was engaged in carrier telephone and radio development work. In 1926 he visited Chile to make a survey for a radio system for a large copper-mining company.

*F. S. Bernhard*

Both men were not only valued members of the Laboratories, but were also held in high esteem by their co-workers and many friends throughout the Laboratories. Their passing is felt with a sense of distinct loss and deep regret.

F. M. Ryan discussed radio requirements with representatives of the Boeing Air Transport at Chicago. He also was in attendance at the annual convention of the Institute of Radio Engineers.

R. C. Carlton was at Washington in connection with tests on Western Electric radio-telephone equipment for the United States Navy.

At Waterloo, Iowa, F. H. McIntosh supervised the installation of speech-input equipment for station WMT, owned by the Waterloo

Broadcasting Company. Later Mr. McIntosh made an inspection tour of Western Electric equipped stations in the Central States, visiting stations KOIL (Council Bluffs), WLB (Minneapolis), WMBI (Chicago), WOW (Omaha) and WBCM (Bay City, Michigan).

J. M. Henry was in Boston in connection with a survey of radio transmission conditions in and around Boston harbor.

F. M. Ryan and R. S. Bair attended a meeting of the Liaison Committee on Aeronautical Radio Research in Washington. The program of the committee included an interesting demonstration of the equipment developed by the Bureau of Standards to enable airplanes to make blind landings.

### Transmission Apparatus

Problems concerned with lamp measuring equipment and the development of a new switchboard lamp were discussed by J. C. Wright and N. Insley in a recent trip to Hawthorne.

C. A. Webber and P. Komroff visited the Paramount Studios at Long Island City to investigate the use of rubber-jacketed cables for sound-picture recording.

To confer on the manufacture and testing of a group of neutralizing transformers C. A. Brigham was recently in Hawthorne.

J. R. Reeves and C. T. Grant went to Point Breeze to give instruction in the use of a new cross-talk measuring set for toll cables.

A. C. Walker talked on *Presentation of Data* at the A.S.T.M. convention in Chicago. He also assisted in the installation of a humidity recorder for controlling cable storage ovens and calibrated inspection test equipment for cotton purification at Hawthorne. While on this trip he also visited the Forest Products Laboratory at Madison, Wisconsin.

### Materials

The convention of the A.S.T.M. at Chicago was attended by H. N. Van Deusen, J. M. Wilson, J. R. Townsend, C. H. Greenall, C. H. Marshall, and G. R. Gohn.

While in Chicago, J. R. Townsend discussed materials problems with Hawthorne engineers, and C. H. Greenall was occupied with matters in connection with improved methods for the manufacture of lead cable sheath.

T. S. Huxham visited the plant of the United States Tool Company at East Orange to confer with engineers there on molded materials.

### Manual Apparatus

A. H. Reiber of the Teletype Corporation visited the Laboratories in connection with printing telegraph apparatus.

C. F. Swasey visited the plant of the Weston Electrical Instrument Company at Newark for a discussion of meter problems.

### Dial Apparatus

B. Freile at Hawthorne discussed problems encountered in manufacture of step-by-step apparatus.

Investigations of improved operating requirements for step-by-step apparatus required C. G. McCormick's attention in Scranton and Easton, Pennsylvania.

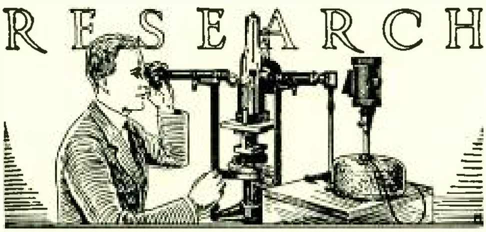
H. O. Siegmund was in Hawthorne in connection with various relay problems.

At Albany, C. R. Steiner observed a trial of chromium-plated relays.

E. J. PRATT completed twenty years in the Bell System on July 3.

DRAFTING AND SPECIFICATIONS

A. M. BANSCHER rounded out twenty years in the Bell System on July 31.




TRANSMISSION INSTRUMENTS

H. A. LARLEE at Hawthorne discussed several problems pertaining to handset transmitters and receivers.

B. E. BEHRENS completed twenty years in the Bell System on July 17.

TRANSMISSION RESEARCH

B. G. BJORNSON has returned from Charlotte, North Carolina, where he assisted at the field trial of the four-thousand mile cable.

CHEMICAL RESEARCH

A VISIT TO the Point Breeze plant was made by A. R. Kemp and J. H. Ingmanson on drop-wire developments. Before the New York group of the Rubber Division, American Chemical Society, Mr. Kemp described the utilization of rubber in the telephone industry.

J. E. HARRIS was at Hawthorne to confer on the manufacture of lead cable sheath. With E. E. Schumacher he attended the meeting of the National Advisory Council of Metallurgists at Washington.

METAL FINISH problems required R. M. Burns' attention in a recent Hawthorne visit.

C. L. HIPPENSTEEL and R. B. Mears attended the convention of the American Society for Testing Materials at Chicago and visited the Hawthorne plant. Mr. Hippensteel also investigated corrosion in lead cable in company with engineers of the Illinois Bell Telephone Company.

ELECTRO-OPTICAL RESEARCH

RESEARCH in applied physics was described by Herbert E. Ives in an address before the Society for the Promotion of Engineering at Purdue University.

K. K. DARROW is now at the University of Chicago where he will conduct a special summer school course in advanced physics.

ACOUSTICAL RESEARCH

H. FLETCHER attended the annual convention of the American Federation of Organizations for the Hard of Hearing at Chicago. Dr. Fletcher, who has been president of the Federation for the past two years, was succeeded by Dr. Austin A. Hayden of Chicago. The convention was also attended by J. B. Kelly who read a paper on measured hearing.

Dr. Fletcher is a representative of the Acoustical Society of America on the Board of Managers of the newly formed American Institute of Physics.

D. D. FOSTER presented a paper entitled, *The Effect of Exposure and Development on the Quality of Variable Area Photographic Sound Recording* before the Los Angeles meeting of the Society of Motion Picture Engineers.

A VISIT to Baltimore was made by E. G. Shower and M. B. Gardner for tests on the Laboratories' audiometers which are being used at Johns Hopkins Hospital.

W. B. SNOW at Los Angeles set up

the apparatus used in the demonstrations given by H. D. Arnold in his address before the American Association for the Advancement of Science at Los Angeles. While there he visited the west coast laboratories of the Electrical Research Products, Inc., and the Paramount studios.

### Radio and Vacuum Tube

H. M. Thomson is at Bradley, Maine, conducting antenna studies at the new long-wave transatlantic radiotelephone station.

### Submarine Cable

B. Trebes returned June 22 on the *S.S. Berlin* from Nordenham, Germany, where he has been engaged in work on the transatlantic telephone cable project.

For the purpose of inspecting various types of apparatus J. B. Johnson visited the General Radio Company in Boston.

## OUTSIDE PLANT

New features of drop-wire design were discussed by D. A. Quarles and C. S. Gordon with engineers of the Western Electric Company at Point Breeze.

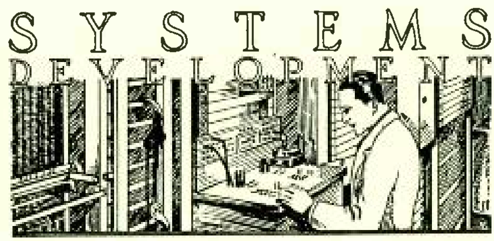
R. J. Nossaman represented the Laboratories in a joint investigation of No. 14-type cable terminal performance, in Chicago and St. Louis.

G. A. Anderegg was present at a conference at Hawthorne to discuss the development of cable sheath and lead-covered cable.

The annual meeting of the American Society for Testing Materials held in Chicago was attended by C. S. Gordon, C. D. Hocker, and F. F. Farnsworth.

T. A. Durkin is now stationed in Morristown in connection with the study of methods of maintaining cable under continuous pressure and the locating of faults caused by breaks in lead cable covering.

During July S. C. Miller, R. E. Alberts and R. C. Jones each completed twenty years in the Bell System. Mr. Miller's service date is July 3; Mr. Alberts', July 10; and Mr. Jones' July 24.




### Local Central Office

On July 30 F. S. Irvine was twenty-five years a member of the Western Electric Company and Laboratories.

Mr. Irvine's activities have been devoted chiefly to panel systems developments. He was a member of the small group that worked on the initial

*F. S. Irvine*

development of panel semi-mechanical switching and was as a supervisor closely associated with the semi-mechanical installations at the Mulberry and Waverly offices in Newark and the Wilmington installation that followd shortly after. For several years he supervised the testing of all full mechanical offices installed in New York City.

He started his career in the telephone industry as a circuit draftsman in the Clinton Street, Chicago, factory, and shortly afterward assumed charge of the work. He came to New York to work on machine switching during the year 1912.

His extensive experience in installation and testing resulted in his appointment as supervisor of the Methods and Results work in 1923. He was in charge of installation methods and aided installation foremen in various engineering and technical difficulties. For several years he has been engaged on the development of panel circuits.

*T. H. Roberts*

A SERVICE button of six stars was conferred on Thomas H. Roberts on July 10 at the completion of his thirty years in the Bell System.

Mr. Roberts came to the Laboratories in 1920. Prior to this time he had pursued a very active career in the Installation Department of the Western Electric Company. He was division foreman in Illinois, Ohio, the Northwest and New York in charge of manual office installations. He also made special trips to Rio de Janeiro and Port of Spain, Trinidad, to supervise the installation of No. 1 switchboards at these places.

As a member of the circuit design group of the Laboratories, he worked on the original tandem dial central office development and lately has been engaged on the development of the sender, decoder connector, decoder and call announcer circuits at the new tandem office installed for the East 13th Street office. He has specialized on the development of sender circuits.

A. S. PAGE rounded out a quarter of a century in the service of the Bell System on July 16.

His career has been one of extensive experience in practical telephone work. Following his graduation from Tufts College he entered the employ of the New England Telephone and Telegraph Company. During his early years he was engaged in field studies for toll-line loading, central-office construction, and in substation, loop and

*A. S. Page*

cable work. The survey on which he was engaged for toll-line loading was in preparation for the first installation of loading coils on open-wire lines in the New England region.

In 1909 he was placed in charge of central-office and PBX installation in the Pittsfield district. He later changed to the headquarters of the Western Division of the New England Company at Springfield where he worked on the listing and cost estimating of central-office installations until coming with the Laboratories.

Mr. Page at the present time is in charge of the maintenance and demonstration of the panel system set up in the panel systems laboratory for testing purposes. He previously has been a member of the methods-of-operations group where he was engaged on preparing circuit descriptions. He worked also on the analysis and testing of panel systems. For the past six years he has been in the panel systems laboratory.

E. S. Gibson rounded out twenty years in the Bell System on July 14.

L. D. Plotner with B. Freile of the Apparatus Development Department visited Hawthorne to discuss manufacturing problems relative to step-by-step switches.

At Pleasantville, New Jersey, H. W. Flandreau made a trial of tripping relays in the No. 11 switchboard.

R. H. Ross was called to Westport, Connecticut, to study ringing problems on PBX long-line circuits.

H. J. Appel visited Scranton and Easton, Pennsylvania, spending several days in each city making tests on step-by-step switches.

W. J. Lacerte at Albany observed a comparative trial of chromium-plated and zinc-plated relays.

### Equipment Development

H. E. Marting visited Hawthorne to discuss the manufacture of a line-message register rack of improved design.

The step-by-step office and associated unattended dial offices at Jamestown, New York, were inspected by C. E. Boman.

A. E. Petrie visited the factory of the Electric Storage Battery Company in Philadelphia to discuss experiments on storage battery plates for central office use.

H. M. Spicer was at Schenectady to inspect the new power-control equipment to be used with the Waldorf-Astoria public address system.

G. H. Paelian was twenty years a member of the Bell System on July 17.

### Toll Development

G. C. Crawford visited the Allentown repeater station to observe noise tests on the 12-C Program Supply Repeater. He was accompanied by members of the D. & R. Department.

W. E. Regan was at Princeton in connection with tests of the new Philadelphia-Newark cable.

M. R. Kleist modified some 22-A-1 telephone repeaters at Allentown and Harrisburg in connection with the development of wider-band two-wire circuits.

J. H. Bell completed twenty years with the Western Electric Company and Laboratories on July 1.

## INSPECTION ENGINEERING

During the latter part of June, L. E. Gaige, Field Engineer, Detroit, visited the Laboratories in connection with current problems.

G. D. Edwards visited Chicago and Milwaukee to introduce H. K. Farrar as Field Engineer in the Chicago territory.

R. M. Moody and A. N. Jeffries visited the Automatic Electric, Inc., at

Chicago for a quality survey on step-by-step relays.

R. B. MILLER made a trip to Binghamton, New York, to inspect the new No. 3 Toll Switchboard.

## PATENT

H. A. FLAMMER was in Washington to make a search through the classified files of the Patent Office.

G. C. LORD attended a hearing before the Board of Appeals in the Patent Office.

THE TAKING OF testimony required the presence of F. Mohr in Washington and Richmond, Virginia.

## PERSONNEL

G. B. THOMAS attended the annual meeting of the Society for the Promotion of Engineering Education held at Purdue University.

## STAFF

E. J. SANTRY has been appointed to represent the Laboratories on the Office Equipment Standardization Committee and the Office and Methods Group of Western Electric.

*E. J. Santry*

The purpose of these committees is to give consideration to office developments and equipment standardization. The work of the Committee is carried on to a large extent through operating sub-committees assigned to specific studies. E. C. Walsman and H. F. Lynch of the Methods and Audits Department have been appointed to the sub-committee.

T. J. Murtha completed twenty years in the Bell System on July 21.

MISS H. M. CRAIG attended the annual convention of the American Library Association at New Haven. As President of the Graduates Association, she presided at the reunion dinner of Pratt Institute School of Library Science held at that time.

A FIVE-STAR service button emblematic of twenty-five years in the Bell System was conferred on Dennis Cronin on July 1.

*Dennis Cronin*

Mr. Cronin has been doorman in Section H since the opening of this section and comes into daily contact with a large number of Laboratories members who hail him by the familiar name of Denny. For a number of years he was elevator operator at the 463 West Street entrance. He has become known to many past and present officials of the Bell System in taking them to their offices when the present building was the headquarters for the Western Electric Company.

# Contributors to this Issue

F. T. Meyer joined the Plant Department of the New York Telephone Company in 1912. After five years' field experience, including substation and PBX maintenance, and finally as PBX wire chief, he obtained a leave of absence to join the Navy. At the end of the World War he joined the Laboratories at West Street. Here with the Equipment organization he spent eleven years developing step-by-step dial equipment, and in 1930 was placed in charge of the Methods group.

E. R. Lundius began his telephone career as a cable tester with the New York and New Jersey Telephone Company. With the introduction of the common battery system in 1899 he transferred to the New York Telephone Company where he engaged in switchboard maintenance work. In 1905 he became division wire chief in the San Joaquin division of the Sunset Telephone and Telegraph Company, but returned to New York the following year where he was associated with the District Inspector's office. Later he transferred to the Pacific Telephone and Telegraph Company where he was wire chief of the Inland Division. In 1909 he transferred to Portland, Oregon, and later to Seattle as Equipment Superintendent. In 1914 he transferred to the Engineering Department of the New York Telephone Company, and the following year joined the Laboratories. At the present time he is supervisor of a group handling Manual Development for the Systems Department.

*F. T. Meyer*

A. A. Roetken entered the University of Cincinnati in 1922 and at the end of his junior year shifted to Ohio State University, where he received the degrees of B.E.E. in 1927 and M.S. two years later. Joining the Radio Research group of the Laboratories in 1929, he set to work at once upon the design of the measuring set which he describes in this issue of the Record. He is now engaged in the further development of short-wave radio receiving and measuring equipment.

R. L. Case received the A.B. and S.B. degrees from Denison University in 1921 and immediately joined the Laboratories. He was first associated

*E. R. Lundius*

*A. A. Roetken*

*R. L. Case*

*R. C. Davis*

*A. L. Samuel*

*E. C. Erickson*

with the design of circuits for telephone repeaters. Since 1922 he has been engaged successively in the design and development of echo suppressors for two and four-wire circuits, of terminal circuits for the transatlantic radio, and of telephone repeaters for two-wire circuits. While at the Laboratories he has taken graduate work at Columbia and received his M.S. degree in 1926.

R. C. Davis became associated with the Bell System in 1912 when he joined the Plant Department of the Central Union Telephone Company. Staying with the Indiana Bell Telephone Company when its predecessor was split, he transferred to its Engineering Department in 1916. From 1918 to 1919 he held a non-commissioned position with the Navy as a general electrician. Coming to these Laboratories in 1921, Mr. Davis began his present participation in our circuit development work in the analyzation group. In 1924 he became supervisor of a group developing manual switchboard circuits, and three years later he took charge of the development of circuits for dial systems operators.

After getting an A.B. degree from the College of Emporia (Kansas), A. L. Samuel went to the Massachusetts Institute of Technology where, as the result of a cooperative course with the General Electric Company, he received an S.B. degree in 1925 and an S.M. degree the following year. He remained as an instructor in the Electrical Engineering Department for two years. In 1928 he joined the technical staff of the Laboratories, and at the present time is supervisor of a group developing vacuum and gas filled tubes.

E. C. Erickson received a B.S. degree from Princeton University in 1922 and joined the Laboratories a few months later. For some six years he was with the Transmission Apparatus group engaged in the design of condensers and loading coils. Since 1928 he has been with the Materials group where he is specializing in precision linear measurements.