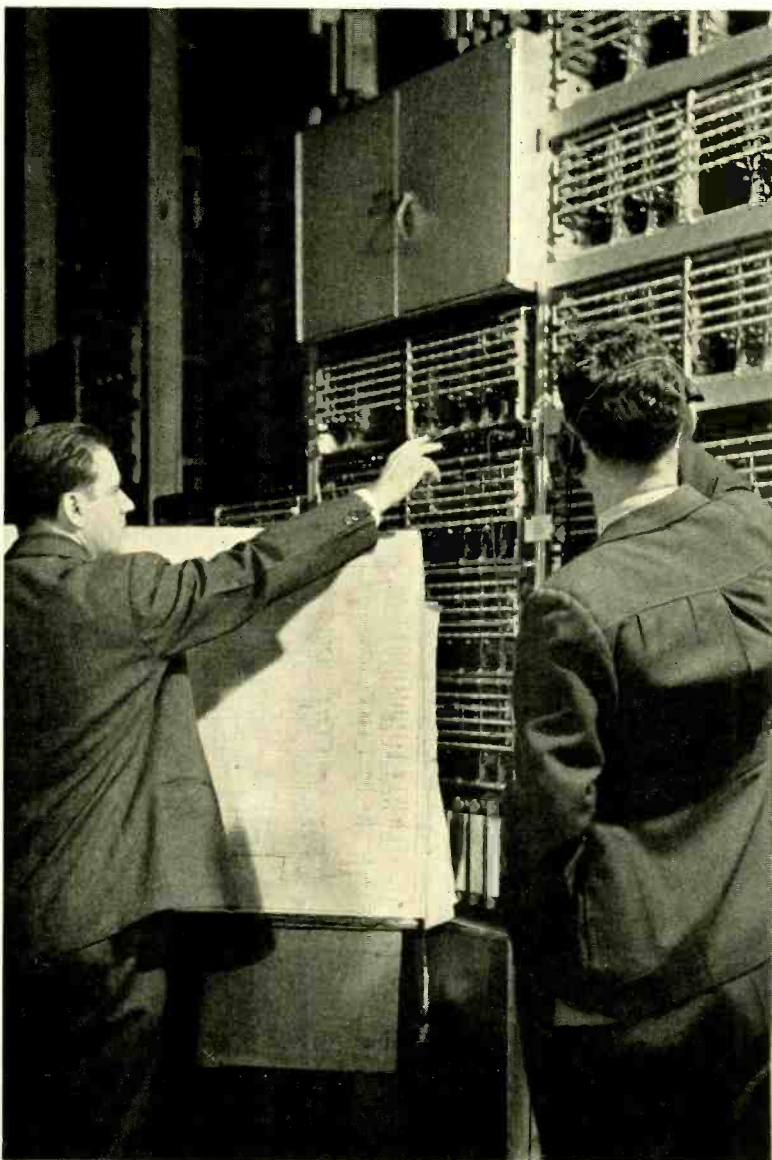# ELL LABORATORIES RECORD

JULY
1938

VOLUME XVI

NUMBER XI

Testing line-link circuit in crossbar laboratory

Carrier Supply
for
Type K Systems

By C. H. BIDWELL

Equipment Development Department

groups in different frequency positions by modulation. In the type K system, one additional carrier frequency is required.

The carrier-supply equipment employs a basic frequency of 4 kc and provides all the carriers by harmonic generation. The "odd" harmonics of 4 kc are obtained directly from the output of a magnetic harmonic generator, while the "even" harmonics are obtained through a copper-oxide rectifier bridged across the generator output. Six filters, passing frequencies of 68, 76, 84, 92, 100 and 108 kc, are connected in parallel across the "odd" harmonic branch, and six filters passing frequencies of 64, 72, 80, 88, 96 and 104 kc, are bridged across the "even" branch. From the output of each of these filters, branch circuits are connected to supply a total of ten terminals from the same carrier-supply equipment. The additional carrier of 120 kilocycles, required for group modulation in the type K system, is taken off through another filter connected to the "even" branch, and after amplification this carrier frequency is distributed to the group modulators and demodulators.

The method of harmonic generation employed is described in a previous

THE channel terminal, described in a previous issue*, will be common to all the new broad-band carrier systems. It provides the basic twelve-channel group and requires twelve carrier frequencies spaced four kilocycles apart from 64 to 108 kc, inclusive. Besides these twelve-channel carrier frequencies the broad-band systems require other carrier frequencies to locate complete

*May, 1938, page 315.

article.* The carrier-supply equipment designed for commercial systems includes, in addition, precautions to guard against failure of carrier power. An interruption of the supply for the type K systems, for example, might mean that 120 talking circuits would be out of service. Consequently, it is necessary that adequate protective measures be provided.

Dependability of supply is secured partly by precautions taken to guard against accidental short circuits or grounds at points where the carrier supply for a large number of circuits would be affected, and by the use of protective resistances in the leads supplying each modulator and de-

*RECORD, *July*, 1937, *page* 357.

modulator circuit. The major precaution, however, is the provision of two complete carrier generators, one of which normally carries the load, and the other of which automatically picks up the load on failure of the carrier supply.

The arrangement of the circuit is indicated by the simplified schematic of Figure 1. Here the regular carrier generator is shown at the upper left, and the emergency generator—exactly like it—at the lower left. Between them is the transfer circuit that, in case of failure of the carrier, transfers the load to the emergency generator so rapidly that there is no appreciable interruption of telephone service. At the right of the schematic
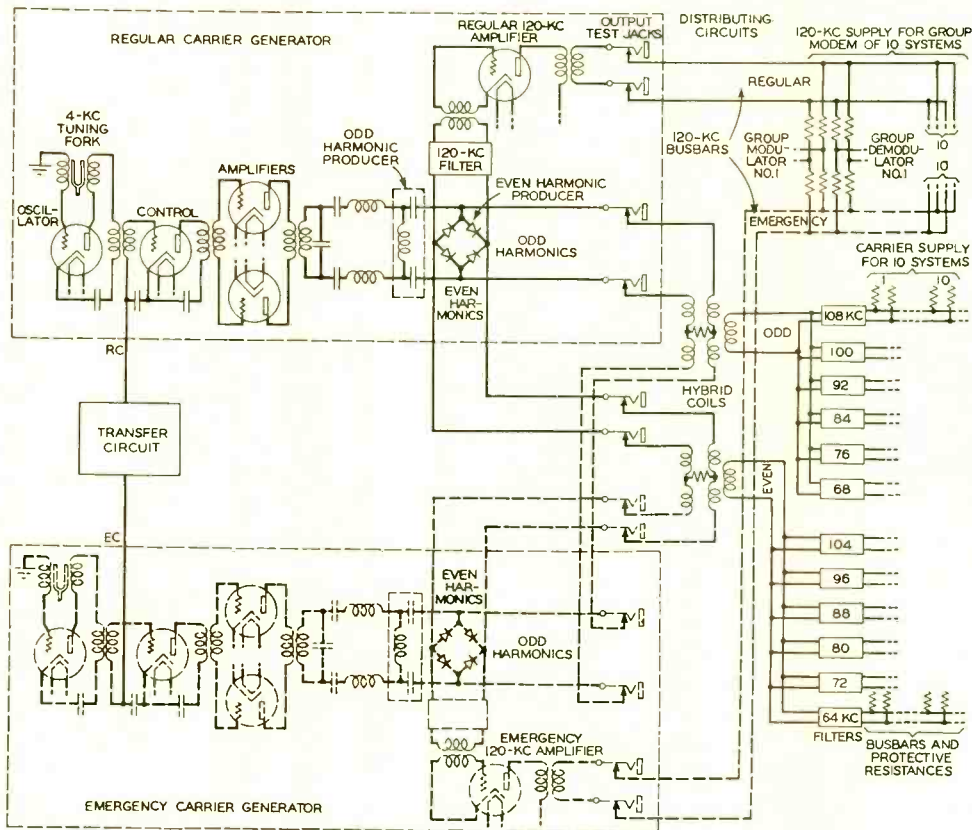

Fig. 1—*The carrier-supply equipment includes a regular and emergency generator, both connected to the same output circuits*

are the filters and distributing circuits that select the twelve channel harmonics and distribute them to the ten systems. The 120-kc filter and amplifiers for the group carrier are also shown in Figure 1.

Both the regular and emergency generators are connected permanently to the twelve carrier filters through
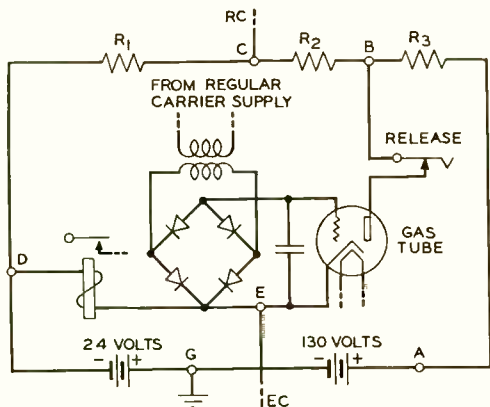

Fig. 2—Simplified schematic of the transfer circuit which starts the emergency generator on failure of the regular one

hybrid coils so that in case of carrier failure no switching through contacts is required; the connections to the hybrid coils are such that the carriers will flow from either generator to the load but not into the other generator. There is one hybrid coil for the group of odd harmonics, and one for the even. The 120-kc supply does not pass through a hybrid coil, but is taken directly from the output of the copper-oxide rectifier of each generator. Normally the regular generator supplies the carrier, and the emergency generator is made inoperative by a negative bias on the grid of its control tube. When the regular generator fails, this negative bias is at once reduced to zero, and the emergency generator immediately picks up the load with practically no interruption.

A simplified schematic of the transfer circuit is shown in Figure 2, where lead RC runs to the grid of the control tube of the regular generator, and lead EC, to the grid of the control tube of the emergency generator. Either generator becomes inoperative when the potential over its control grid is below about −9 volts, and becomes operative when the voltage is at zero potential or above.

The transfer circuit consists of a potentiometer formed of resistances R_1, R_2 and R_3, and a circuit consisting
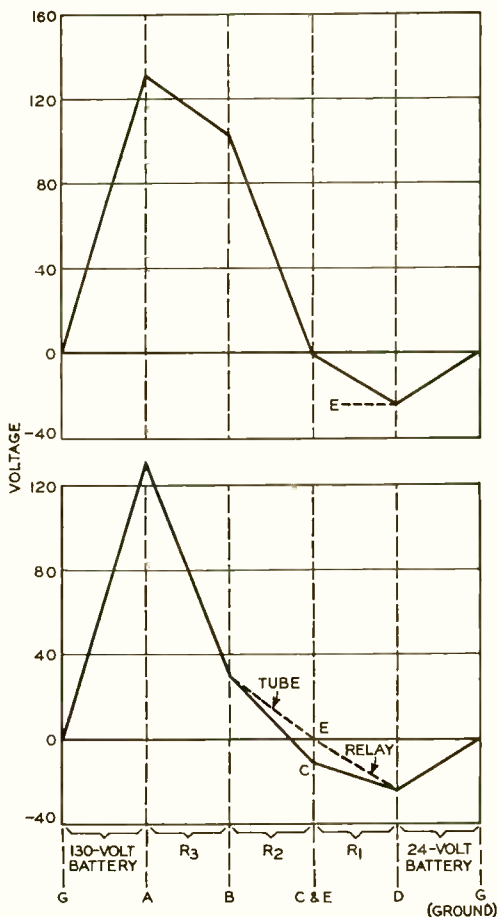

Fig. 3—Potential diagrams for the transfer circuit: Above, when the regular generator is operating, and below, when the emergency generator is operating

of a gas-filled tube and a relay that shunts resistances R_1 and R_2. The grid of the gas-filled tube is held negative by the output of the regular carrier generator through a copper-oxide rectifier, so that the gas-filled tube is non-conducting as long as the regular supply unit is generating. When the regular generator fails, however, the negative bias on the suppressor grid disappears, and the gas-filled tube breaks down and passes current.

The lead from the control tube of the regular generator connects to the transfer circuit at point c, and that from the emergency generator at point
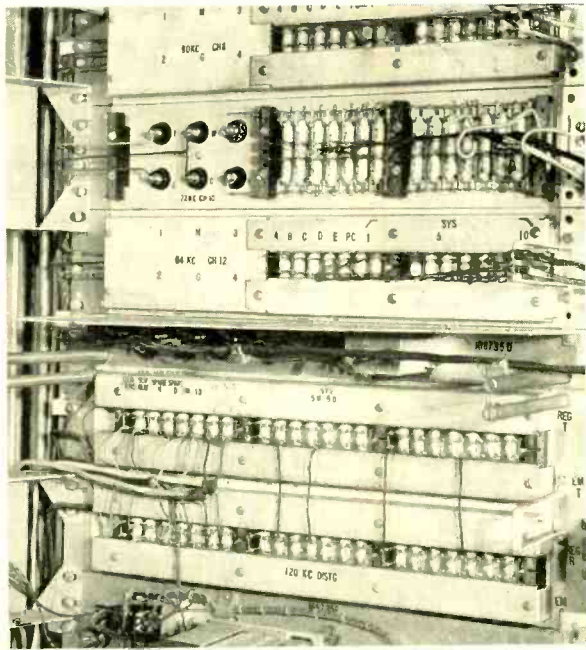

Fig. 5—*Two of the even-carrier distributing panels are shown at the top while the 120-kc distributing panel is shown below*
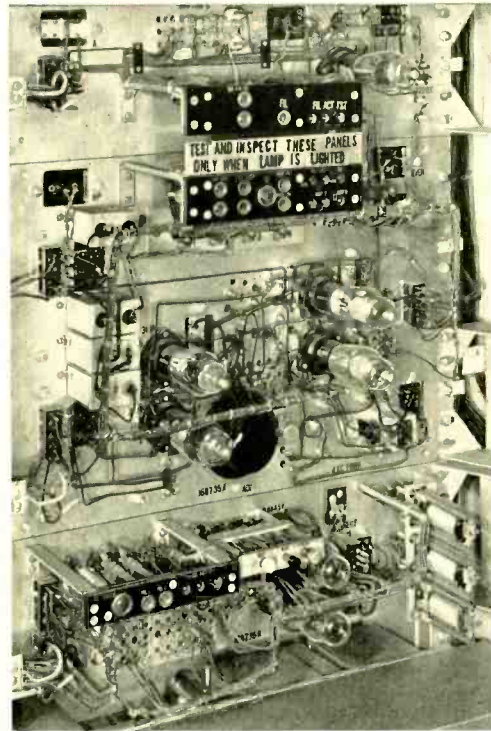

Fig. 4—*The 120-kc amplifier and filter panel is shown at the top and the carrier generator below it. The narrow panel at the bottom is the transfer circuit*

e. These two points of the circuit have different potentials depending on whether the gas-filled tube is passing current or is non-conducting. Under the latter condition point c is at zero potential and point e at −24 volts, while when the gas-filled tube is passing current point c is more negative than −9 volts and point e is zero.

The potentiometer consisting of R_1, R_2 and R_3 is supplied from a 130-volt and a 24-volt battery with a ground between them, so that one end of the potentiometer is at −24 volts, and the other at +130 volts. The potential distribution around the circuit when the gas-filled tube is non-conducting is as shown in the upper part of Figure 3. The entire rise in potential through the 130-volt battery is lost across resistances R_3 and R_2 so that at point c the potential is zero. Across R_1 the potential drops to −24
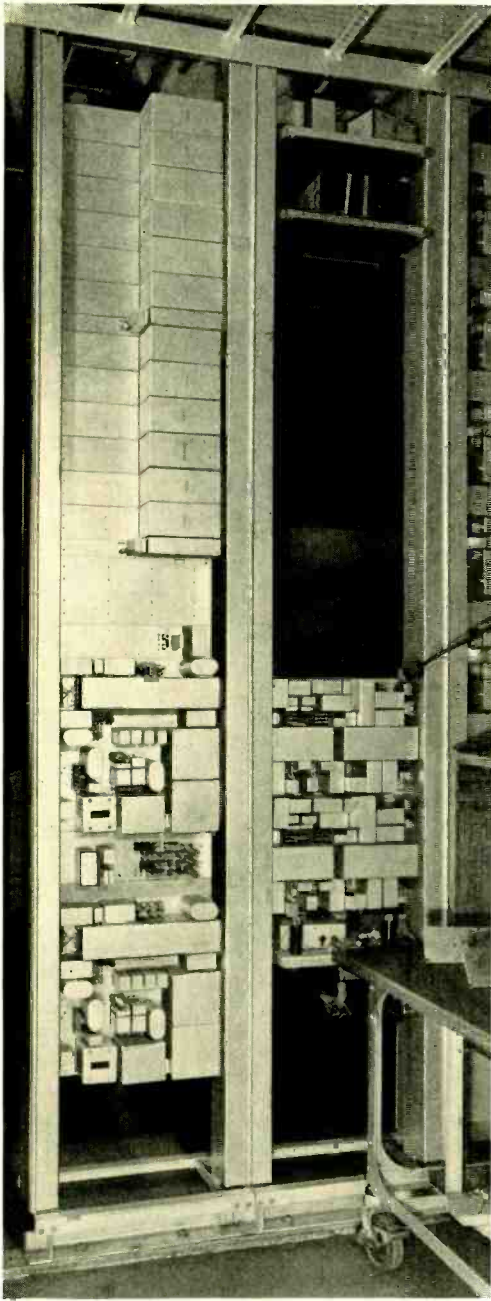
Fig. 6—Rear of carrier-supply equipment

shown in the lower part of Figure 3. Under these conditions there is a shunting circuit of comparatively low resistance from B to D, and the potential curve between these points will have two branches. As a result of the shunt, a heavier current flows through R_3 and the voltage drop across it is much greater than before. The potential over path B-C-D shown by the solid line drops to about −12 volts at C, and thus holds the regular generator inoperative. The drop over branch B-E-D is divided between the gas-filled tube and the relay, and results in a potential of zero at E, which makes the emergency generator operative. This transfer is accomplished almost instantaneously. With the interruption of the carrier supply to the copper-oxide rectifier, the voltage on the grid of the gas-filled tube—which was held negative by the rectified carrier voltage—drops to zero, and the tube at once discharges, forming the branch path between B and D and starting the emergency generator.

Besides the circuit elements already discussed, the transfer circuit also includes a key, marked RELEASE on the diagram, which is used to transfer the load back to the regular generator after the trouble has been cleared. Other keys are used for transferring the load to either generator manually. The relay shown is to give an alarm on failure of the regular generator, and other alarms, not shown, are included in the transfer circuit.

As a further precaution against interruption, the ten branch circuits from each of the twelve channel-carrier frequencies have protective resistances of such values that a short circuit across any one of them will not cause a material reduction in the carrier voltage at the bus bars. A similar provision is made for the

volts, and point E, connected in an open circuit branch at this point, is at the same voltage.

The potential distribution when the gas-filled tube is passing current is

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branch circuits from the regular and emergency 120-kc busses. These circuits are not connected through hybrid coils, but are tied directly together by pairs of protective resistances, with the branch circuits connected between each pair. These 120-kc supply circuits include amplifiers because of the higher level of carrier power required, and since the amplifiers prevent any back feed from one supply circuit to the other, a hybrid coil is not needed. All the carrier-supply circuits are protected by insulating guards over all terminals or exposed parts where a short circuit would put a number of circuits out of service.

This carrier-supply equipment is mounted on a single bay of relay rack as shown on the photograph at the head of this article. Each carrier generator is mounted on a separate panel with its 120-kc supply on a narrower panel immediately above it as shown in Figure 4. These two panels are mounted under a single can cover. The two generators are mounted on the lower part of the frame, with the transfer circuit, shown in the lower part of Figure 4, mounted on a separate panel between them. The distribution units are at the top of the frame: one for the even and one for the odd harmonics, and one for 120 kc. The units for the odd and even harmonics each consist of six panels mounted under two can covers as shown in Figure 7, while that for the
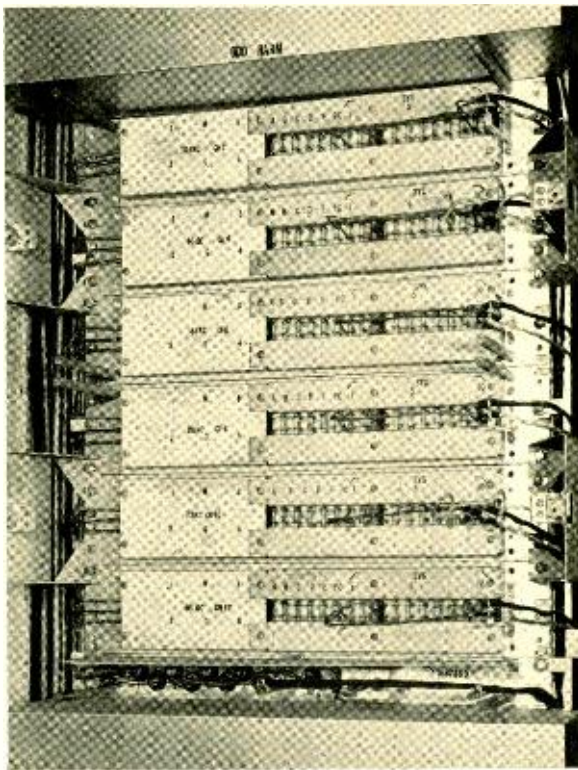

Fig. 7—The even harmonic distributing unit consisting of six panels is mounted between the odd harmonic and 120-kc units. The hybrid coil for the even harmonics is on the small panel at the bottom of the unit

120-kc has one panel under a single can cover. Figure 5 shows the two lower panels of the even unit and the 120-kc unit below it. The protecting strips have been removed from the terminals of the busses of one of the even-harmonic panels. All the equipment that might require maintenance attention is mounted on the front of the panels, where it is readily accessible, while such equipment as filters, and hybrid coils, which are assembled in sealed containers, is mounted in the rear of the panels as shown in Figure 6.

Paper As a Medium in Microanalysis

By H. W. HERMANCE
Chemical Laboratories

A STREAK of dirt across a strip of paper is an unpromising specimen for chemical analysis and yet this is often all that can be obtained from the tiny surfaces which the micro-chemist is asked to examine. Flasks, test tubes and other glass vessels of conventional form, even when reduced to the smallest dimensions, are practically useless for manipulating such minute amounts of matter. Instead a narrow strip of purified, hardened paper is used to collect the sample and then serves as the medium in which many of the subsequent analytical operations are carried out. This avoids, to a large extent, the handling and transferring of the material. The method has been used to determine among other things the composition of foreign matter which sometimes accumulates on the
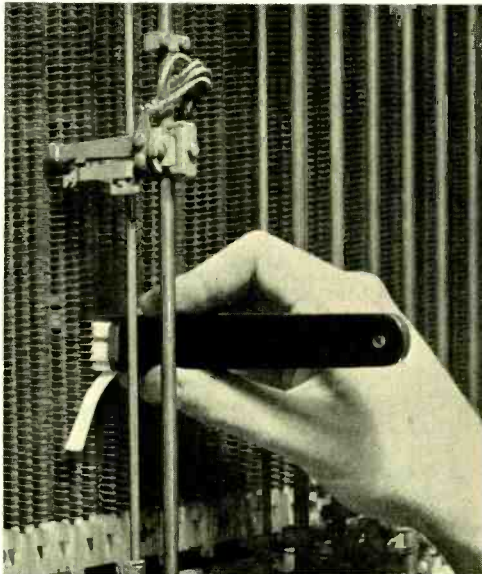

Fig. 2—*The substances on the paper strip are separated into groups by capillary extraction with volatile solvents. They are deposited by evaporation in separate narrow bands on the paper above the sample streak*

Fig. 1—*The minute amounts of foreign matter which accumulate on contacting surfaces are collected on a purified, hardened paper strip for microanalysis*

contacting surfaces of machine switching apparatus. By rubbing the contacts with the paper, which is held in a suitable holder, as shown in Figure 1, a composite sample from fifty or more such contacts is obtained as a dark streak of gummy material weighing only a few tenths of a milligram.
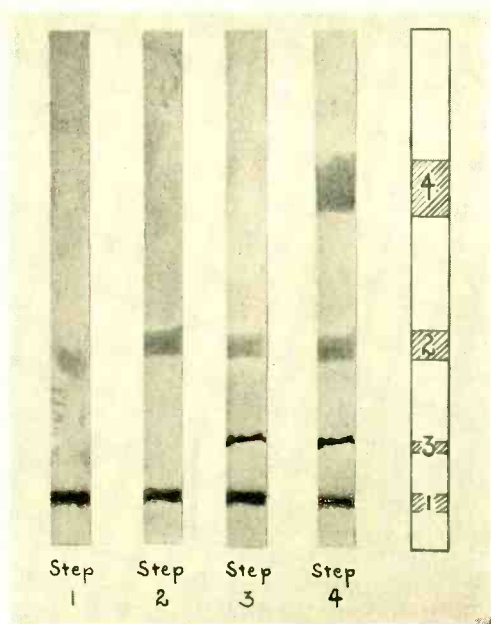
Fig. 3—*Paper strips showing bands of material deposited from various solvents*

The first step in the analysis is to suspend the paper strip vertically with the lower end dipping into a volatile solvent so adjusted that the surface of the liquid is slightly below the streak of collected material, Figure 2. Capillary action draws the solvent upward into the strip as oil is drawn up a lamp wick. As the solvent moves upward through the streak, certain of its components are dissolved and carried along. Eventually evaporation of the solvent leaves the extracted substances in the form of a narrow deposit on the paper considerably above the streak. A special flask with an elongated neck controls the location of the deposition zones by protecting the solvent against evaporation until it has climbed to the desired height. At this point, evaporation is accelerated by a current of air, which restricts the area over which evaporation occurs and produces narrow deposition bands. By varying the solvent, the lengths of the flask necks and the intermediate treatments with reagents such as acid vapors, a series of extractions can be made which give several separated zones on the paper each of which contains a particular group of components from the original complex mixture. In Figure 3, for example, zone 1 consists of materials insoluble in benzene, water and acid; zone 2 of
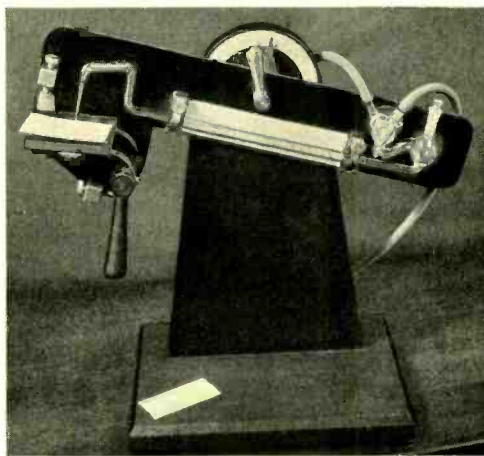
Fig. 4—*A capillary burette for controlling the introduction of minute quantities of solution into impregnated paper to effect automatic separation of two or more metal ions*

metals originally present as salts of fatty organic acids; zone 3 of uncombined metals and inorganic combinations of metals such as oxides and sulphides; and zone 4 of asphaltic and gummy substances with the organic acids liberated in zone 2. Each zone is cut out and examined separately.

The nature and amount of the insoluble mineral matter in zone 1 are determined by microscopic study after destruction of the paper; for example, by careful incineration in a small platinum capsule that is placed in a tiny quartz-lined electric furnace.

Copper and iron are among the metals most likely to be found in

zones 2 and 3. Their simultaneous detection, based on a separation of products by capillary flow, is another interesting example of the use of paper as a medium for analytical reactions. The metal salts contained in the zones, from which all superfluous paper has been trimmed, are extracted in small drops of water. The
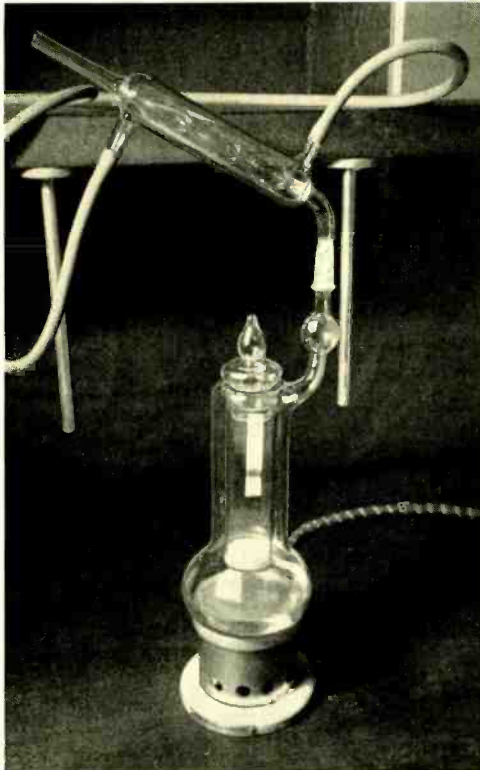

Fig. 5—*Reactions involving volatile reagents and acid fumes are carried out in a heated vapor chamber*

extract is then drawn into the capillary burette shown in Figure 4, and flowed out slowly from the extremely fine orifice of this burette into paper impregnated with barium carbonate. The iron precipitates at the point of entry as hydroxide while the copper remains dissolved and flows out with the spreading drop. After drying, a second drop of water washes any
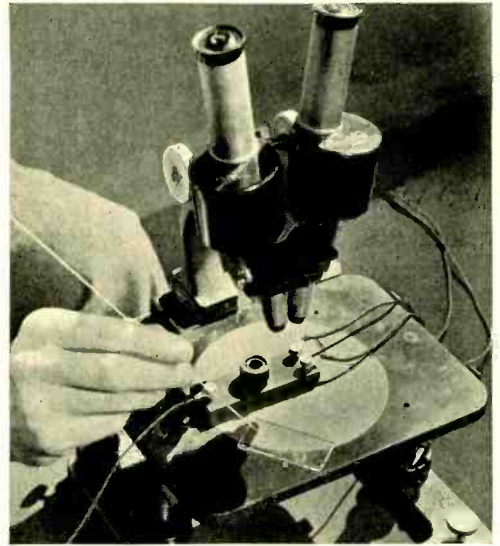
Fig. 6—*A minute electrolytic cell is used to separate metallic constituents. The deposition is observed under a microscope*

copper which remains in the central portion to the periphery of the original wet area. The paper is dried again and then dipped into potassium ferrocyanide which converts the iron into a deep blue spot and the copper into a brick red ring. Less than a millionth of a gram of these metals can be detected in this way.

Sometimes substances can be removed from the liquid, as it ascends the paper strip, by precipitating them in zones on the strip which has been previously impregnated with suitable reagents. These transverse bands are prepared by precipitating in the paper reagents not readily soluble in the liquids used but at the same time capable of precipitating certain substances as the liquid flows upward through the reagent.

When acid treatment is required to transform a substance the paper strip is hung in the closed vapor chamber, shown in Figure 5, and exposed to the fumes of the acid. Gaseous reagents and vapors of volatile substances can

also be admitted to the chamber to develop color or other characteristic reactions in the paper strip.

Zinc is found by depositing it from an acidulated drop of the paper extract in a minute electrolysis cell under a microscope as shown in Figure 6. As little as five ten-thousandths of a milligram of this metal can be detected by this procedure.

Organic acids are separated by placing the paper section from zone 4 in a microdistillation apparatus and depositing tiny droplets or crystals of the acids, under reduced pressure, on a microscope cover-slip. Such droplets may then be transformed by reagents into crystalline metallic salts. These are identified under the microscope or, when the distillate appears pure and crystalline, their melting points determined by using a heated stage on the microscope.

Only a few of the special techniques which have been developed in the new field of microanalysis can be mentioned but these show the unusual means used and the ingenuity required to identify the constituents of such minute quantities of matter.

SUNSPOT ACTIVITY

Sunspot activity and radio transmission disturbance are of particular interest in relation to transatlantic short-wave radio-telephone circuits. The curves below show how sunspots and radio disturbance effects have varied since the transatlantic short-wave circuits were put into service in 1928. Data for four months in 1938 indicate that the peak of the present sunspot cycle is passed but that radio disturbance is increasing. Magnetic and radio disturbances reach a peak some time later than the peak of sunspots. Past experience and present trends suggest that the peak of radio disturbance will be reached within the next year or two.
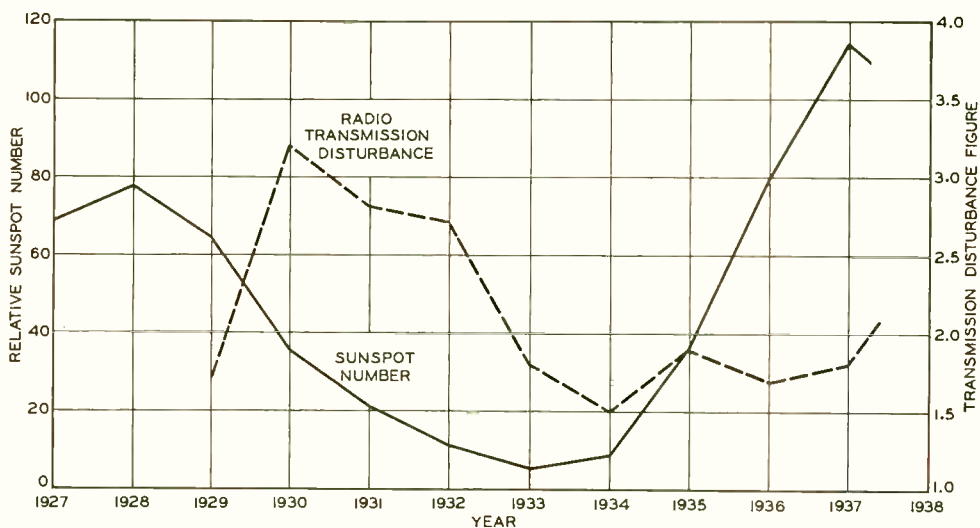
Experiments on Talking Contacts
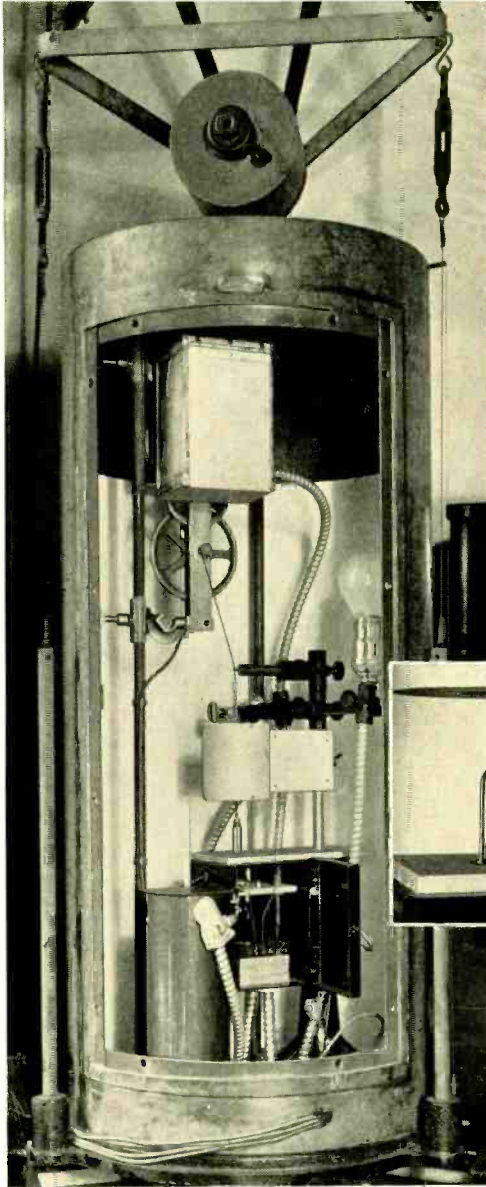
IN A typical telephone connection, the voice currents pass through as many as twenty or thirty metallic contacts. It is extremely important that these contacts behave themselves during a telephone conversation. They must not introduce high resistance or contribute an appreciable amount of noise. Experience has shown that they do not always work satisfactorily, for reasons which are by no means obvious, and it is therefore necessary to study them to find out why.

The apparatus shown here was devised to investigate a contact pair under controlled conditions of temperature. In the square box near the top of the picture is a synchronous motor; through a gear train it slowly unwinds a wire which lowers one contact onto the other one. This wire passes through the cover of an electric heater (here shown raised); temperature of the heater is measured by a thermocouple. A close-up view of the contact mountings is shown in the insert. To prevent mechanical vibration from reaching the contact during test the entire apparatus is mounted in a soundproof cylinder which is suspended by springs. All the controls are operated after the container has been closed and the various electrical measurements are made externally.

A Voice-Operated Return-Loss Measuring Set

By D. MITCHELL
Toll Transmission Development

ONE usually thinks of a loss as something that should be kept as small as possible. Return loss, however, is different in this respect; it should be kept high. The reason is that the return loss is not a loss suffered by a usable portion of the signal current but rather that suffered by an undesirable portion. It represents the loss over a path along which it is desirable that no current should pass; and such current as does pass is an echo which interferes with speech transmission. The net loss at which any toll circuit can be operated often depends in large measure on the value of the return losses of the lines at the terminals.

The effect of return loss can be most easily illustrated by a four-wire circuit, commonly used for long distance transmission. Such a circuit employs a separate path for transmission in each direction; but at terminals, the two paths must be changed to a single path for connection to the subscriber loop through the switchboard. This conversion is accomplished by hybrid coils, marked T1 and T2 in Figure 1 which shows the arrangement of a four-wire circuit in schematic form. West-bound speech current, travelling over the lower path, divides in the two central sections of the hybrid coil; part going to the network, where it is dissipated, and part to the subscriber. If the impedance of the network is exactly equal to that of the subscriber's line, the currents in line and network will be equal. These currents will then oppose each other in the windings of the upper transformer and no current will be transferred to the upper part of the hybrid circuit.
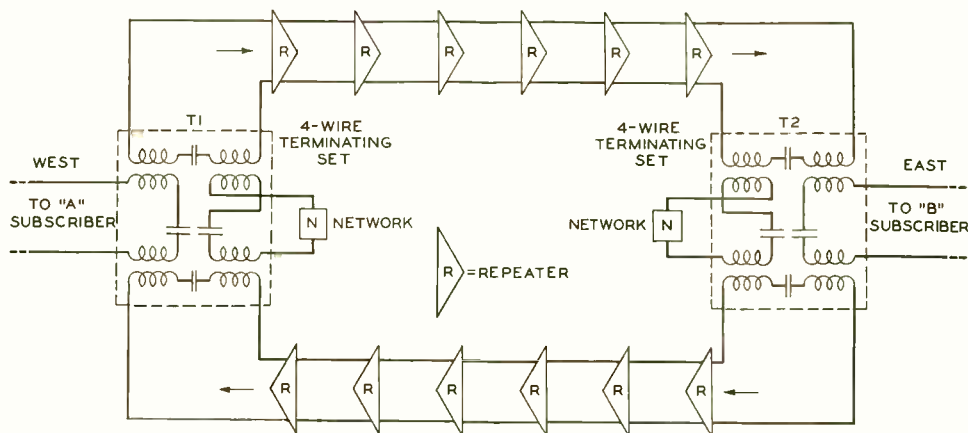

Fig. 1—*Simplified schematic of a typical four-wire circuit*

To the extent that the network does not balance the line, some of the west-bound speech current will be returned from the subscriber's line through the hybrid coil to the east-bound channel. The "return loss" is defined as the amount by which this returned current is below that delivered to the subscriber's line. Obviously it should be high if echoes are to be small.

This particular return loss is called terminal return loss to distinguish it from that at an intermediate switching or two-wire repeater point where the outgoing circuit is another toll line rather than a subscriber's loop. Since a toll line usually consists of fixed facilities, its balancing network can be made to duplicate it very closely; and thus it is not difficult to keep this return loss at a reasonably

high value. Subscribers' loops, however, vary widely. They differ in length and in characteristics; and also they may have different types of station apparatus associated with them. There are also differences in the local circuits within a central office; so that all in all it is impracticable to approach an accurate balance with the local network.

For any one set of conditions, the return loss could be calculated, but since each toll call may have a different local connection, the task of calculating all of them and then determining the relative frequency of occurrence of the various types would be an exceedingly arduous undertaking. For the proper design of toll lines and equipment, however, it is necessary to know the range and
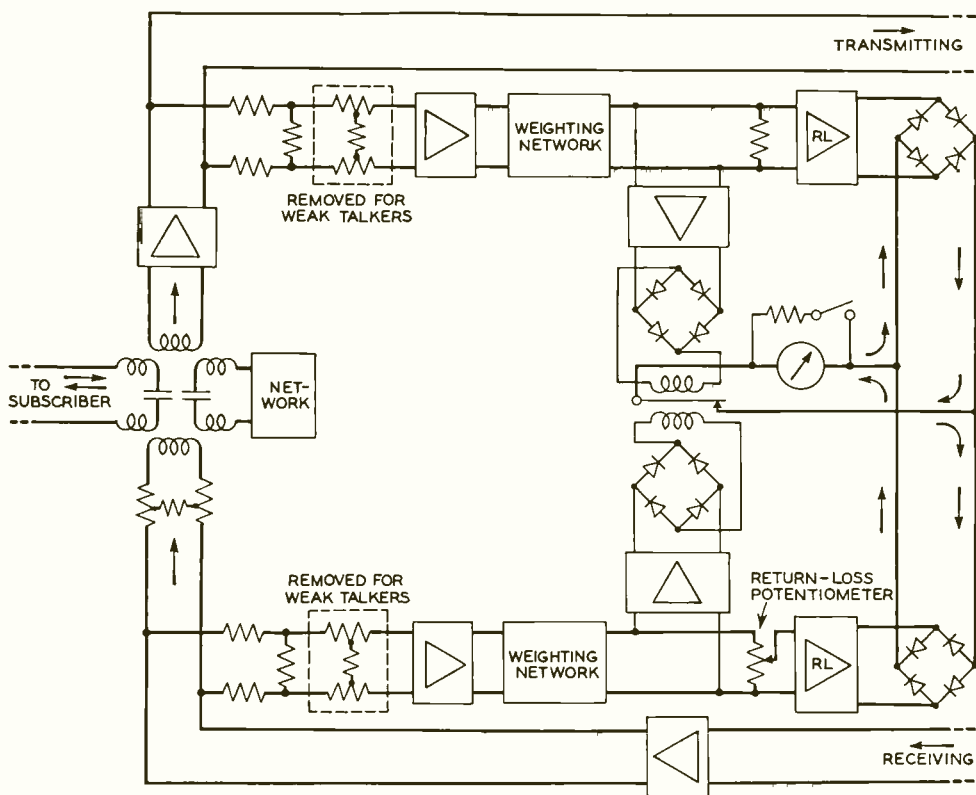

Fig. 2—Arrangement of the voice-operated return-loss measuring set

relative frequency of occurrences of existing values of terminal return loss. A circuit was therefore developed some years ago with which rapid measurements of return loss could be made on large numbers of calls. It was arranged for connecting to the two sides of a four-wire circuit on the output sides of the terminal repeaters, and it measured return loss by a determination of the loss that had to be inserted in the signal on the incoming side to make it equal to the echo signal in the return path.

The arrangement of this circuit is shown schematically in Figure 2. The two branches of the measuring circuit are connected to the two sides of the four-wire line through high-resistance pads to avoid having an appreciable effect on the talking circuits. The main part of each of these branches includes an amplifier, a weighting network, another amplifier, and a dry-disk rectifier. The outputs of the two rectifiers are connected together and the return-loss galvanometer is bridged across them. The branch connected to the incoming side of the four-wire circuit also includes the return-loss potentiometer.

The direction of current flow in the outputs of the two rectifiers is indicated by arrows, and is such that the currents from the two rectifiers tend to deflect the galvanometer in opposite directions. If they are of equal value the galvanometer will remain undeflected. Return loss is measured by inserting loss with the potentiometer until the galvanometer remains undeflected, the reading of the potentiometer giving the loss directly.

If the circuit included only the elements described above, and shown in heavy lines on the diagram, there would be very large deflections of the galvanometer whenever the local subscriber talked. Since the direction of conversation changes very frequently, a balance under these conditions is difficult to obtain, and there is even
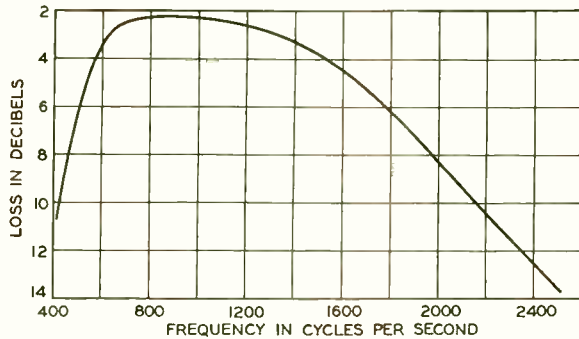
Fig. 3—Characteristic of weighting network used with the return-loss measuring device

danger of damage to the meter by its large swings when the local subscriber talks. To avoid this, the circuit shown in light lines is included. This circuit also has two branches, each of which is connected to one branch of the main measuring circuit, and includes an amplifier and a rectifier. The output of each rectifier is connected to one coil of a relay; one coil tending to close the relay contact and the other to open it; the contact itself is in the galvanometer circuit. The amount of current in these two sub-branches is such that with the incoming speech and the lowest possible value of return loss, the relay contact will remain closed, and a return-loss measurement can be made. When the local subscriber talks, however, the currents in the upper branch become much greater, and the relay contact will operate and open the galvanometer circuit. This voice-operated feature makes the circuit automatic in that no attention need

be paid to the direction of flow of speech; it is necessary only to adjust the potentiometer so that the galvanometer needle remains undeflected, or deflects equally on both sides, during a single call.

To be able to balance the energy in the two branches of the measuring circuit, it is necessary that the input-output characteristics of the RL amplifiers and their rectifiers in each branch

Fig. 4—*Analysis of local return losses*

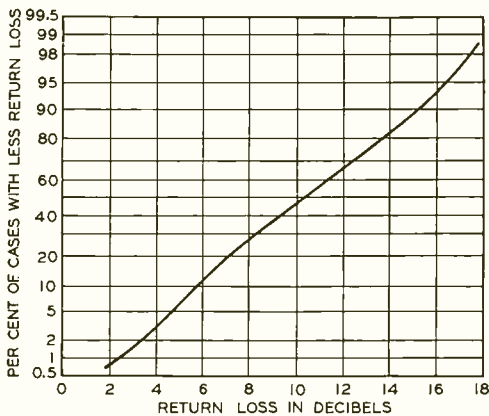be closely matched over a fairly wide range of energy input. It was not found practicable, however, to balance them satisfactorily over a range greater than 20 or 25 db, which is less than the range covered by very weak and very loud talkers. Two resistance pads were therefore added to the circuit—one in each branch—which could be connected into the circuit or taken out by means of a key. They are normally left in the circuit, but for very weak talkers, which would be indicated by very small deflections of the galvanometer, they are removed.

It was also found that if the potentiometer setting was wrong by a large amount at the beginning of a measurement, the galvanometer might be deflected violently enough to damage it. A shunt resistance was

therefore provided that could be connected across the galvanometer by a key. At the beginning of a measurement the key is closed, and an approximate setting of the potentiometer is made. The key is then opened to give full sensitivity.

As originally built, the circuit did not include weighting networks. It was soon found, however, that even after the best possible balance was obtained, there would occasionally be large kicks of the galvanometer. This was due to the fact that the return losses at the edges of the voice band varied widely from their values over the important range from 500 to 1500 cycles. Talking tests were therefore made to determine the echo effects for various band characteristics. It was found that with a characteristic as shown in Figure 3, the echo effects, judged by the annoying effect on conversation, were practically the same as for a full-width band. Weighting networks were thus installed, and they eliminated the occasional large kicks of the galvanometer.

This circuit was used some time ago in an extensive study of terminal return losses. The results for three thousand different connections on calls between Detroit and New York are shown in Figure 4. This distribution curve shows, for example, that for ninety-nine per cent of the connections, the return loss was less than 18 db and that for fifty per cent of the calls it was less than 10.5 db, but that in only one per cent of the connections was it below 3 db. Since then the measuring circuit, somewhat modified, has been combined in a unit with other testing equipment, and is now in use in other tests. For the time being it is expected that this equipment will be used only in special investigations by the Laboratories.

A Teletypewriter Switchboard for Private
Line or PBX Service

By L. A. GARDNER
Telegraph Facilities Department

SWITCHING arrangements for teletypewriters were introduced commercially in private line networks shortly after the introduction of the teletypewriter itself, and at the present time there are a number of both special and standard arrangements in use. One of the standard arrangements, the No. 65-B-1 teletypewriter switchboard, was developed for state police authorities and business concerns having private-wire networks extending over wide areas, and was described in the RECORD for September, 1936. It has also been found desirable to provide as a com-

plement to the No. 65-B-1 switchboard a new switching arrangement for application in restricted rather than extensive areas, and arranged for station-to-station and broadcast service. Furthermore, since the introduction of teletypewriter exchange service it has become desirable to develop equipment that could be used as a private branch exchange, and this new equipment, the No. 67-A-2, is suitable for either local private-line or private-branch-exchange service. It has a flexible basic design that permits special features to be added in an economical manner. The first installa-

tion of a standard board of this type, for the Buffalo municipal police, is shown in the photograph at the head of this article.

This new board utilizes the framework of the 551A PBX,* and provides for twenty subscriber lines. To serve these lines, ten cord circuits and two switchboard-attendant circuits are provided, although a partially equipped board may be obtained if desired. Each line jack has a calling lamp associated with it, and each cord circuit has an attendant's teletypewriter key, a ringing key, a broadcast key, and two supervisory lamps, one associated with the calling and one with the answering cord. Beneath the line jacks is space for incoming trunks from a TWX office when the board is used as a PBX. The number of these trunks ordinarily required is determined by traffic conditions, but is generally not more than two or three.

*Record, *July*, 1928, *p.* 363.

The cords of previous teletypewriter switchboards have generally been equipped with repeating relays, which permit the connecting lines to be about thirty miles long. Since the new board is of small capacity, and designed primarily to serve only restricted areas, no relays are provided in the cord circuits. This limits the length of the lines to about fifteen miles, but gives a simpler and less expensive board, which was one of the objectives sought. Service to stations at approximately twice this distance, however, may be supplied by the use of extension repeater equipment. This equipment is arranged in a small wall-cabinet and may be mounted adjacent to the switchboard.

A simplified schematic of the line and cord circuits is shown in Figure 1, with the help of which the usual operation of the board may readily be followed. When a subscriber wishes to place a call, he closes his power
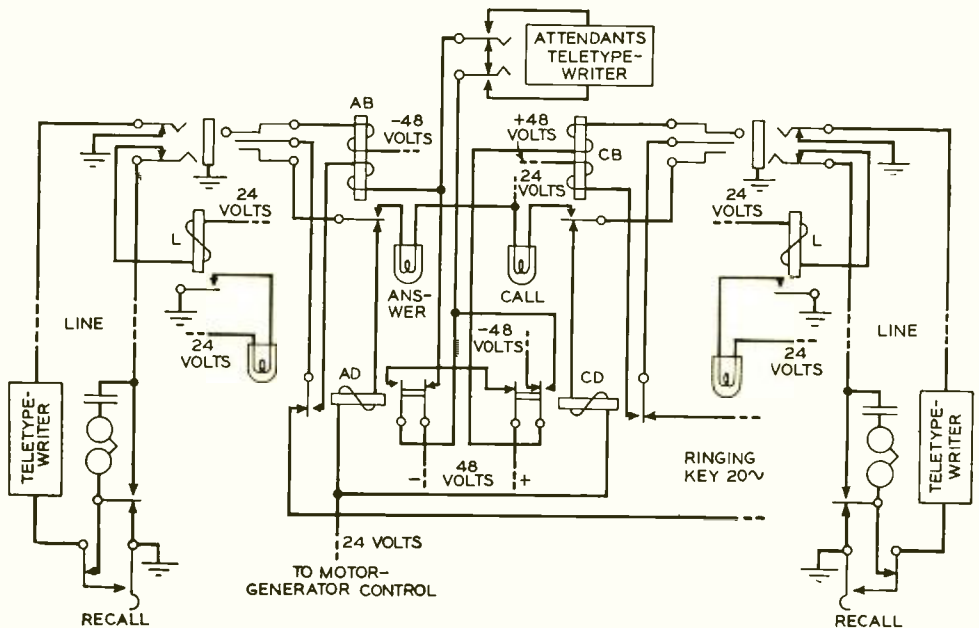

Fig. 1—*Simplified schematic of a line and cord circuit as used for connecting two teletypewriter subscribers for an ordinary call*

switch, thus closing the loop. Relay L at the board then operates, and lights the line lamp. The attendant inserts the answering plug of a cord into the jack of the calling line, which opens the circuit to the line relay, and the calling lamp goes out. He then operates his teletypewriter key and communicates with the subscriber to obtain information as to the line wanted. With this information, he inserts the calling plug of the cord into the jack of the line called, and rings the called station. At any time after this the attendant may remove his teletypewriter from the circuit and use it in connection with other calls, although ordinarily he will remain on the line until the called party answers.

by the attendant to any or all of the stations, or by any one of the stations to any or all of the others. When the attendant is to broadcast, he connects the stations that he wants to reach in pairs with the cords, and then operates the cord keys to the proper positions.
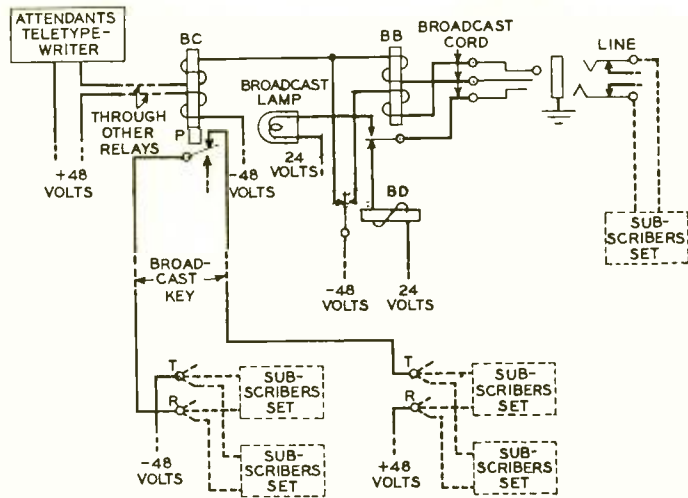

Fig. 2—Simplified schematic of the broadcasting-cord circuit, used to enable one station to broadcast to a number of others

The two windings on relays AB and CB oppose each other, and thus these two relays remain unoperated during the transmission of telegraph signals. Should one of the subscribers wish to recall the operator, he operates intermittently a station key which grounds one side of the line. As a result the currents through the windings of AB or CB are unbalanced, and the relay operates intermittently, and depending on which subscriber is recalling flashes either the "calling" or the "answering" lamp. At the end of the communication the station attendants release the power switches, stopping their respective teletypewriters, opening the lines, and grounding one side so that the cord lamps will light.

The circuits of the new switchboard permit broadcasts to be made either

With his teletypewriter connected to all stations, he types his message.

When one station is to broadcast to some or all of the others, a special broadcast cord is employed. This is a single-ended cord which is plugged into the line that is going to broadcast. The stations that are to receive are connected together with the regular cords as before. A schematic for this cord circuit, indicating the connections during such a broadcast, is shown in Figure 2. An associated key provides for connecting the attendant's teletypewriter into a broadcast connection, or for ringing a station which has previously requested a broadcast circuit—thus notifying it that the connection is ready for use. When the attendant at the broadcasting station operates his teletype-

writer, the signals are repeated to the other stations through the polarized relay BC. Recalling and disconnecting are performed through relay BB as with other calls.

Positive and negative 48-volt power is required for the transmission circuits, and is supplied from two motor-generators arranged in a cabinet about three and a half feet high and three feet wide. The motor-generators are plug-connected to facilitate rapid replacement with a spare machine if necessary. The cabinet is floor-mounted, and may be located in any convenient place. Twenty-four-volt power is required for the supervisory lamps, and this as well as ringing current may be obtained from a nearby central office. The 48-volt motor-

generator sets are operated only when the board is in use, and are started automatically by the insertion of a plug into any of the jacks.

Besides its provision for TWX trunks, the board also provides for tie lines to another PBX of the same type. Both the trunks and the tie lines require terminating equipment, which is mounted in the cabinet used for the extension repeater equipment. Every effort has been made to incorporate in the board only the types of equipment that will be required regardless of how the board is to be used, but the quantity of equipment supplied will vary to meet individual specifications. In this manner, the price of the switchboard has been kept moderate without restricting its wide applicability.
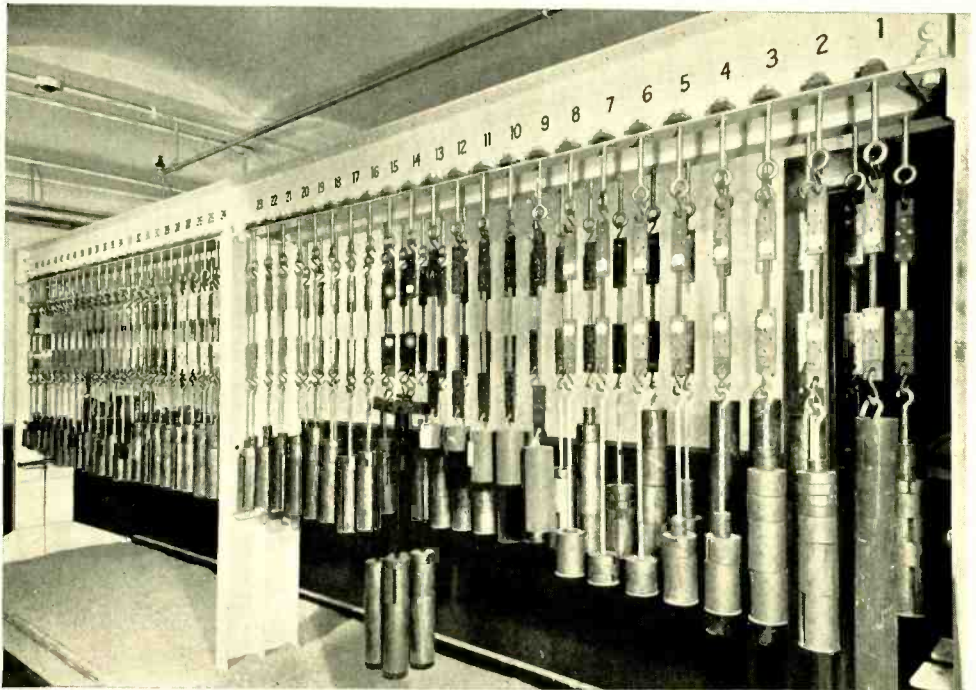
To measure the stretching which lead-cable sheath and other sheet metals show under heavy tension, heavy weights are hung on thin strips of these materials and the stretching is determined by measuring the rate at which two marks on each strip separate. The time required to increase the length by one-half varies from three days to six months depending on the stiffness of the metal. The temperature of the test room has to be maintained constant within two degrees to avoid effects of expansion or contraction

The 281A Program Line Panel

By R. E. KUEBLER
Special Products Department

A MODERN broadcasting studio requires extensive facilities for program switching and dispatching. Such a studio really comprises a group of individual studios of various sizes, and at almost any hour of the day an actual broadcast will be in progress in one of them while the others are in use for rehearsals or are in preparation for the next broadcast. At the dispatching center for the studio system there are channels from all the individual studios, incoming and outgoing program and order-wire lines or trunks for connection to the various broadcast networks and to the radio station, and incoming program and telephone order-wire lines from other pick-up points in the immediate area, such as hotels or auditoriums. The apparatus associated with these circuits consists, for the most part, of standard panels each of which is intended for a particular purpose in the coördinated system, although in many cases, such as the larger broadcasting systems, a combination of standard units with special units incorporating switching, control, and supervision facilities is employed to meet the requirements of the particular studio.

The 281A program line panel is an example of a standard unit of recent design for use with program network circuits between the broadcasting studios or the radio transmitter locations and telephone toll offices. This panel provides terminal equipment such as repeating coils, equalizers, and artificial lines for incoming and out-going program lines. Occupying only 8¾" of vertical mounting space in the relay rack or cabinet, the original complement of apparatus includes one repeating coil, fixed pads with impedances suitable for operation into or out of the local studio equipment associated with the particular program network, and a full complement of terminals and jacks. Mounting positions and wiring are provided, however, for a total of three repeating coils and two line equalizers. When fully equipped the program line panel thus accommodates a maximum of one order-wire and three program cir-
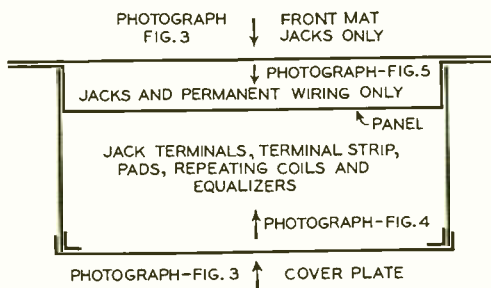
Fig. 1—*A cross-section reveals the division into two compartments: one for permanent and the other for semi-permanent connections. Arrows show points-of-view of subsequent illustrations*

cuits. The limited complement of apparatus is furnished so as to make the panel economical for the smaller studios where there is employed only a single incoming program network together with an emergency program circuit which may also serve as a telephone order-wire. In many such cases

the length of the program loop will be short enough to give satisfactory transmission without an equalizer and with only a repeating coil at each end of the circuit. The additional equipment may then be added as the needs of the system increase.

A simplified schematic of the circuit arrangement is shown in Figure 2, where the original equipment is drawn in solid lines, and the optional later additions in dotted lines. Besides the apparatus that would normally be associated with the three lines, there are two impedance translating pads, used for connecting the lines to speech amplifier circuits or local micro-phones, and several spare jacks. Each piece of apparatus is wired either to jacks or terminals so that a maximum of flexibility in possible circuit arrangement is secured. The spare jacks are of two types as indicated in the diagram, and by simple connections at the terminal strip may be connected into almost any part of the three lines. All jacks carrying voice currents are provided with parallel contacts so that more positive connection is assured. The impedance pads are also connected to the terminal strip so that their insertion in any one of the circuits is equally simple. When the program line panel, fully
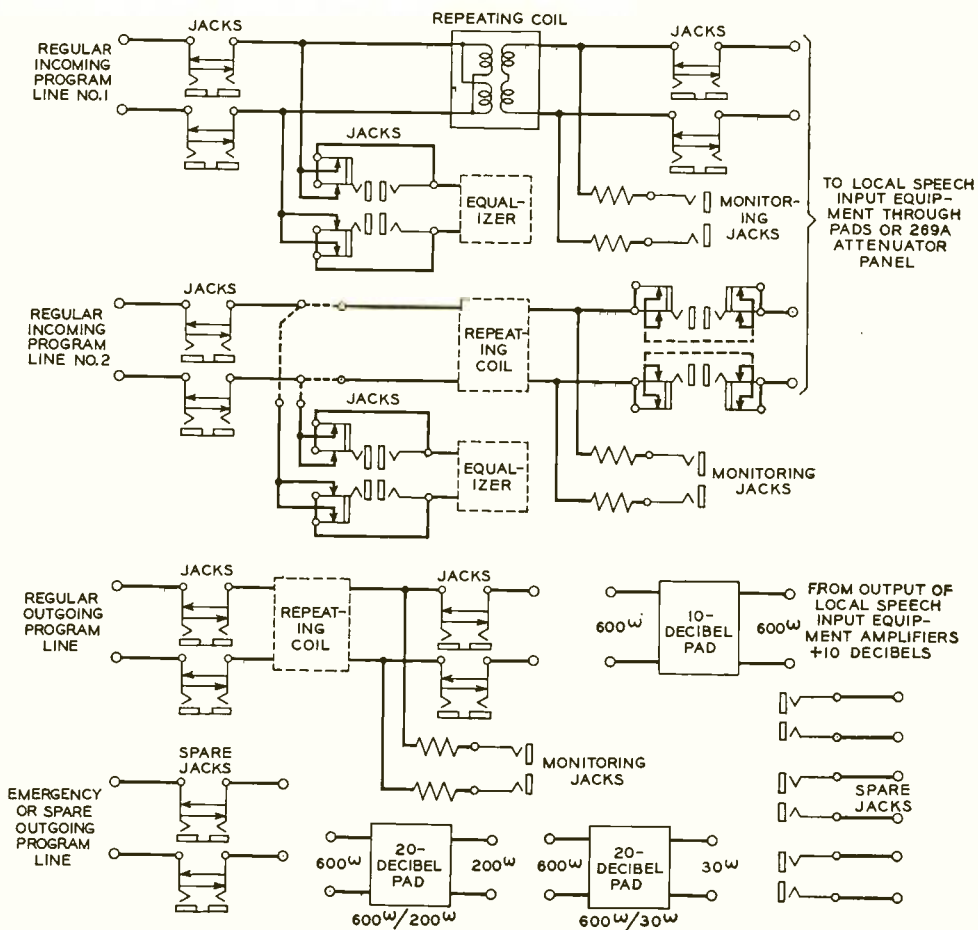

Fig. 2—Simplified schematic of the 281A program line panel
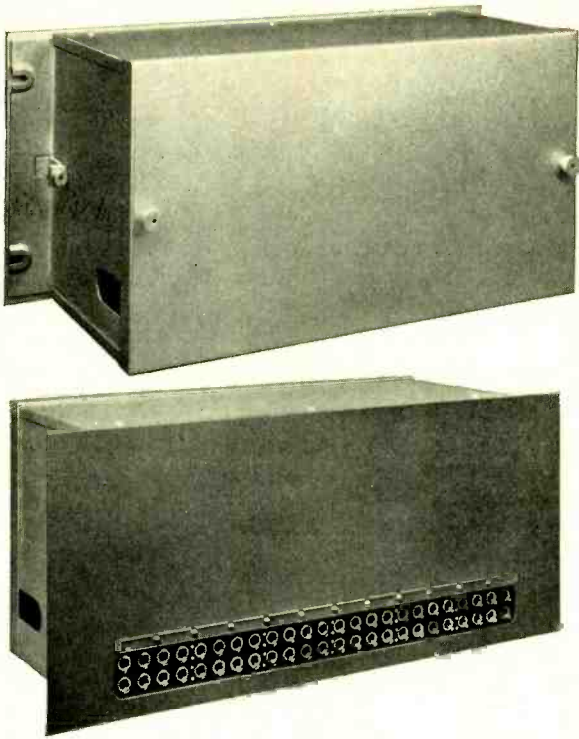
Fig. 3—*The front assembled view shows only the jacks. The mat is fastened by screws from the back of the dished mounting panel. The rear cover is readily removed by unscrewing two knurled nuts*

paratus a very simple matter. As shown in Figure 1, the recessed, or concave, part of the panel faces the front, and is covered with the front mat through which the faces of the jacks project as shown in the upper part of Figure 3. On the rear of the panel, Figure 4, is mounted all the apparatus — repeating coils, equalizers, and pads—and also the terminal strip to which the apparatus is wired. The terminals of the repeating coils, equalizers, and resistance pads project through the panel to the front side, as shown in Figure 5, and cabling from one side of the terminal strip runs through an opening in the panel to the front where it is permanently connected to the various pieces of apparatus. The terminals of the jacks, which are located on the rear of the program line panel, are connected either to the terminal strip or to the permanent wiring as required.

Switching of circuits or patching

equipped, is called upon to handle two regular incoming loops or two incoming and two outgoing loops, the use of a No. 269A attenuator panel is desirable. This panel provides variable attenuation as well as impedance translation to 30 ohms for two incoming programs, utilizing two repeating coils in the program line panel.

The recessed-panel construction employed for this equipment makes the insertion of spare apparatus or the rearrangement of ap-

Fig. 4—*As normally supplied, only one repeating coil is furnished with the panel, but space is provided for two additional repeating coils and two equalizers*

where these operations are required, is accomplished by patching cords and plugs from the front of the frame, while the more permanent connections are made by jumper wires along the terminal strip at the rear. A rear cover plate, secured with two knurled nuts, is readily removable when such connections are required. Shield connections for the inside wiring pairs are not shown in Figure 1, but they are connected to separate terminals instead of to the panel ground, so as to permit each shield to be tied independently to the shield of the connecting external pair, which in turn is grounded at the associated amplifier bay or to the sheath of the cable through which the lines enter or leave the building. This arrangement insures a minimum of noise due to differences in ground potential.

The appearance and general design of the 281A program line panel harmonize with other components of the latest Western Electric speech-input equipment. When fully equipped it offers an appreciable saving in cost compared to equivalent apparatus components furnished on the former basis. Besides the advantage of small size, low cost and flexibility, the provision of improved-type repeating coils and equalization equipment brings the 281A panel into line with the best practice of the present day.

Fig. 5—Nothing but permanent wiring and the terminals of the apparatus appear on the front of the mounting panel

Gas Tube Voltage Recorders

By L. K. SWART

Protection Development

IT is sometimes necessary to determine, under field conditions, the magnitude and time of occurrence of voltages which are induced in telephone circuits by faults on neighboring power lines. Since these disturbances are infrequent and cannot be anticipated, 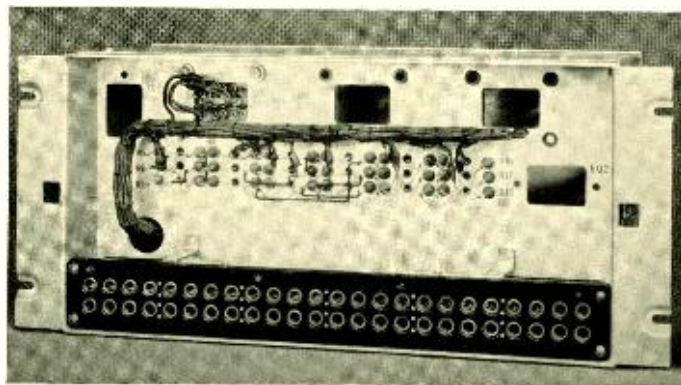their investigation requires an automatic device which is always ready to record. It is also desirable that it consume no energy except when recording. These requirements have been met in a voltage-recorder controlled by cold-cathode tubes which become conducting when the applied voltage exceeds a critical value. Records of disturbances with any desired range of voltages can be handled readily by using several tubes in a suitable circuit arrangement.

The cold-cathode tubes employed have two activated cathodes and a non-activated anode and contain at low pressure a mixture of gases of which either neon or argon is the most important constituent. The circuit to be tested is connected to the two cathodes or control electrodes. The anode is used in conjunction with one of the cathodes and a local battery as a secondary circuit to operate the recording equipment. When the voltage induced in the telephone line exceeds a certain value, the gas in the tube becomes ionized. This reduces the impedance of the secondary circuit sufficiently to allow current from the battery to actuate the recording equipment. The potential applied by the battery, however, must be sufficient to sustain ionization but insufficient to initiate it. Also necessary are means for extinguishing the tubes after the disturbing voltage is recorded, and for preparing the recording mechanism for the next disturbance to occur.

One method introduces a restoring relay which shunts out the battery from the anode and cathode circuit after the record has been made, and thus reduces the potential between these electrodes below that required

Fig. 2—Rear view of a two-stage voltage recorder which is equipped with message registers and a time-delay circuit

to sustain ionization. Simultaneously, current is withdrawn from the restoring relay which therefore releases and removes the shunt, and thus restores the anode to a condition of readiness to record. If disturbing voltage suffi-

Fig. 1—Circuit of a single-stage voltage recorder showing the restoring relay which short-circuits the gas tube

cient to produce ionization is still present, the restoring relay will repeat this cycle of operations until the voltage disappears. Across the terminals of the relay are bridged a condenser and resistance to prevent transient voltages, caused by opening the relay circuit, from re-ionizing the gas in the

tube. The simplified circuit of Figure 1 illustrates a single-stage recorder and shows one method for restoring the tube to normal.

Several types of voltage recorders have been constructed on these principles. They range from single-stage recorders, which operate only when the voltage on the telephone line exceeds a predetermined magnitude, to multi-stage recorders which indicate voltages in twelve steps. In the simpler types message registers associated with each stage have been employed to count the number of times each tube is operated. Other types have been constructed which give on a paper tape a permanent record of the magnitude of the voltage and the date and time of occurrence of the disturbances. The duration of the event is also indicated if in excess of one minute.

In the simple schematic diagram of Figure 1, the circuit on which the voltage is to be measured is connected to the input. The minimum operating voltage of the recorder is determined by the adjustment of the voltage

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divider and biasing potential. For measurements of voltage in excess of seventy volts peak, no bias is employed and the operation of the tube takes place at either half of the a-c cycle. Voltages of sufficient magnitude produce ionization of the gas within the tube, resulting in operation of the message register and the restoring relay through the anode-cathode circuit of the gas tube. Closing of the contacts of the restoring relay and message register completes a circuit which shunts the battery from the restoring relay and the tube intermittently, but which holds the register operated during the vibration of the restoring relay. The vibration of this relay continues for the duration of the applied voltage which produces ionization of the tube at its input. As soon as this potential disappears the tube becomes non-conducting, and the relay and register are released.

In multi-stage recorders the circuit operating at the lowest potential is used as a control stage and only this stage is equipped with the restoring device. Means are provided for opening the battery circuit to other stages after the control stage has been restored. Since recording devices, such as message registers or time stamps, operate more slowly than other relays in the circuit, the operation of the restoring circuit is delayed to allow the recording equipment to function.

In Figure 2 is shown a two-stage recorder with message registers. The power for the instrument may be supplied from 130-volt office battery or from ordinary dry-cell B batteries. The life of the batteries will approximate their normal shelf life since, in general, very little duty is required of them. This instrument requires little attention except to take readings of the message registers at desired intervals and to check the battery voltage.

Recorders of this type, since they operate from any voltage which is sufficient to cause ionization in at least one tube, will indicate the occurrence on a telephone line of all voltages above a predetermined value, whether they originated from power induction,
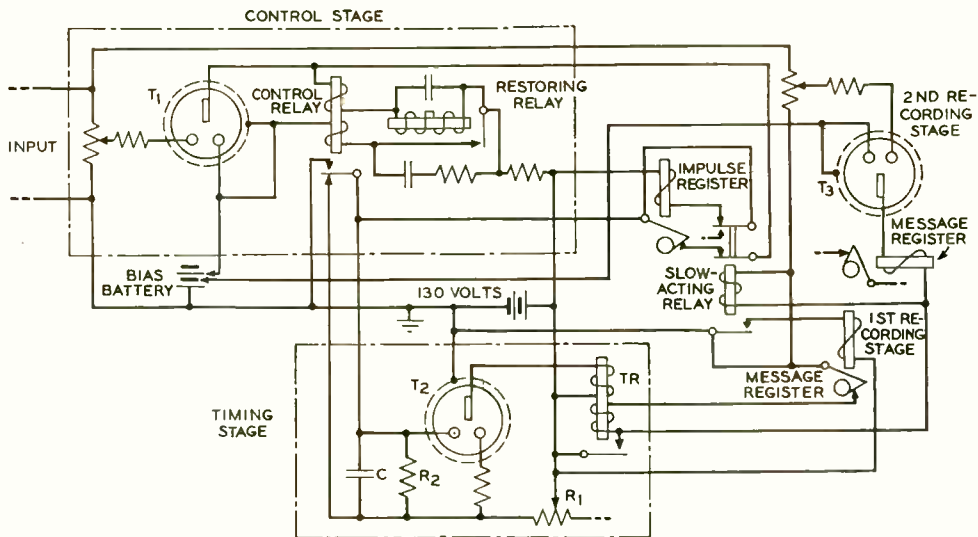

Fig. 3—Schematic of a two-stage voltage recorder showing the time delay circuit which separates the disturbances caused by static discharges from power induction effects

lightning or static. In most studies of inductive coördination, however, it is desirable that the occurrences of voltages due to power induction be separated from those caused by lightning or static disturbances. An addition known as a "time delay" stage has, therefore, been incorporated to retard the complete functioning of the recording stages for approximately 0.1 second after the beginning of ionization in one or more of the tubes. This arbitrary time delay was chosen on the basis of data which indicated that single disturbances due to lightning seldom lasted longer than that.

The time delay circuit is shown in Figure 3. If a voltage across the input terminals of the recorder is sufficient to cause ionization of the tube T_1 in the control stage, the control relay will operate. When the contacts of this relay are closed the 130-volt battery is applied to a circuit which consists of a resistance R_1 in series with a condenser c, which in turn is shunted by a high resistance R_2 and by the control electrodes of a gas tube T_2. Dependent on the constants of this circuit is the rate of increase of the voltage across the condenser c. When this voltage has built up sufficiently to cause ionization of the tube T_2 in the timing stage, the secondary circuit of that tube operates a relay TR, which applies 130-volt battery to the anode of the measuring tube T_3. If the voltage is still present at the input of the recorder and is high enough to cause ionization of the second recording stage, its associated message register will then operate.

On disappearance of the surge, the restoring relay in the control stage restores the control relay to normal; the timing condenser will discharge immediately through the back contacts of the control relay; the relay TR associated with the timing tube will become de-energized; and thus the entire instrument will again be ready for a subsequent record. If, however, the disturbance does not persist for the required length of time for the condenser in the timing stage to charge to the breakdown potential of its associated tube, the battery potential will not be applied to the secondary circuit of the recording stage, tube T_3 and the associated message register will not operate. The impulse register however associated with the control stage will act regardless of the duration of the surge. Therefore by subtracting from its readings that of the message registers, the number of surges from lightning may be obtained as well as those from power induction.

Development work is being continued on these devices with the objective of associating with the two-stage recorder means for making a paper tape record of the time at which disturbances occur. An electrically controlled time stamp is being used for that purpose. In addition, experimental work indicates possibilities for a six-stage recorder to operate with the time stamp; and models are on trial.

Voltage recorders, of course, are not limited to the measurement of induced voltages on telephone circuits. They may be employed to advantage as recording voltmeters in other investigations where there are wanted the approximate values and times of occurrence of transient voltages.

Tool Kit for Teletypewriter Maintenance

By W. M. BACON
Systems Development

SINCE many teletypewriter stations are located some distance from company repair shops or storerooms for teletypewriters, the repairman who maintains these stations must be equipped to do a variety of work. Maintenance must also be carried out with a minimum of service interruption and the tools used as well as their accessibility have an important bearing on the time consumed on the subscriber's premises as well as the quality of the workmanship. To meet these needs a set of tools has been provided which includes several special devices to facilitate the work. They are all carried in a case designed for the purpose.

The ordinary equipment consists of wrenches, spring balances, thickness gauges, spring benders, screw drivers and pliers. The special tools include a volt-ohm-milliammeter, a grease gun, an adapter used in measuring rectifier voltages, and a tuning fork for stroboscopically checking the speed of governed motors.

The volt-ohm-milliammeter is provided to test line voltages and currents at a teletypewriter station and to check the continuity of the wiring. It measures o to 50,000 ohms, o to 150 volts, o to 75 milliamperes and o to 150 milliamperes. The circuit for measuring resistance is supplied with current by a small 4½-volt battery mounted within the case of the meter, and the ohm scale reading can be ad-

justed by means of a battery adjuster. The current measuring circuits are protected from overloading by a 0.25 ampere fuse mounted inside the meter box and so located in the circuit that it protects both the meter element and the shunt coils. Two cords terminating in test picks at one end and "pin plugs" at the other are provided to make connection to the meter which is supplied with seven pin jacks to receive the plugs. The meter element is designed for a full scale deflection on 1.5 mils and the voltage circuit provides resistance of 1000 ohms per volt. The voltage output of the rectifier in teletypewriter stations can be adjusted under load conditions by inserting the special tool shown below between the plug on the d-c power cord from the teletypewriter and the receptacle on the table which is in the output circuit of the rectifier.

A standard commercial grease gun equipped with a special nozzle properly shaped is supplied to grease the ball bearings of teletypewriter motors. These guns are also used as grease carriers for greasing other parts of the mechanisms where pressure is not required, such as the gears.

The carrying case is made of a hard leather-grained fibre which gives a wear-resistant surface and at the same time is neat in appearance. It resembles a suitcase and is fastened shut by means of brass clamps and a lock. Small rubber feet are attached to the bottom of the case and to the flat side on which it rests when being used, to prevent the fibre covering from touching the floor and picking up dust and dirt. The tools are conveniently available so that the correct one for a particular test or adjustment can readily be selected.

Volt-ohm-milliammeter to test voltages, resistances and currents at teletypewriter stations. It measures 0-50,000 ohms, 0-150 volts, 0-75 milliamperes and 0-150 milliamperes. The tool in the center measures rectifier voltages under load

Contributors to this Issue

R. E. KUEBLER's contact with speech input systems began in 1922 when as a field engineer he participated in the installation of several of the early public-address systems. From 1926 to 1932 he was concerned with recording systems for sound pictures, particularly the portable and truck-mounted types. During the last few years as a member of the Radio Development group he has been active in the design of speech-input equipment for radio broadcasting. Mr. Kuebler graduated from Pennsylvania State College in 1917; before entering the Laboratories in 1920 he had seen overseas service in the 305th Field Signal Battalion and had been a member of the research staff of the New Jersey Zinc Company.

D. MITCHELL joined the Department of Development and Research of the American Telephone and Telegraph Company immediately after graduat-

ing from Princeton University with the degree of B.S. in 1925. He transferred to the Laboratories in 1934. His time has been largely devoted to problems involved in interconnecting radio and wire telephone circuits. More recently he has worked mainly on the application of voice-operated devices to wire lines with a brief interval spent on the development of special testing apparatus for application to picture-transmission circuits.

L. K. SWART graduated from Union College in 1920 with the degree of B.S. in Electrical Engineering. Previously he attended the Sorbonne, University of Paris, for one year. Immediately upon graduation he became associated with the Development and Research Department of the American Telephone and Telegraph Company. His early work was concerned with the development of telephone repeaters and economic

R. E. Kuebler

D. Mitchell   *L. K. Swart*   *W. M. Bacon*

L. A. Gardner   C. H. Bidwell   H. W. Hermance

aspects of the layout of cable and open-wire circuits. Later his interest centered on inductive interference problems and the development and uses of cold cathode gas-filled tubes. Since 1934 he has been engaged in the development of voltage recording devices and special means of protecting open-wire lines and apparatus.

W. M. BACON has been concerned with teletypewriter development problems since he joined the Department of Development and Research of the A. T. and T. Company on graduating with the E.E. degree from Cornell in 1930. This work has continued with the Laboratories' Telegraph Facilities group since 1934 and has involved maintenance, repair, and installation methods and procedure as applied to teletypewriters.

L. A. GARDNER graduated from Worcester Polytechnic Institute in 1917 with a B.S. degree in Electrical Engineering. After two years in the U. S. Naval Reserve Force, he joined the Department of Development and Research of A. T. and T. Company, and engaged in the development of telegraph repeater equipment and associated apparatus. In 1925 he became design and development engineer for an automotive accessories concern and later was associated with the manufacturing of gas-filled tubing for display signs. Since 1929, with the D. and R. and the Laboratories, he has been concerned with the development of central-office exchange and private switching systems for teletypewriter equipment.

C. H. BIDWELL received a B.S. degree in physics and electrical engineering from the California Institute of Technology in 1926. After a year engaged in experimental work with the California oil companies, he joined the Technical Staff of these Laboratories. Here he spent several years with the trial-installation group, and then engaged in the design of toll and telegraph test boards. More recently he has been working on the design and development of carrier telephone equipment, chiefly that for carrier in cables.

H. W. HERMANCE joined the Laboratories in 1927 with prior experience in chemical analysis gained in toxicological and criminological work. He had also worked with the Crucible Steel Company and had spent four years with Procter and Gamble developing analytical methods for controlling the quality of raw materials and manufactured products. During this period he carried on part-time study at Newark Technical School and later at Columbia University. From 1925 to 1927 Mr. Hermance was at Kearny working on the analytical control of materials. Since coming to the Laboratories he has specialized in micro-analytical methods and has had a prominent part in developing the techniques and laboratory facilities for this relatively new phase of analytical chemistry.