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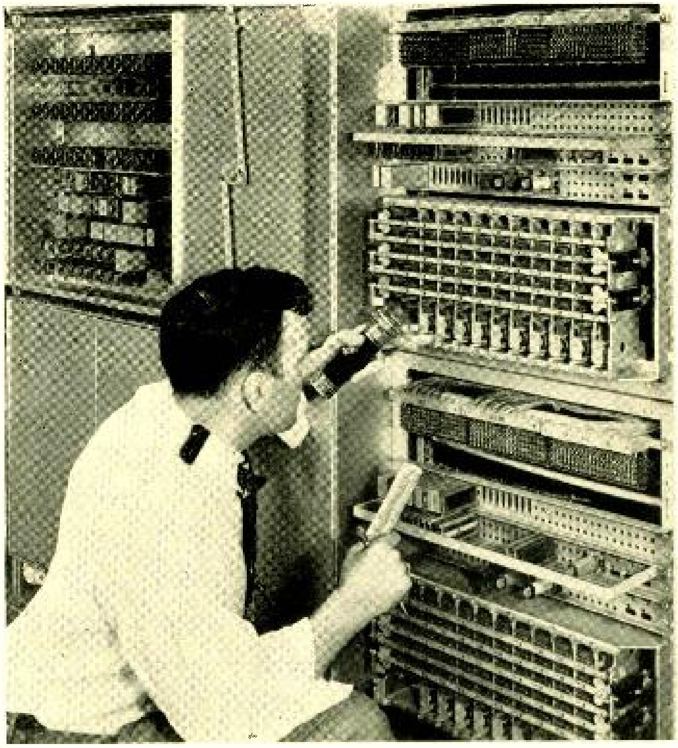
Studying magnetic assymetry by measuring the torque on a specimen oriented in different directions in a magnetic field



Crossbar Senders

By J. B. NEWSOM
Central-Office Switching Development

THE crossbar, like the panel system,* does not employ a decimal system of trunk and line selection, and thus requires senders. The crossbar switch, however, does not "hunt" as do the panel selectors, and the equipment for testing lines and trunks for busy condition, and for finding idle paths through the crossbar switches, has been incorporated in modified decoders known as "markers." They are of two types: an originating marker, in the office of the calling subscriber, is employed to find an idle trunk and an idle path from the line to the trunk through the district and office frames; and a terminating marker, in the office of the subscriber called, is used to locate the called line and to find an idle path from the incoming trunk to the called line through the incoming and line frames. Two senders are generally employed: a subscriber, or originating, sender in the office of the calling subscriber, and a terminating sender in the office of the subscriber called. The originating sender corresponds more nearly to the sender of the panel system, while the terminating sender is generally employed to work in conjunction with the terminating marker.

One of the functions of any sender

*Record, *Dec.*, 1931, *p.* 102.

is to record the number dialed by the subscriber. In the later panel senders this is done by a group of relays,* while in the crossbar sender, the digits are stored on a crossbar switch. This number-recording switch is of the ten-vertical type—instead of the twenty-vertical type used on the main switching frames. In the originating sender, four of the verticals are used for the three digits of the office code—two being used for the first digit—and five verticals record the station number, four being used for the thousands, hundreds, tens, and units digits, and one—on calls to manual offices—for the party letter, where one is used. When the subscriber's dial has returned to normal after each digit, a select magnet and a hold magnet of the crossbar switch are operated to record it. In each case the select magnet operated corresponds to the digit dialed—i.e. the fifth magnet for the digit five or the eighth for eight—and the hold magnet corresponds to the position of the digit in the number. Ahead of this crossbar switch in the sender are relays that count the pulses of the various digits and operate the proper select and hold magnets. A separate vertical on this switch—together with two relays where there are more than ten district frames—is used for recording the number of the district-link frame with which the calling line has been associated.

The system is not idle while this recording is going on, however. As soon as the three digits of the office code have been recorded, the sender connects itself to an originating marker and transmits to it the office code and the number of the district frame to which the calling line is connected. The marker then finds an idle trunk to the office called and selects an idle path through the district and office-link frames between the district junctor and the chosen trunk. It then informs the sender of the type of trunk it has chosen, that is, whether it goes to a crossbar, panel, or manual office, or to an operator, and whether it goes by a direct trunk or through a tandem office, and after this is released by the sender.

During this time the subscriber continues to dial, and as soon as part of the number has been recorded, the originating sender starts to pass signals over the trunk to the called office, where they are recorded by a terminating sender. This sender was connected to the incoming trunk after the latter had been seized by the originating marker. As soon as the terminating sender has completed its record, it acknowledges receipt of the number to the originating sender, which closes the talking circuit at the district junctor and then disengages. Besides acknowledging the number, the terminating sender seizes a terminating marker which locates the line called and—if the line is idle—finds an idle path between it and the incoming trunk. When this has been completed, it informs the terminating sender that the call is ready for connecting through, and the sender releases it. The terminating sender then closes the talking circuit at the incoming trunk and disengages itself. Ringing is handled by the incoming-trunk circuit and requires no attention from the sender.

This simple outline of the duties of the originating sender has assumed that the call was to a crossbar office. The circuits of the sender are arranged, however, to provide for all possible conditions, and are thus more intricate than would be required for the functions given above. In the first place, cross-

*Record, *June*, 1929, *p.* 400.

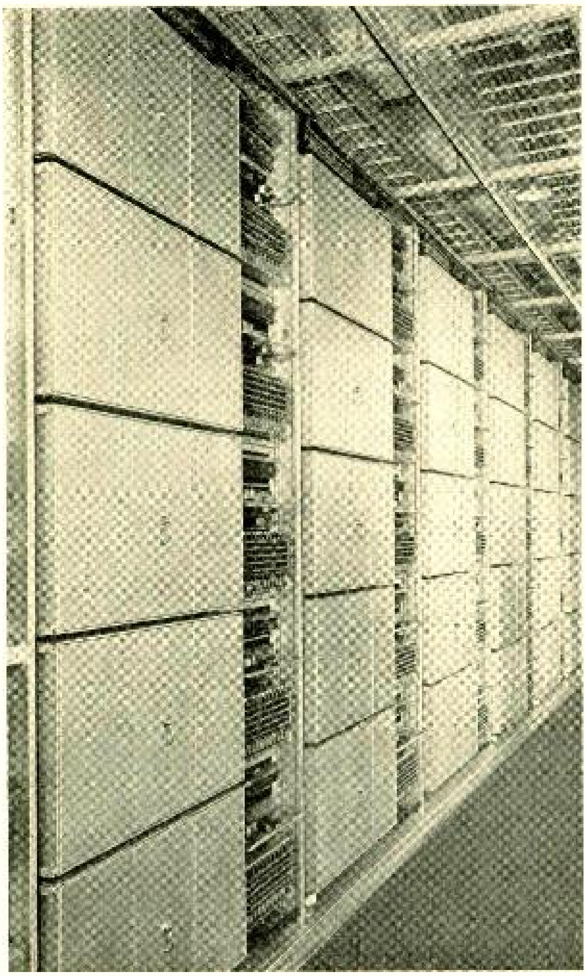


Fig. 1—Originating senders in the Murray Hill office in New York City

bar offices are being installed in areas where other types of offices are already in use. The crossbar sender must thus be able to complete calls to panel and manual as well as to crossbar offices.

In the panel system, the sender controls brush and group selections of the panel frames by the method of "revertive" pulsing.* Because of this fact, the originating sender is designed to operate on revertive pulses. Where the called office is of the panel type, the sender uses these pulses to guide the panel selectors in the completion of the call, and where the called office is of the crossbar type, the same type of pulsing is employed for transmitting the number called to the terminating sender. This permits the originating sender to transmit the same kind of signals regardless of whether the office called is of the panel or crossbar type; and a terminating crossbar sender will operate with calls incoming from either a panel or crossbar office. The originating sender includes a group of relays that count the revertive pulses sent to it from the terminating senders, or from the panel frames in a panel office, and interrupt the circuit after the correct number for each group is received.

A novel feature of the crossbar sender is the ability to make two or three attempts to complete a call when trouble or busy channels are encountered. Should the originating marker fail—for any reason whatever—to establish a connection to an idle trunk, it will signal the sender that it has experienced difficulty, and at once the sender will release that marker, seize another, and make a second attempt. The terminating sender can also seize a second marker if difficulty is encountered in completing the call by the first marker. This is one of the many features of the crossbar system that make for more satisfactory service for the subscriber.

Both originating and terminating senders are connected to the calling circuit through sender-link frames. The originating sender is connected

*Record, *June*, 1929, *p.* 395.

to the line through a sender link, a district junctor, and a line-link frame. As soon as the line-group controller circuit has seized an idle district-junctor group, it in turn seizes a sender link, which proceeds to find an idle district junctor in that group, and connects a sender to it. When the sender is seized, dial tone is returned to the calling subscriber, and the line-group controller circuit transmits to the sender the classification of the calling line. The sender is arranged to record a maximum of twelve possible classes of service. These include coin-box lines, two-party lines, and the various other types of service that may be provided; and the sender must know the class of line that is being used in making the call to be able to handle the call correctly.

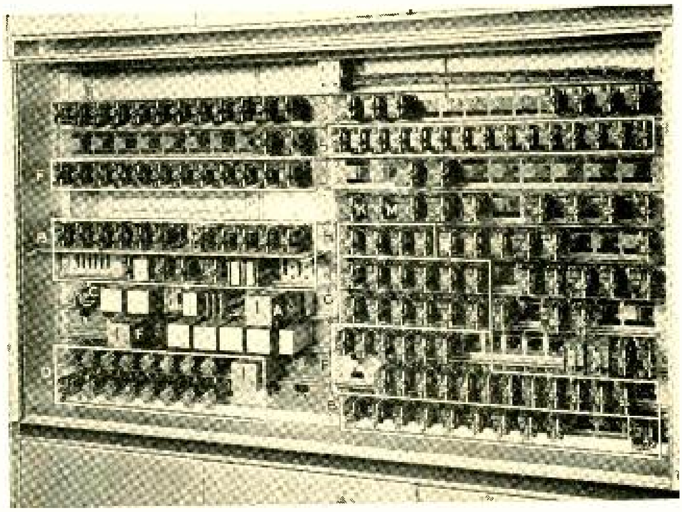


Fig. 2—Relay section of an originating sender

The links for the terminating senders are connected to the incoming trunk at the called office, and are seized as soon as the originating marker has established a connection to the trunk. Since the terminating sender is associated with the call only while the number of the called line is being recorded and a path through the incoming and line-link frames is being found, its "holding time," or the time it is associated with a line, is shorter than that of the originating sender, being under five seconds instead of approximately fifteen. The number required per office is thus less.

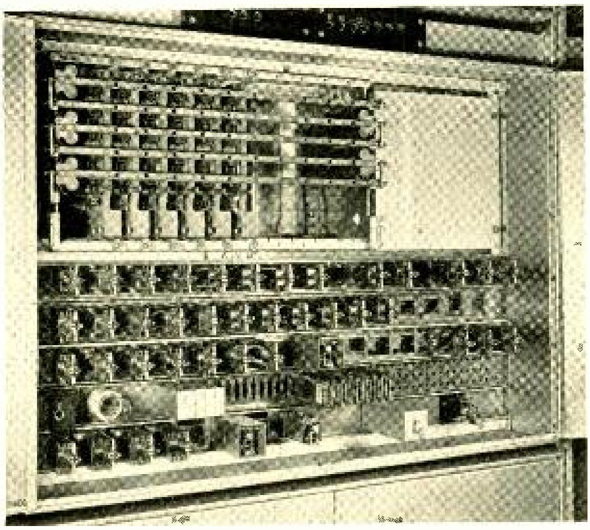


Fig. 3—A terminating sender with doors open

Five originating senders are mounted one above the other to form a sender frame. A row of such frames for the Murray Hill office in New York City is shown in Figure 1. As installed, the originating sender is arranged in two parts: at the left is a cabinet enclosing a large group of relays, shown with doors open in Figure 2, and at the right is the number-recording crossbar switch and some miscellaneous equipment. This part is shown more clearly in the photograph at the head of this article. The smaller amount of equipment required for the terminating sender permits the crossbar switch to be mounted in the cabinet with the relays, as shown in Figure 3. This crossbar switch in the terminating sender is equipped with only six vertical units: five for recording incoming brush and group selections, and final brush, tens, and units selections, and one for recording the frame on which the incoming trunk terminates. This latter information is transmitted to the sender when it is seized by the incoming link frame.

Except for the recording of the number dialed, the originating and terminating senders perform all of their functions by relays. Certain of these relays for the originating sender are indicated in Figure 2. The relay marked A follows the subscriber dial pulses and in turn operates the counting relays in group B. In this latter group are also the relays that operate the crossbar switch. Relay C follows the revertive pulse sent to it by the terminating sender, or by the incoming and final selectors in a panel office, and group D counts these pulses. Group E includes the relays by which is recorded information regarding control of the call, which is sent to the sender by the marker. These relays record whether the call is to a crossbar, panel, or manual office, whether the call goes by a direct trunk or tandem office, and so on. On calls to manual or tandem offices, the sender transmits call-indicator* signals, and the relays that send these are included in the two groups marked F. Group G comprises the selections-progress relays, which coöperate with the revertive-pulse counting relays to control brush and group selections for the various frames. Relays in group H control the second-trial features, while those marked K and M are the relays controlling the connection to and release of the marker. Many of these relays, such as the dial pulse counting, and call-indicating relays, are not required in the terminating sender, which thus has a less extensive circuit.

*Record, *Dec.*, 1929, *p.* 171.

Coördinated Induction Tests on an A-C Electrified Railroad

By K. L. MAURER
Foreign Systems Coördination

THE wire network of a railroad system powered by alternating current contains transmission circuits, used to transmit energy in bulk to substations, and traction circuits, which conduct energy from the substations to electric locomotives and cars. Wires of the transmission circuits are insulated from ground but the traction circuits use the track rails as the return conductor and hence some of the current carried by these circuits escapes into the earth. As a result of this, voltages are produced in neighboring communication circuits both by magnetic induction and by differences in ground potential. Under certain circumstances, these voltages may be large enough to cause interference.

Since American railway electrification practice has not yet become standardized, it has not been possible for the Associated Telephone Companies to adopt standardized practices for the avoidance of interference from this type of power circuit. The Protection Development Department has therefore maintained close contact with major electrification projects, both for the purpose of furnishing technical assistance to the Associated Companies in the avoidance of interference and for the purpose of developing a technical basis upon which coördination procedures ultimately may be standardized. This work is being carried on with the active coöperation of the railroad companies.

For a given electrification project, once the railroad has decided upon the main details of its system, and well in advance of electrical construction, estimates of expected induction are prepared, a process which often involves a certain amount of field testing. After the electrification has been completed, there usually is opportunity before it is placed in regular service, to check these estimates by coördinated tests. These tests consist essentially in energizing the traction circuits at reduced voltage and meas-

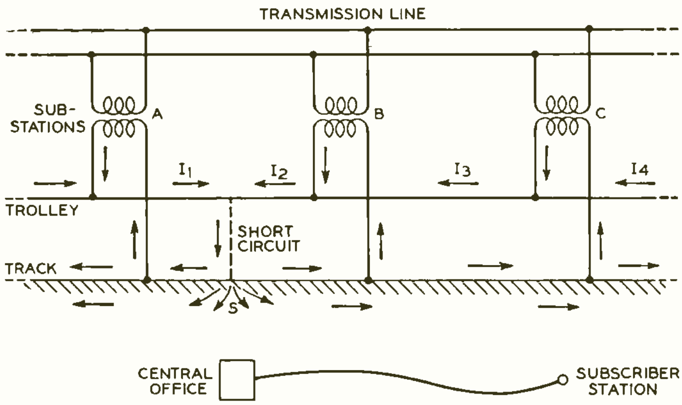


Fig. 1—A typical subscriber line exposed to sections of an electrified railroad using alternating current

Fig. 2—This truck contains an electric power plant for testing

uring the resulting induction in exposed communication circuits.

A simplified diagram of an alternating-current electrification network is shown in Figure 1. The system illustrated is of the so-called "two-wire" type, consisting of a single-phase transmission line (25 cycles is used in this country) to which step-down transformers are connected at intervals as at substations A, B and C. The low-tension windings of these step-down transformers are connected between the contact wire of an overhead trolley system and the rails of the track. In current American practice the voltage between trolley and rails usually is 12,000; the transmission-line voltage may be anywhere from four to eleven times the trolley voltage, and step-down transformer substations are spaced at intervals ranging from five to fifteen miles. Since the tracks are in contact with the ground, some of the trolley current will escape to ground and become widely diffused throughout the earth. It is this component of the trolley current which is responsible for most of the induction and ground potential imposed upon neighboring communication circuits. The transmission line, on the other hand, is normally insulated from ground, and neutral resistors usually are provided to limit the flow of current when a fault occurs between one wire and ground. For these reasons the transmission line usually is of secondary interest from the induction standpoint.

The amount of current remaining in the rails at any point between a load or short circuit and the nearest transformer substation on a given electrification system decreases as the distance between load and substation increases, and reaches a minimum value for very long feeding distances. Also, for a given length of feed, the amount of rail current varies from point to point along the track, usually reaching a minimum value at the mid-point of the feeding length.

When a load or short circuit is connected between a trolley and the tracks, as for example at S in Figure 1, current is fed to it from all of the transformers connected to the trolley. The trolley current in the first section on each side of the load is the largest because each such section contains the sum of currents contributed by all of the transformers on the same side of the load. The amount of current contributed by a transformer diminishes as distance between transformer and load increases. Ordinarily, it is unnecessary, for induction purposes, to consider the contributions of current from more than two or three substations away from the load. If the position of the load or short circuit is shifted, say towards substation B in Figure 1, the proportion of the current fed from substations B and C will increase, while that fed from A and any substation to the left of A will decrease.

Since loads consist of moving trains and since short circuits may occur anywhere on the system, a given exposed circuit will be subject to induction from a large variety of power feeds differing as to length and magnitude of current. For example, in Figure 1, the telephone circuit exposure shown will be influenced by current I_1 fed from substation A over the length AS, by current I_2 fed over distance BS, by I_3 fed over the distance CB and by I_4 fed to C from the next substation to the right. As the telephone circuit does not extend to the left of S, the current in section AS produces no magnetic induction in the telephone circuit, but if the central office is near the track, this current may produce ground potential at the central office ground. In sections BS and CS the electrification circuits and the telephone circuit are side by side. Consequently, voltage may be produced in the latter by magnetic induction, and also by ground potential if the circuit terminals are near the tracks. Current I_4 in this example would produce ground potential only at the subscriber end of the circuit. If the short circuit is shifted, all of the current magnitudes will be altered and, in the section containing the

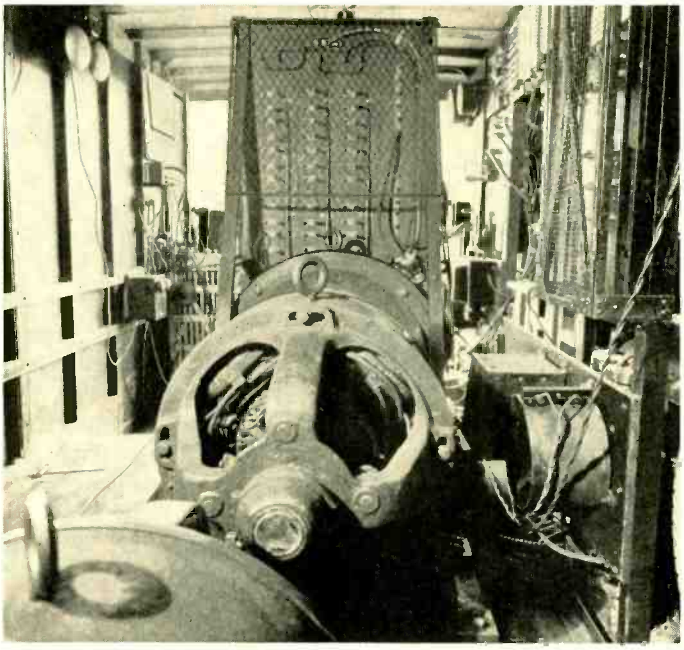


Fig. 3—Power plant for testing. In foreground, a d-c generator driven by the truck engine; in center, a d-c motor which drives the alternator just beyond it

short circuit, the feeding distances and consequently the percentage earth current also will be altered.

It would be unnecessary, and in fact, out of the question to attempt to measure the many combinations of feeding length and current magnitude to which a particular exposure may be subjected. The testing procedure instead makes use of the principle of superposition. As applied to a railway traction circuit, this principle states that if v_1 is the voltage produced through either magnetic induction or ground potential or both, by a given current fed between two points over the trolley, as for example between C and B in Figure 1, and if v_2 is the voltage produced by the same current fed between one end of the first section and a third point, as for example between B and S in Figure 1, then the voltage for the same current fed over both sections (C to S) is $v_1 + v_2$. This principle holds regardless of the composition of the railway circuit as to number of trolleys and number of tracks in the sections involved, and of the fact that the amount of current escaping to ground, upon which the induced voltage largely depends, varies with the circuit length.

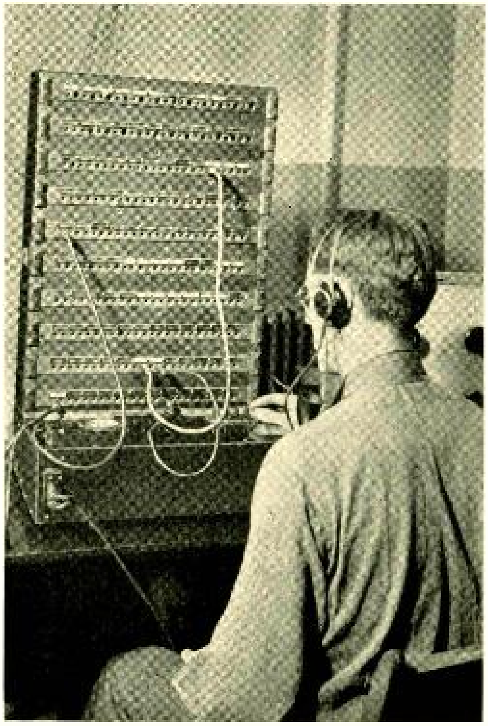


Fig. 4—Jack panel for switching telephone lines under test

In deciding upon the number of sections to be covered in studying a particular exposure, usually it is possible by inspection to select a few points at which a load or short circuit would produce the larger values of induction and the test is confined to a study of these locations. For the situation illustrated in Figure 1, the short circuit at S might be selected as a representative point. The test procedure would then consist in measuring the voltage induced in a circuit of the exposed lead grounded at the central office and at the distant station for a given current fed between substation A and a short circuit placed on the trolley at point S, with the transformers disconnected. The induced voltage would next be measured for a given current fed between substation A and a short circuit at substation B, and again for a current fed between substation A and a short circuit at substation C. Phase relationships between test currents and induced voltages must, of course, be observed in these measurements. Dividing each of these voltage measurements by the corresponding current gives the induction coefficient for the corresponding section. Coefficients for other feeding lengths within the overall section covered by the measurements may then be derived by vector subtraction of the measured coefficients. For example, the derived coefficient for section SB is the difference between the measured coefficients for sections AB and AS, and that for section BC is the difference between the measured coefficients for sections AC and AB. The vector sum of the products of each of these derived coefficients by the calculated short circuit or load current in the corresponding section would then give the total resulting induced voltage for a short circuit or the amount of load drawn at point S.

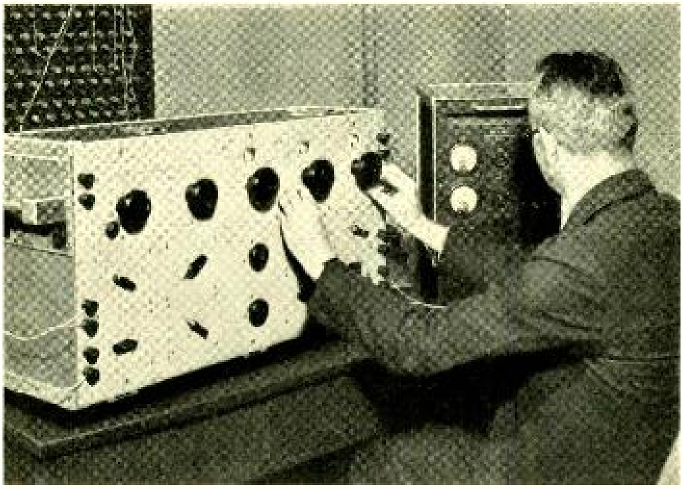


Fig. 5—The alternating-current potentiometer and its associated amplifier and galvanometer

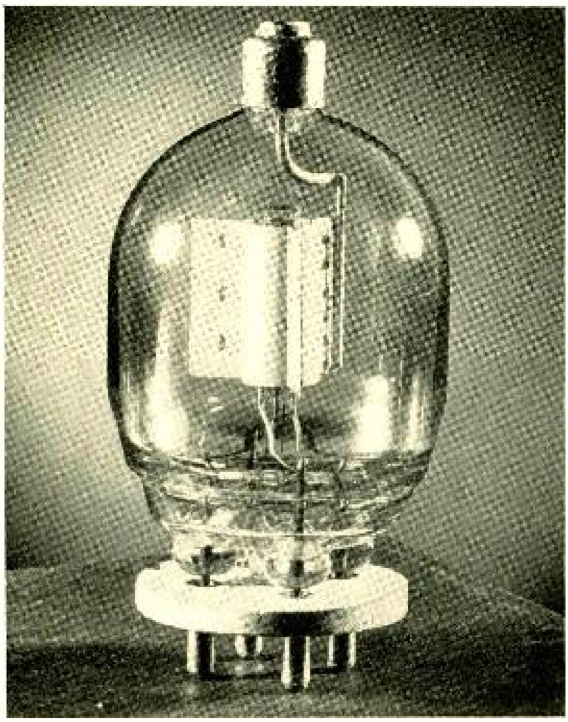
Since it usually is desired to make tests of this kind as far as possible in advance of the operating date for the electrification, it is necessary to make special provision for a source of power with which to energize the trolleys in measuring the coefficients. A mobile power supply unit assembled several years ago is shown in Figures 2 and 3. A 220-volt, d-c generator, driven by the truck engine through a chain drive from a power takeoff, supplies power to a motor generator set, the alternator end of which has a capacity of fifteen kva single-phase. The frequency of this alternator is variable between fifteen and seventy-five cycles and voltages from about ten to about 1,000 volts can be obtained. The truck is provided with a switchboard containing the necessary apparatus and instruments that are needed for regulating output.

The power truck usually is set up at a railway substation so selected that tests can be made first in one direction and then in the other from the substation. Trolley lengths up to about thirty miles in each direction, or a total test section of sixty miles, can be used. In this section there usually will be a number of central-office areas in which induction measurements are required. The apparatus for measuring the induced voltage usually is set up in the central-office nearest the power truck location and test circuits in outlying central-office areas are brought to the test office over trunk circuits, which terminate in a special jack panel shown in Figure 4, through which the circuits are connected to the measuring apparatus.

Measuring apparatus may consist of any frequency-selective voltage-measuring device having high-input impedance and sensitivity, and capable of measuring phase angle. The a-c potentiometer meets all of these requirements. A portable a-c potentiometer developed by the Laboratories for this work is shown in Figure 5. It consists essentially of means for providing a reference voltage known and variable both in magnitude and phase and for comparing the quantity to be measured with this reference quantity, the latter being varied in magnitude and phase until it exactly balances the unknown quantity. Balance is determined by a portable vibration galvanometer provided with an amplifier. The potentiometer model shown has an input impedance of 100,000 ohms and is capable of measuring with satisfactory precision voltages between one millivolt and 200 volts, and angles to about one degree over a frequency range of 15 to 80 cycles.

Since the tests frequently are made close to operating sections of the railroad, stray twenty-five-cycle voltages often are present in the circuit to be measured. In order to avoid interference from these stray voltages, the tests usually are run at twenty-eight cycles, this frequency being near enough to twenty-five cycles to provide sufficiently accurate test values and far enough from the other frequency to provide discrimination.

Since railroads pass through urban and suburban centers of population, a good deal of telephone plant usually is involved in exposures of various kinds. Central offices, or subscriber stations, may be situated close to the tracks, and thus be subject mainly to ground potentials. Or subscriber and trunk lines may have parallel exposures, with circuit terminals at some distance from the tracks, and thus be subject mainly to magnetic induction. Often both types of exposure are encountered in the same circuits. A large electrification project may require measurements in as many as 150 communication test circuits, and fifty or more trolley sections, which shows the need for portable test equipment and an organized test procedure.



356A
Vacuum Tube

This new tube for the ultra-high-frequency range (30 to 300 megacycles) is a recent development of the Laboratories. It will dissipate fifty watts from the plate, and as an oscillator will deliver as much as 75 watts. A lavite terminal plate, to which the terminal prongs are fastened, enables use in a standard 4-terminal socket. One of the prongs is a center-tap on the filament. Molded glass forms the envelope.

Power Plant for Broad-Band Repeater Stations

By H. H. SPENCER
Equipment Development

WHEN the new type-K carrier system is used on voice-frequency toll cables, where the repeater stations are approximately fifty miles apart, two additional stations will in general be required between the existing ones because of the approximately seventeen-mile repeater spacing required by the new system. It is planned that these intermediate or "auxiliary" stations will normally be remotely operated from the existing stations, and for this reason the power plant serving them will be automatic in operation. At the main stations either automatic or manual power plants may be used.

For the auxiliary stations the 420A plant has been developed. Present stations, using filamentary-type tubes for the repeaters, require a 130-volt battery for plate supply and a separate twenty-four-volt battery for filament supply. The new plant differs from the existing ones in using heater-type tubes and this has made it possible to employ a common battery for both filament and plate supply.

The K repeater* requires approximately 1.3 amperes heater current at twenty volts, and a plate potential of 150 volts. The use of a single 150-volt battery for both of these supplies is more efficient, and by eliminating the duplication of charging and battery equipment necessary with separate plants, reduces the maintenance and floor space required. The plates of the vacuum tubes are connected directly across the seventy-cell battery, which is floated at 152 volts, but the filaments of seven amplifiers are arranged in series, each such group being connected across the battery as shown in Figure 1. At each tenth cell of the battery, a connection is made to the series circuit, so that in effect the filaments of each amplifier are connected across ten cells. Without this

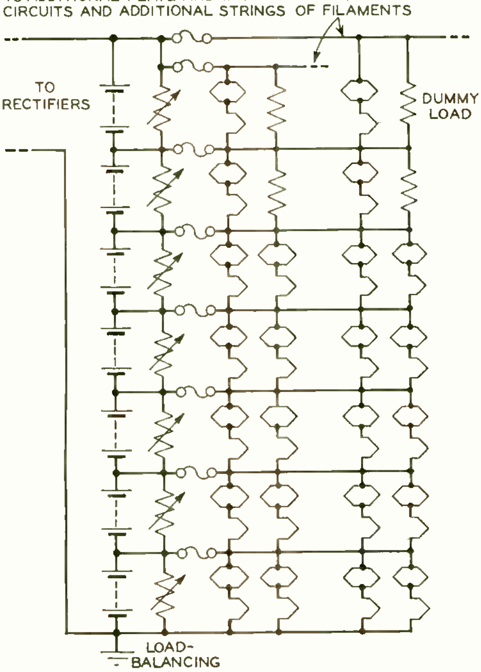


Fig. 1—Series-parallel arrangement of the filaments of amplifier tubes used with the 420A power plant

*Record, *January*, 1939, *p.* 148.

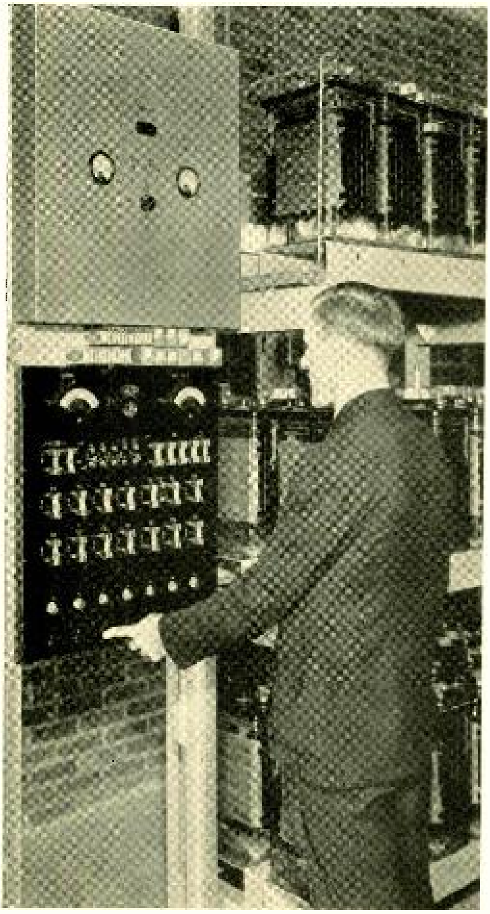


Fig. 2—A main rectifier bay for the 420A power plant

provision, the failure of a single heater would put the seven amplifiers of the chain out of service, while with it, the failure does not extend beyond a single amplifier. Where the total number of amplifiers is not divisible by seven, resistances are inserted in the incomplete chain to balance the load.

With such an arrangement, it is important to avoid an uneven drain on various sections of the battery caused by slight variations in the filament load of the amplifiers. A rheostat is therefore connected across each group of ten cells, in parallel with the amplifier filaments, so that the load of the various amplifier groups may be balanced. These rheostats are adjusted from time to time to maintain the same current into each section. Under these conditions, each cell of the battery supplies the same current and gets the same charge; only in case of the failure of a filament would appreciable current be taken over one of the six intermediate taps.

The number of such strings required depends, of course, on the number of amplifiers. Regardless of the number, however, they are always divided into two groups connected to the battery through two separately fused circuits. This is an additional step to insure continuity of service, since a trouble condition will not affect more than half the total number of amplifiers.

The battery is kept charged by regulated-tube rectifiers, which normally supply the plate and heater current. Since the number of type-K systems that must be supplied by the 420A power plant at any one repeater station will vary considerably, no fixed battery capacity is specified. In general the battery will be of sufficient size to furnish a two-day reserve. For similar reasons the rectifier capacity also is variable. The rectifier employed is of the grid-controlled type already described in the RECORD.* Each of these rectifiers is capable of furnishing eight amperes continuously, and from one to six rectifiers will normally be employed—six being sufficient to handle the load of one hundred repeaters, which is the maximum number that has been planned at the present time.

In addition to the repeater supply, power is also required at each of these stations for the pilot-wire regulating†

*RECORD, *July*, 1937, *p.* 350.

†RECORD, *January*, 1939, *p.* 160.

system. Fifty-five volts a-c is needed for the motors driving the condensers that control the gain of the amplifiers, and two independent ungrounded 140-volt d-c supplies are required for the bridge circuit. The panel shown in Figure 3 has been designed to supply this power. Normally the panel is fed from the 115-volt a-c mains, and carries two rectifiers for the bridge current—one for each direction of transmission—and a transformer to step down to fifty-five volts for the motors. This panel is fed through the front contacts of a relay as indicated in Figure 4. The relay is held operated by the 115-volt supply, but on power failure, releases and transfers the regulator supply panel to the a-c end of the dynamotor. A similar relay that releases on power failure, connects the d-c end of the dynamotor to the battery. The operation of this dynamotor is further controlled by relays that operate it for only a half a minute for each ten minutes of power failure. Such intermittent operation reduces the battery drain and yet provides sufficient pilot-wire regulation to take care of changes in cable temperature during the period of the power failure. Each of these regulator

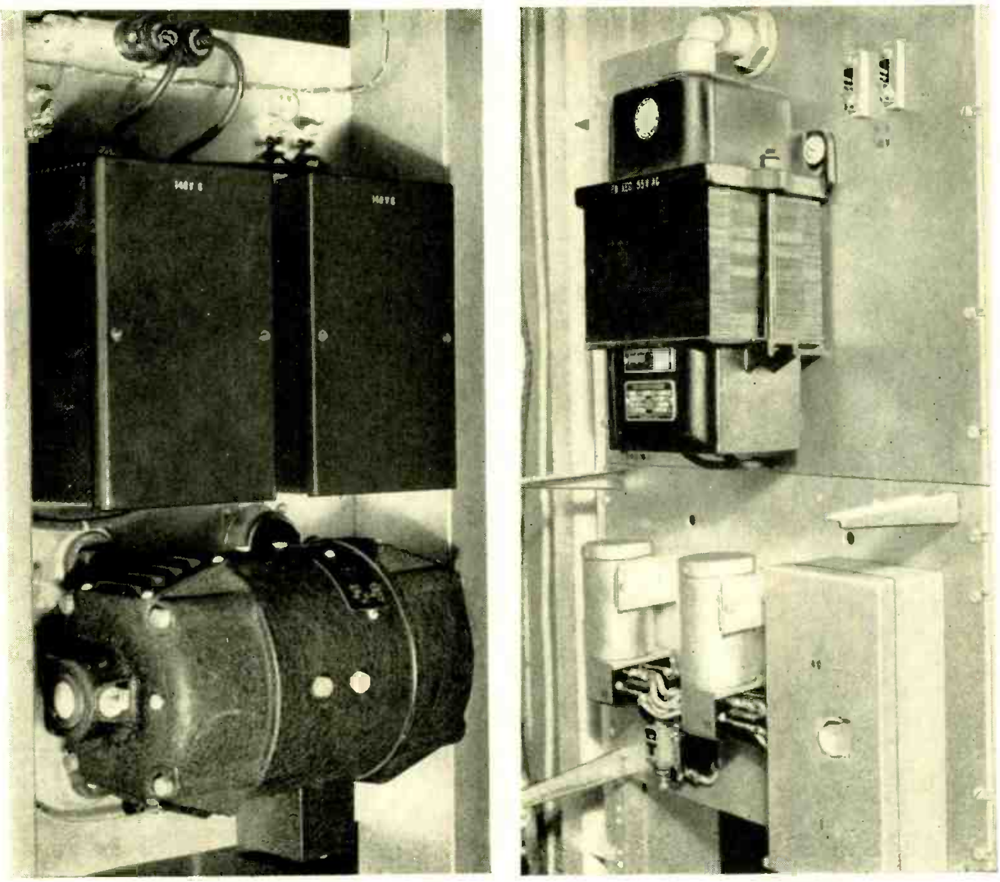


Fig. 3—The major equipment of the regulator power panel includes an emergency dynamotor and two rectifiers for the bridge current, on the rear—shown at the left—and a transformer for the 55-volt motors and the control relays on the front

power units has sufficient capacity to provide for fifty repeaters. An additional power unit is employed where there are more than fifty of these regulators.

Typical power-supply arrangements have been worked out based on the use of buildings with uniform equipment layouts for ultimate capacities of twenty and one hundred systems. Similar arrangements will be made for ultimates of forty and sixty systems, as the need arises. These arrangements cover service entrance equipment, usually installed by the customer at the time the building is constructed so as to have power available for the equipment installer, and a typical arrangement of service distribution, including lighting and appliance outlets. The power supply is 230 volts, three-wire, giving 230 volts across the two outer wires and 115 volts across either outer wire and the neutral, grounded conductor.

At existing stations, the capacity of existing power supplies will ordinarily be adequate to take care of the added K equipment. New power units will usually be required only to supply fifty-five volts a-c and 140 volts d-c for the regulating system. These units will be similar to those already described for the auxiliary stations.

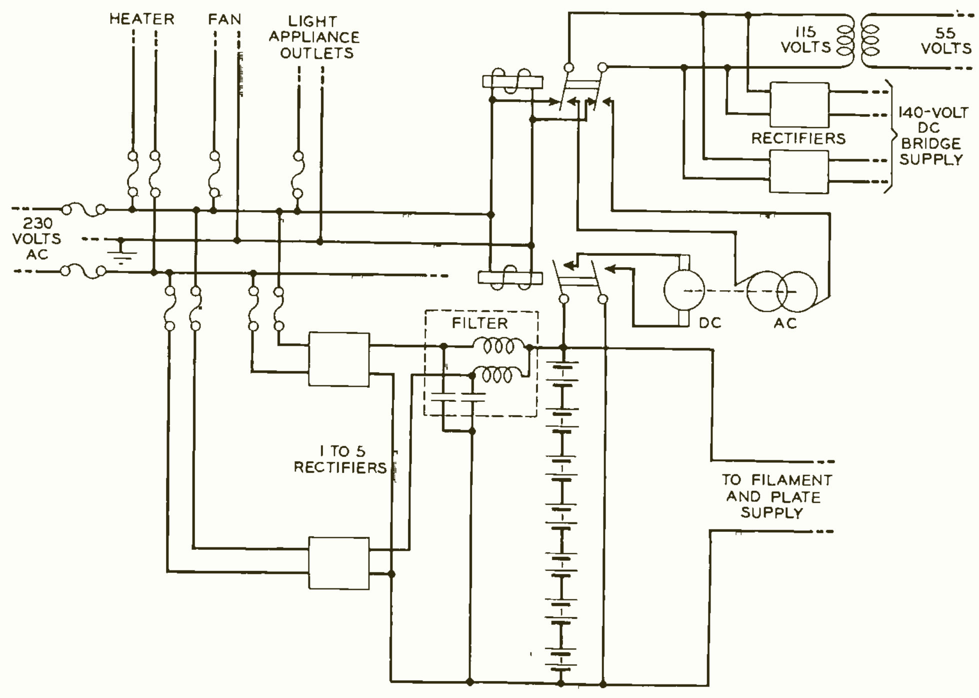
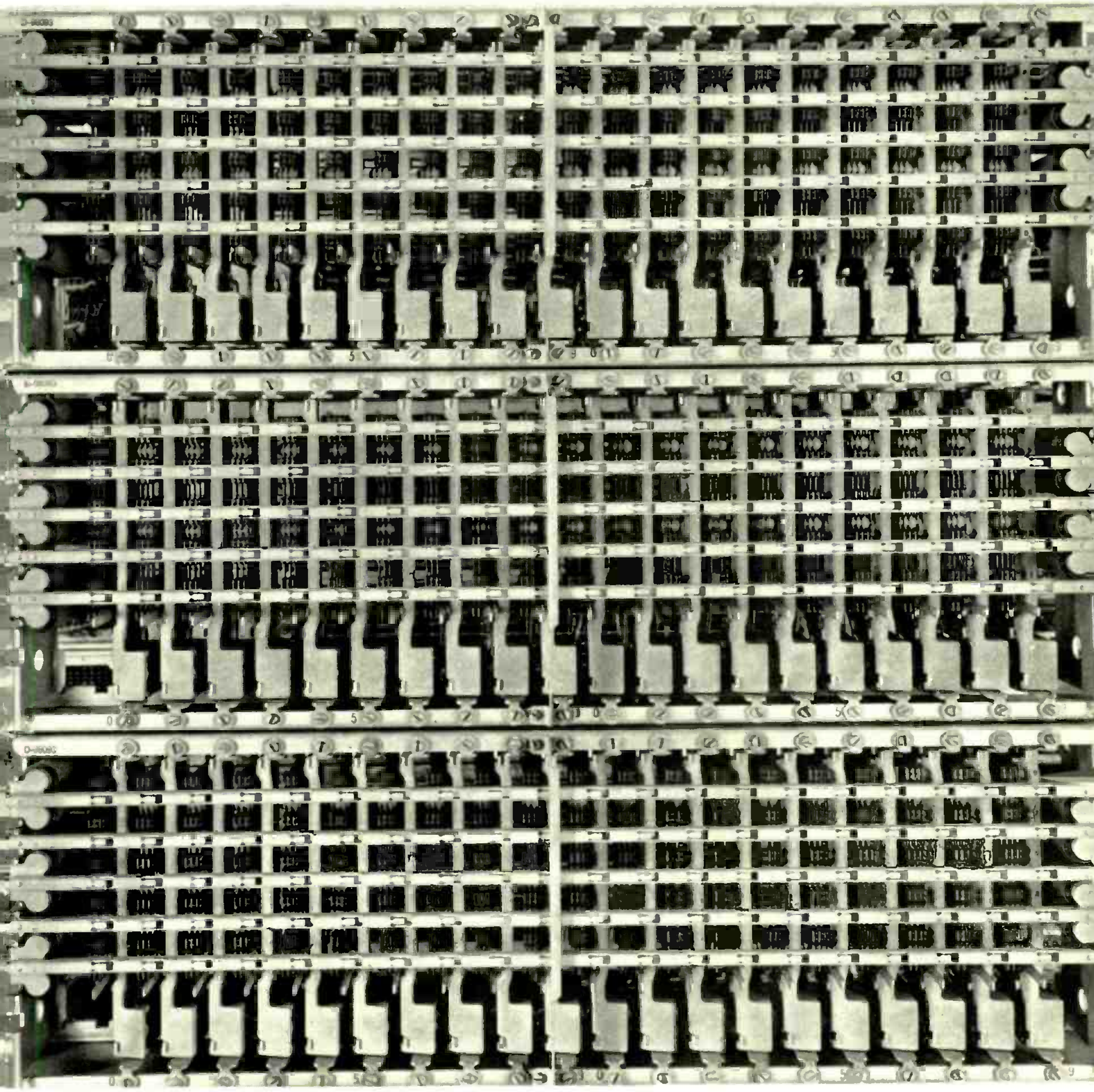
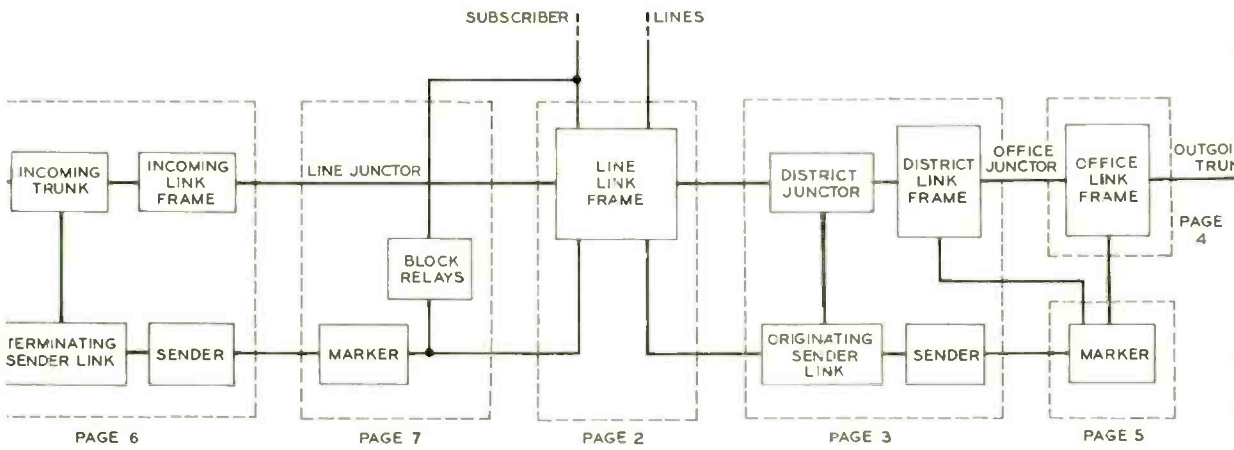
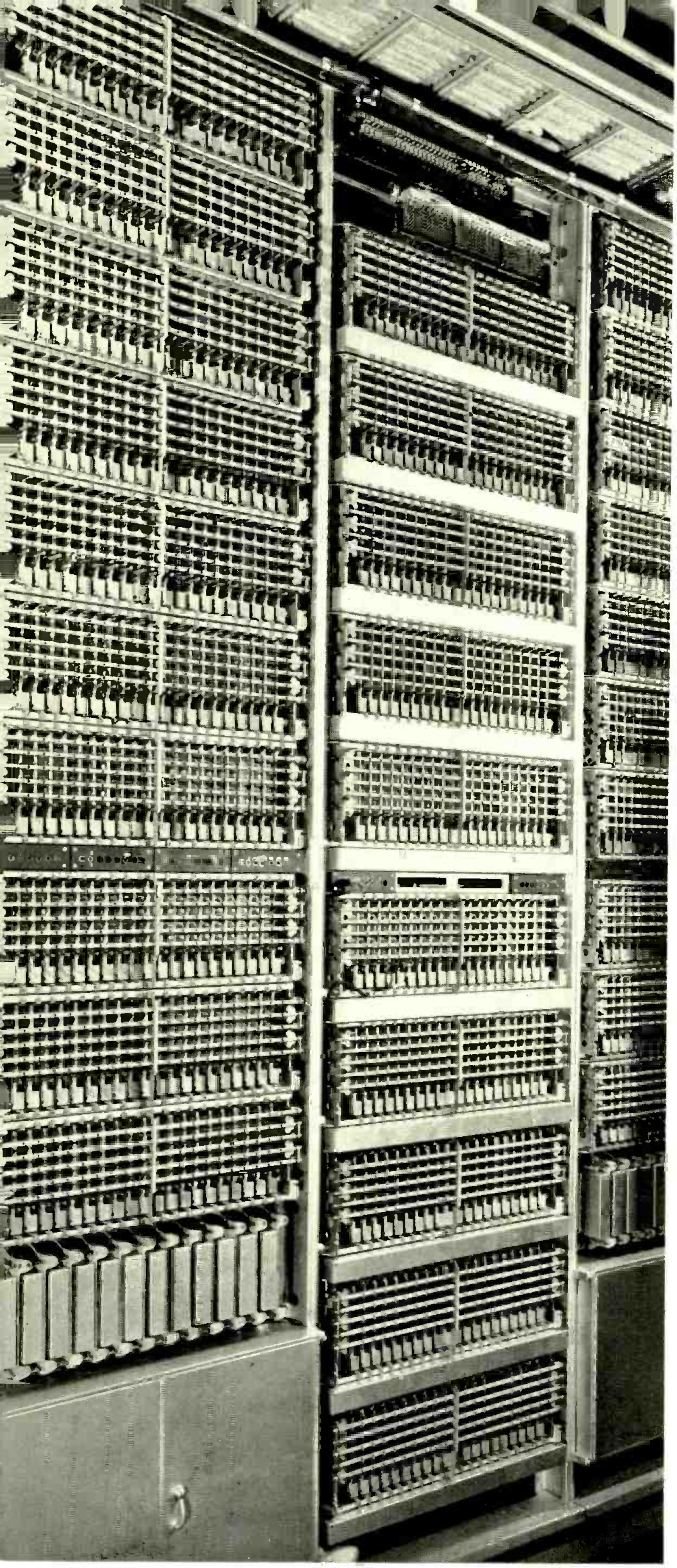


Fig. 4—Simplified diagram of the 420A power-supply system

MURRAY HILL SIX



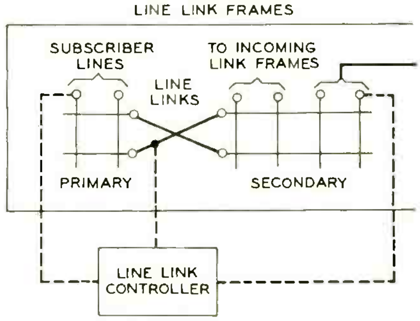


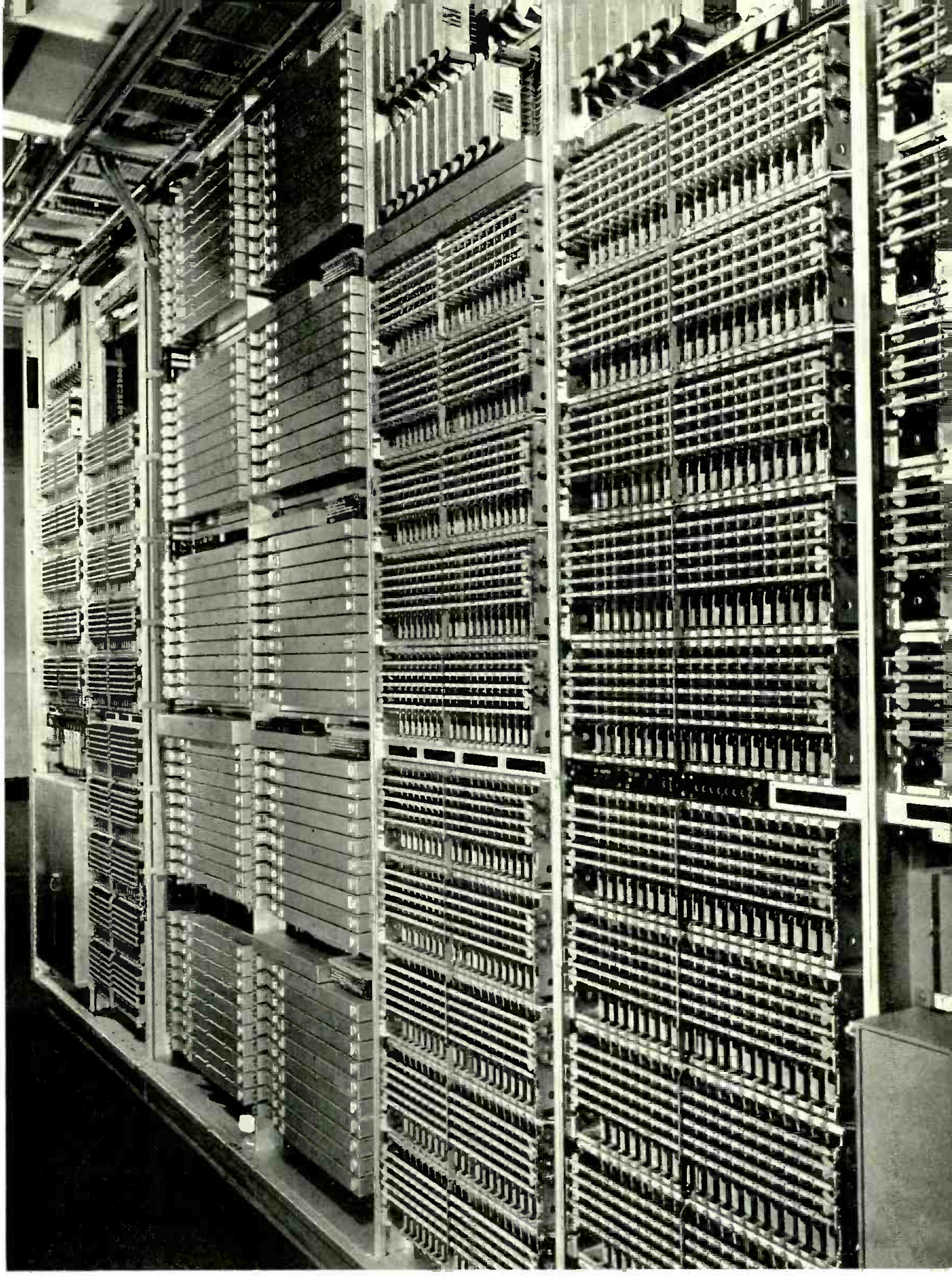


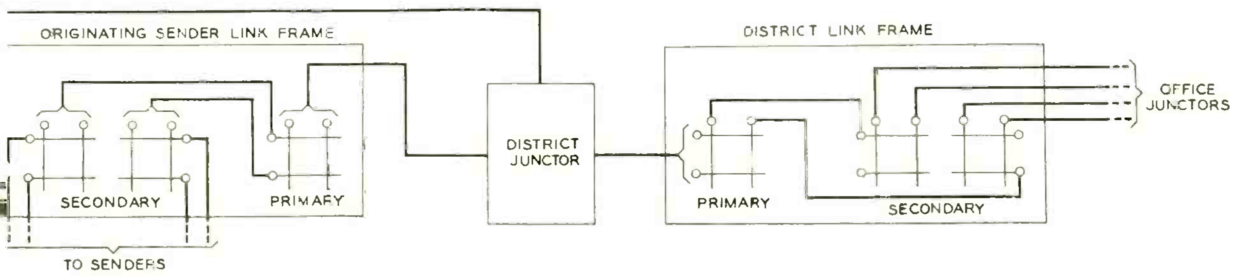
A crossbar office differs from the previous types not only in its circuits and general switching plan, but in the type of apparatus it employs. The major piece of apparatus, the crossbar switch itself, is used for all the main switching frames, and was described in the RECORD for July, 1937. An important feature of the system, however, is the use of common controller circuits, and these are composed—for the most part—of the U and Y-type relays, described in the RECORD for May, 1938. These relays are in all the cabinets and under all the long horizontal covers shown in the accompanying photographs. In addition there is the multi-contact relay; these are used in large quantities on the block-relay frames, page 7, and to a lesser extent with the originating marker, page 5, but they are used to some extent with all the frames. One of their major uses, however, is as number-group and line-choice connectors, which are not illustrated in this folder. A general description of the crossbar switching system appeared in the RECORD for February, 1939.

The photograph at the left shows a line-link frame, with its common controller circuit in the cabinet at the bottom of the primary bay

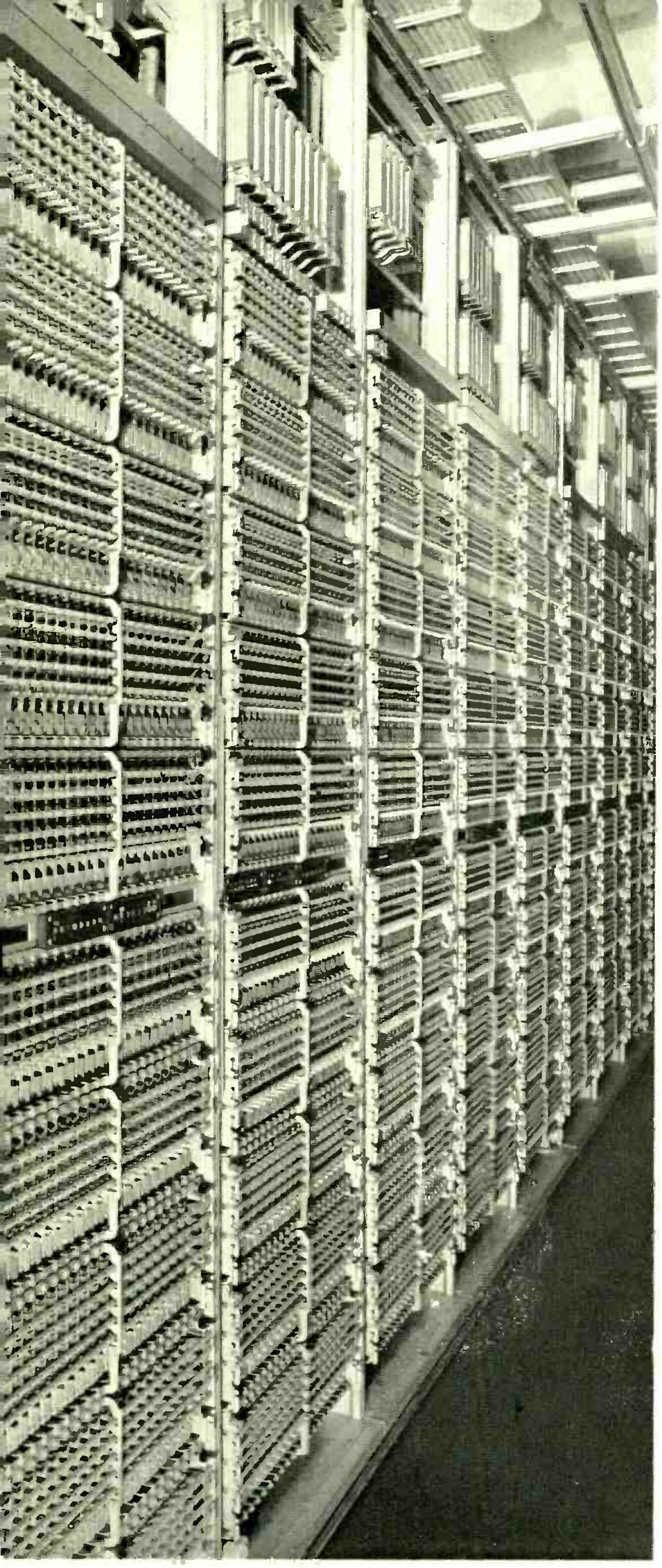
(Opposite page) An originating sender link, the two bays at the left; district junctor circuits, the two bays of long horizontal covers; and district link frame, primary and secondary





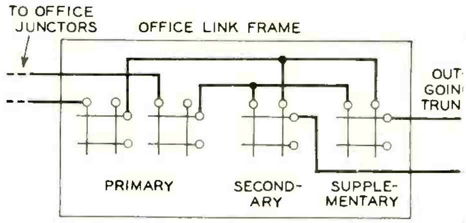


ORIGINATING SENDER LINK FRAME
SECONDARY
PRIMARY
TO SENDERS
DISTRICT JUNCTOR
DISTRICT LINK FRAME
PRIMARY
SECONDARY
OFFICE JUNCTORS

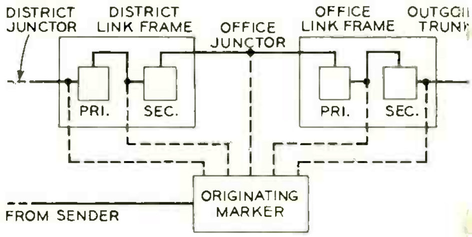


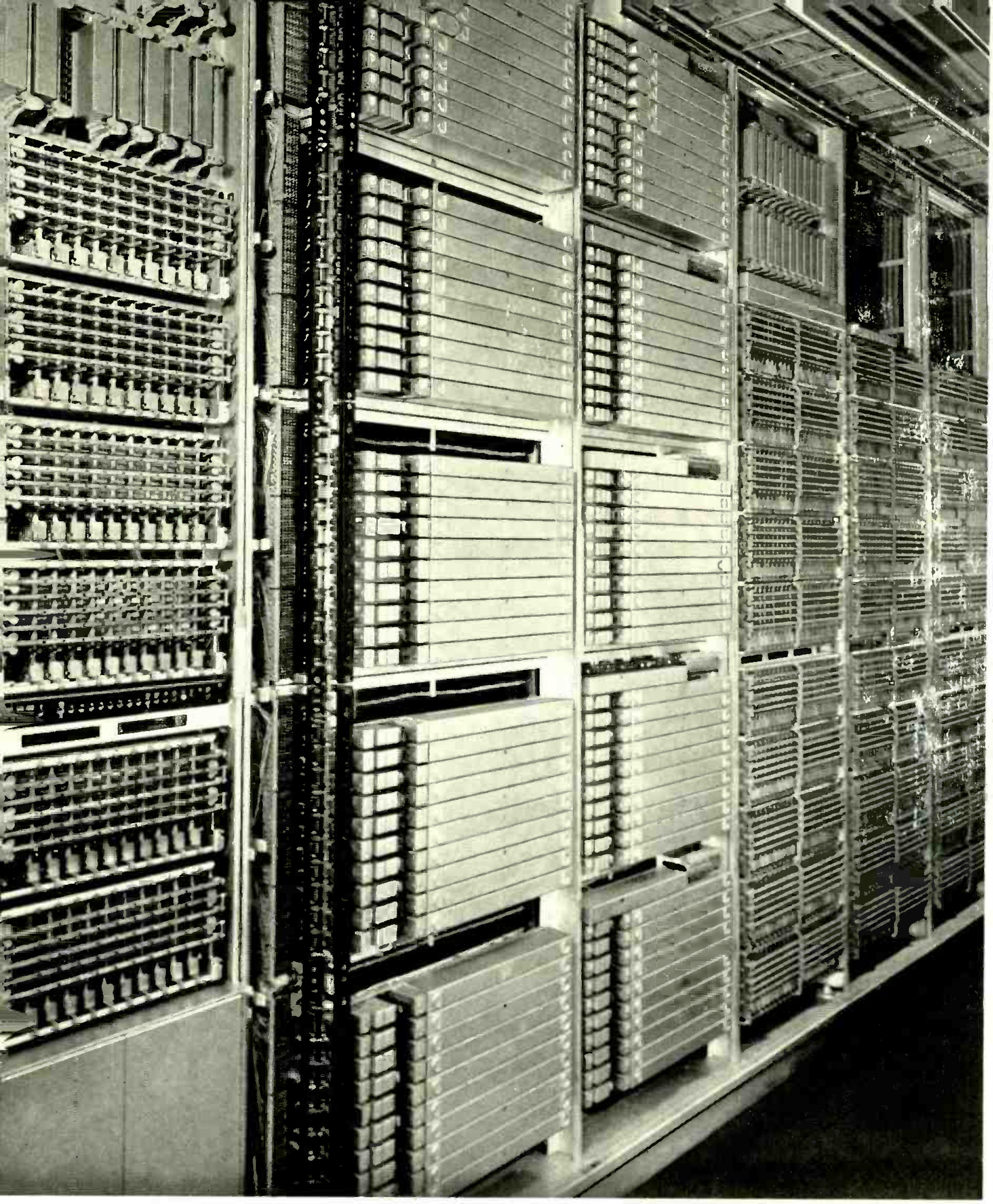
In general a crossbar switching frame consists of two bays of crossbar switches, ten in each bay. These are referred to as the primary and secondary switches. In some cases, however, additional bays are added when greater access to trunks, junctors, or lines is needed. In the office shown here — Murray Hill 6, New York City—a single supplementary secondary bay is required for the office and incoming link frames, shown on this page and page 6, respectively.

Office link frame: primary at left, and secondary and supplementary bays adjacent

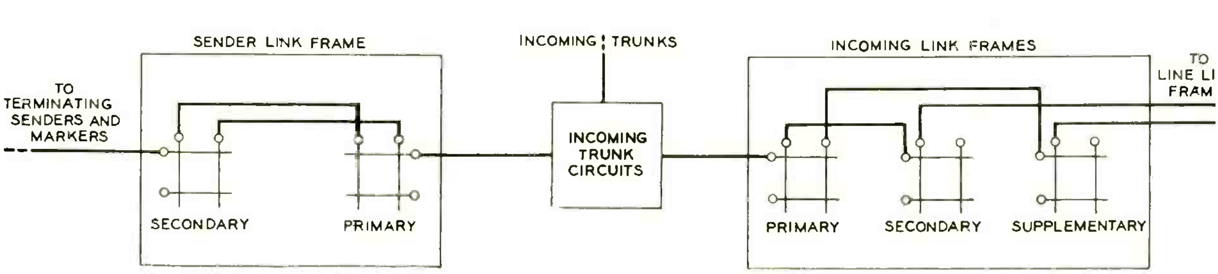


(Opposite page) An originating marker includes three cabinets of U and Y-type relays, at the left and four bays of route relays and cross-connecting terminals

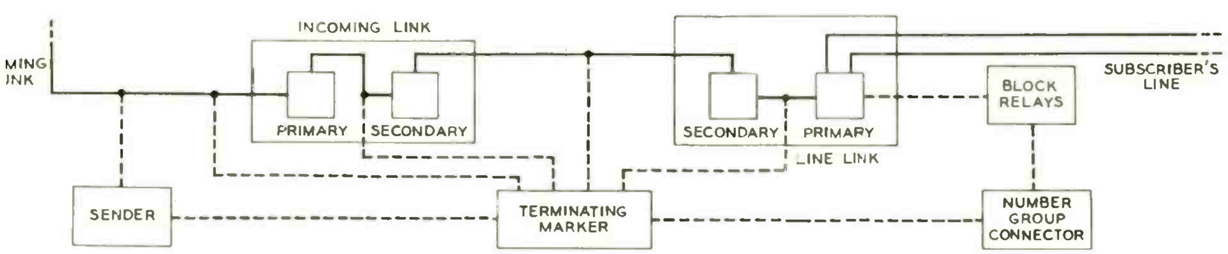


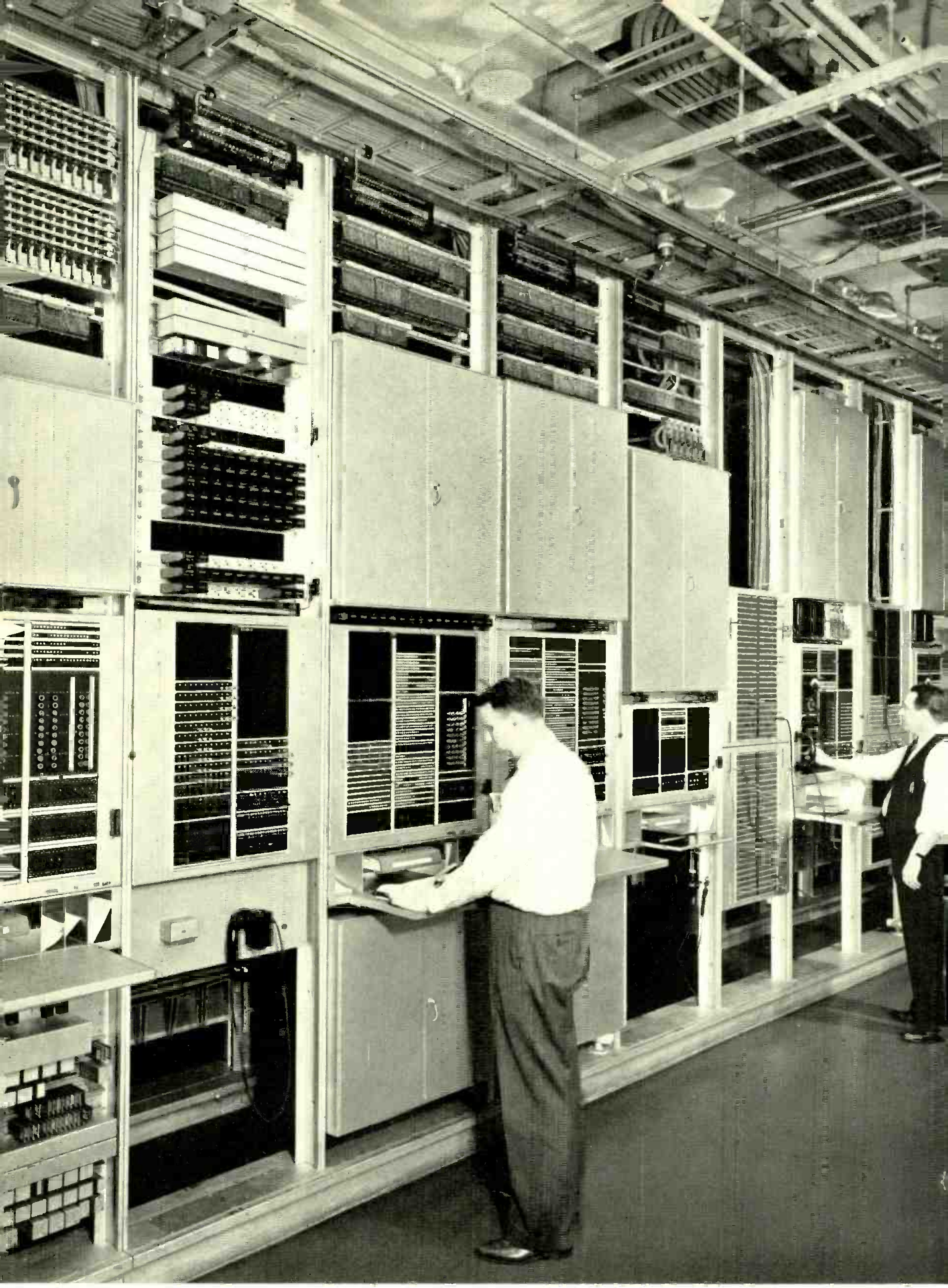


Terminating sender-link frame, left-hand bay; incoming trunk circuits—two bays of long horizontal covers; and incoming link frame—with primary and secondary and supplementary bays—at right



Block relay bays. These are used by the terminating markers for testing lines and determining their location on line-link frames





This set of bays gives maintenance supervision and facilities for routine testing for the crossbar office. The major equipment bays, from left to right, are sender test, sender make-busy, originating and terminating trouble indicators, incoming trunk test, and four bays for outgoing trunk tests

Lockout in Long Telephone Circuits

By A. W. HORTON, JR.
Circuit Research Engineer

LONG four-wire telephone circuits employ echo suppressors to eliminate the reflected currents that would otherwise interfere with communication. The arrangement of such a circuit is indicated in simplified form in Figure 1. Speech current for example, from the east subscriber, E, passes over the lower side of the circuit to W, the west subscriber. Part of it is reflected at the west hybrid coil, however, and starts back over the upper side of the circuit. Without the echo suppressor, it would reach E as an echo. With the echo suppressor in the circuit, however, the speech currents in the lower path actuate relay F through the echo-suppressor circuit, and disable the upper path so that the echoes cannot return to E. The suppressor will operate on speech in either direction, operating relay C for east-bound speech, but when it has operated on speech in one direction, the input in the other direction is blocked until the other relay has released.

Relays F and C have an adjustable slow release characteristic, which is necessary because of the delay in the circuit. After west-bound speech has reached the echo suppressor at B, for example, it will require a time, τ_w, to reach the west terminal, and the echo from there will again require a time, τ_w, before it gets back to the suppressor at D. If relay F released as soon as the last speech current passed B, echoes would be passed back to E for a period equal to twice τ_w. To avoid this, relay F is given a release time equal to $2\tau_w$ plus a small additional amount, and relay C is given a release time similarly related to τ_e. Subscribers talking over such a circuit are not usually aware of the presence of the echo suppressor unless one subscriber attempts to talk before

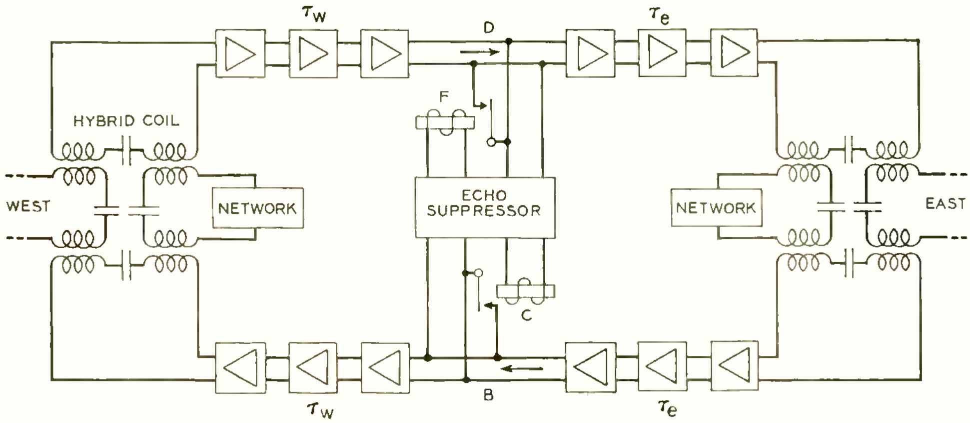


Fig. 1—Simplified schematic of long telephone circuit with an echo suppressor

the other has finished. Under these conditions his speech would be blocked by the echo suppressor. When, for example, E is talking, he has control of the circuit through relay F. If W starts to talk before E has ceased, his speech will be blocked, and E will be aware that W has been talking only by failing to hear the first part of his reply.

Sometimes, however, a very long circuit may be built up from two of these shorter circuits, each with its echo suppressor. Under these conditions it is possible for a condition known as lockout to occur. With lockout, the transmission path is blocked in both directions, and although both subscribers may be talking, neither will hear what the other is saying. On ordinary circuits these lockouts last for so short a time when they do occur that there is no serious interference with ease of conversation. The frequency with which lockout occurs, however, and its duration when it does occur, are both related to the transmission times of the circuit, and so for such very long connections as those including a transoceanic link with long cable circuits at both ends, it is conceivable that lockout might become serious. It seemed desirable, therefore, to undertake a study of lockout and the factors causing it, so that from the knowledge gained, circuits could be designed to minimize its harmful effects.

The study was made on a tie line used only for company business between the Western Electric plant at Hawthorne, just outside of Chicago, and its New York office. The regular echo suppressor on the circuit was removed, and two were installed in New York together with artificial delay circuits* to be connected into the circuit between and on both sides of the echo suppressors. This permitted the delays to be changed at will, and to be made much longer than they normally would be, so that lockout could be studied under a wide range of conditions. The number of lockouts and their total duration were obtained from a counting circuit and an electric clock operated by auxiliary relays controlled by the echo-suppressor circuits. To determine the effect of the lockouts on the conversations, monitors were employed to record the number of repetitions that

*RECORD, *August*, 1938, *p.* 400.

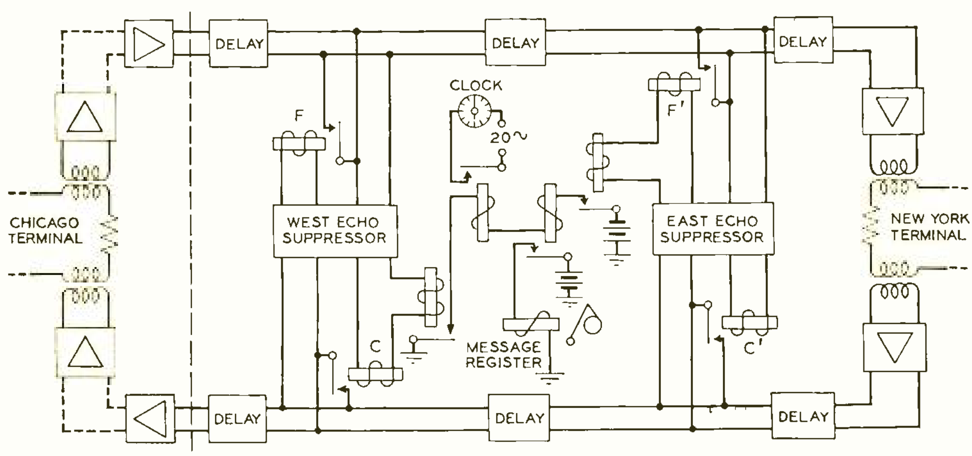


Fig. 2—Circuit arrangement for study of lockout

were called for and made during each conversation. The arrangement of this circuit is indicated in Figure 2.

Although it is the presence of two echo suppressors that makes lockout possible, its occurrence and duration is largely dependent on the relationship between the transmission times of the circuit and the release time of the relays and on the talking habits of the speakers. Speech is not continuous, but is composed of spurts of sound separated by short intervals called "resumption times." It is the length of these times in relation to the various circuit delays, and in relation to the period between the ending of speech by one talker and the response by the other, called the "response time," that controls the number and duration of lockouts.

A very long circuit with two echo suppressors—it is really two circuits in tandem, of course—could be represented schematically as in Figure 3. Here the delay times are indicated as in Figure 1, and the release times of the two sets of relays F and F′, and C and C′ are indicated by h_w and h_e, and h'_w and h'_e, respectively. Lockout occurs when F′ and C are both operated during the same period. Although the concurrent operation of F and C′ would also cause lockout, this condition has no practical significance because F cannot be operated without F′ being operated first, in which case C′ could not be operated by east-bound speech. For similar reasons C′ could not be operated by east-bound speech without operating C first and thus preventing the operation of F. The conditions causing lockout are thus those that will cause both F′ and C to be operated jointly.

The relationships of the various factors involved in lockout are illus-

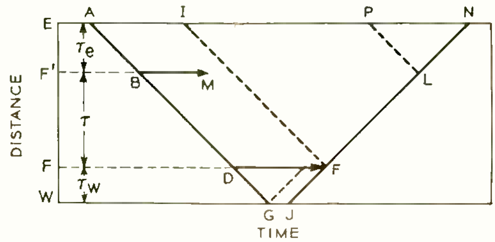


Fig. 4—Time relations causing lockout

trated schematically in Figure 4. On this diagram distance is plotted vertically, from the west terminal at the bottom to the east terminal at the top. The positions of the two echo suppressors F and F′ are indicated and the distances between them and between each and its nearest terminal are designated by the delays which correspond to them $-\tau_w$, τ and τ_e. Time is represented horizontally along the chart. Since time is consumed by the voice currents in passing along the line, the track of a spurt of current flowing from the east to the west terminals would be as represented by the line ABDG.

Assume that E has been talking and that ABDG represents the end of his last speech sound, leaving the east terminal at time A. At time B it will have reached the east echo suppressor, and relay F′ will be deënergized. Because of the slow release, however, it will not be open until time M. At

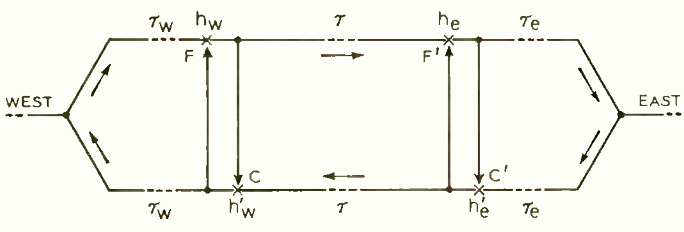


Fig. 3—Schematic of a generalized four-wire circuit equipped with two echo suppressors

time D the west echo suppressor will be deënergized but release will not occur until F, because of its slow release. The slope of the line ABDG is a measure of circuit delay since it is the ratio of distance to time and all speech impulses from east to west would be represented by lines parallel

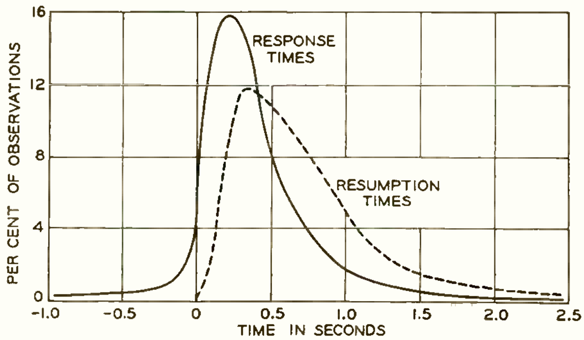


Fig. 5—Observed distribution of resumption and response times

to ABDG. Similarly all speech from west to east would be represented by lines parallel to JFLN. This latter line represents a response by west starting at time J and reaching the west echo suppressor just as it releases. If this response continues and reaches the east suppressor at time L, without east's having resumed speaking before time P, west will control the circuit and he can talk to east. Any resumption of speech by east after time P will be blocked as long as west's speech is continuous. On the other hand, had east resumed before time I, his speech would reach the west echo suppressor before it had released, and he would again control the circuit; response by west would have been blocked.

With a response time by west equal to GJ, therefore, and a resumption time by east either less than AI or greater than AP, no lockout will occur; one or the other of the terminals will be in control. Lockout will occur, for a response time GJ, only with a resumption time by east between AI and AP. A resumption between I and P will actuate the east suppressor and block speech by west, but before it reaches the west suppressor, that will have been actuated by west's speech.

The experimental study of lockout, by giving the number of lockouts, their total duration, and the repetitions they cause in conversation gave data for relating the occurrence and duration of lockout to the various delays of the circuit. Because of the difference in the speech habits of the various talkers, however, and other uncontrollable factors, the results from studies at different times and with different speakers did not always exactly agree. In general, however, there seemed to be a direct proportionality between the total time locked out and the number of repetitions, or in other words, the effect of lockouts on conversations is proportional not to their number but to the product of their number and average duration. There is some indication, however, that when the total lockout time is very small, the effect in causing repetitions is somewhat less than that given by the factor of proportionality that holds for larger values of lockout time.

Since both the number and duration of lockouts depend on the delays and release times already mentioned in relation to the resumption and response times of normal speech, it seemed possible to devise an expression for the effect of lockout in terms of these various factors. With this in view a study was also made* of the

*RECORD, *November*, 1938, *p.* 85.

resumption and response times occurring in actual conversations. Distribution curves of the response and resumption times found are shown in Figure 5. Based on these distributions, both the number and duration of lockouts depend on the delay times of the circuit and the release times of the relays. As already noted, however, the release times are normally made slightly greater than the time for speech to travel from the suppressor to the nearest terminal and back again, and thus the release times also are determined by the delay times of the circuit. As a result it becomes possible to express the repetition rate occasioned by lockout in terms of the delay times of the circuit.

If the suppressors are in the centers of two equal-length circuits, so that $\tau_e = \tau_w = \frac{\tau}{2}$, the repetition can be expressed in terms τ alone. A curve expressing this relationship is shown in Figure 6. This is based on the assumption that the curve expressing the relationship between the repetitions and the total time locked out is a straight line. Since as already noted there is some indication that this latter relationship departs from a straight line for small delays, the curve of Figure 6 would probably follow the dotted curve at its lower end.

Even without the occurrence of lockout a certain number of repetitions occur, and for the studies referred to, this number is taken as unity relative repetition rate. For values of τ less than about 0.04 or 0.05 second, therefore, lockouts have no appreciable influence on conversation. Since most existing lines have delays of about this magnitude, lockout is not a serious factor under present conditions. The data gathered, however, give their effect for considerably longer times, and indicate that for long connections, lockouts might be important unless steps are taken to avoid long distances between echo suppressors.

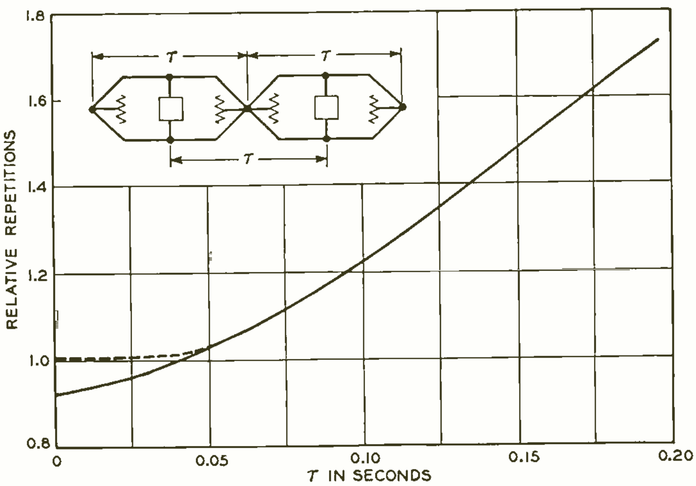


Fig. 6—Calculated relative repetition rate for the circuit conditions indicated

Sound-Level Distribution Recorder

By H. KAHL
Transmission Development

AN automatic device for registering the intensity level of noise or speech currents in successive short intervals is a useful tool for studies of circuit or room noise, particularly where the changes are frequent or rapid. For this purpose a level distribution recorder has been developed to supplement the visual indicating meters used heretofore. Indicating meters are difficult to read for extended periods when the input varies rapidly; and therefore the results of different observers may differ widely. Furthermore, it is frequently impractical to operate the gain control in these meters fast enough to cover the range required for the measurement. The level distribution recorder has been found particularly useful in fundamental studies of room noise, static, speech levels, and experimentally for contact-noise measurements in central-office dial switching areas.

The level distribution recorder, when used with the Western Electric 2A noise-measuring set* and similar devices, replaces the meter and rectifier of these instruments. The recorder consists essentially of a gas tube which operates a series of message registers. The number of registers operated is a measure of the intensity level of the noise. The operating cycle takes one second and the measurement is equivalent to reading and recording the maximum deflection of the indicating meter of the 2A set once per second, which is about three times as fast as readings and recording can be done by observers.

The operating principle of the level distribution recorder is illustrated by the block diagram of Figure 1. An amplifier is connected to the 2A noise-

*Record, *March*, 1936, *p*. 233.

measuring set in place of the usual meter after the copper-oxide rectifier has been removed. The output of this amplifier feeds a full-wave thermionic rectifier. The rectified current passes to a condenser-resistance circuit which integrates short pulses like the meter of the 2A noise-measuring set. It also weights the peak and average values of the complex waves and gives a reading which is reasonably close to the true root-mean-square value in most cases. The voltage-measuring circuit operates relays and registers through the gas-tube circuit.

The voltage across the integrating circuit is measured as shown in Figure 2. The noise current builds up a direct-current voltage in the integrating-circuit potentiometer and makes negative the grid of the direct-current amplifier which is connected to the 0-db point of the potentiometer. This decreases the plate current and raises the potential at the plate of the amplifier and the grid of the gas tube. When this potential is about four volts negative with respect to the cathode potential, the gas tube fires and operates the relay and message register which are in its plate circuit. This relay transfers the grid of the direct current amplifier to the five-db point on the integrating-circuit potentiometer, and switches the gas-tube plate circuit to the next relay and message register in the series. The relay also extinguishes the gas tube. The maximum voltage across the output of the integrating circuit during each one-second interval determines the number of relays and message registers operated. This voltage in turn is proportional to the maximum root-mean-square values of the input voltage taken over 0.2-second periods during that second. The one-second interval

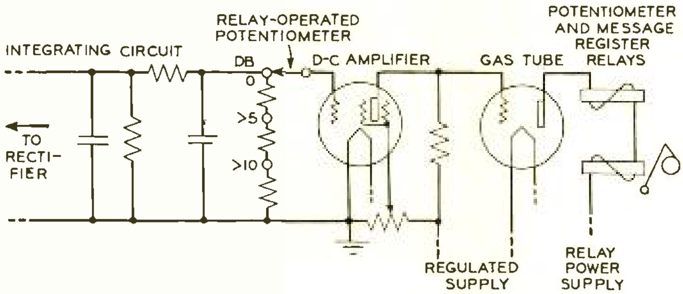


Fig. 2—Simplified schematic of the recorder

is usually determined by a 1 r.p.s. synchronous motor which releases all relays and message registers preparatory to making a measurement in the next one-second interval.

A unique feature of the voltage-measuring circuit is the pentode or screen-grid tube used as a direct-current amplifier. The operating characteristics of the tube are such that the plate current attains its maximum, and the plate potential its minimum, value with no input. With increasing input the grid of the direct-current amplifier goes negative and the plate current decreases. The grid potential at which the gas tube fires is determined by the screen voltage, which is adjustable. The usual practice is to set the operating point of the direct-current amplifier so that the gas tube will fire whenever the potential of the amplifier grid reaches -1.5 volts.

The output of the rectifier is linear but it reads steady complex

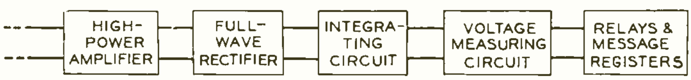


Fig. 1—Operating principle of the level distribution recorder

waves essentially as a true root-mean-square device. The peak amplitude as well as the average amplitude of a wave contributes to the voltage across the output of the integrating circuit. The constants of the circuit determine the weight given the peak amplitude and these can be chosen so that any one complex wave will give the same

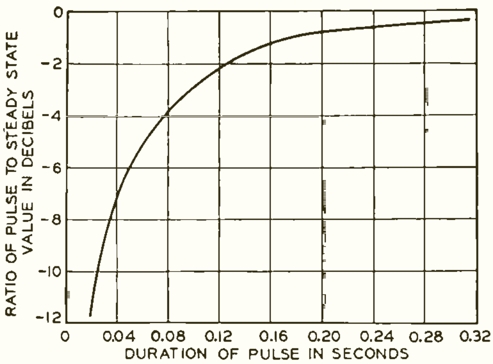


Fig. 3—Short pulses record like steady currents of less intensity

reading as a sine wave of equal r.m.s. value. The error caused by this adjustment for waves such as line noise, a square wave, and rectified harmonics varies from 0.1 to 0.2 db. The response of the integrating circuit to pulses of short duration is shown in Figure 3, where the intensity of short pulses required to give the same reading as steady-state currents is plotted against the duration of the pulses. This curve is similar to that of the time response of the indicating meter of the 2A measuring set.

The level distribution recorder measures satisfactorily noise of a wide range of levels. When calculating average values a 2.5-db correction brings the indicated value to the center of each five-db range. The maximum error for any one value is then 2.5 db, and the probable error 1.25 db. Figure 4 is a typical cumulative distribution curve and shows the per cent of the noise currents which have intensity levels equal to or less than the values shown as abscissas. The blocks indicate the data obtained by the recorder and the curve has been drawn approximately through their midpoints. Although the individual values may be considerably in error the final curve is defined with reasonable accuracy.

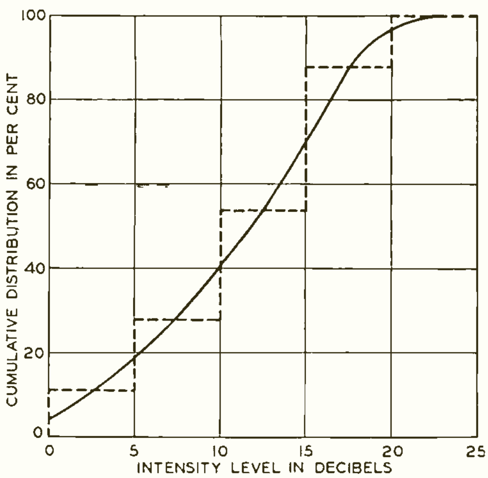


Fig. 4—Per cent of observations having intensities equal to or less than stated values

The recordings are not necessarily made on message registers. An attachment which is particularly useful for making detailed studies of noise variations with time has been developed to print the results. Circuit studies with this apparatus are in progress.

A New Page Teletypewriter

By B. S. SWEZEY
Telegraph Facilities

DURING the past seven years teletypewriter exchange service has grown to a total of over twelve thousand subscriber stations. A number of teletypewriter features used on private lines are not ordinarily required for this service. One or two copies of the messages on plain paper suffice in most cases and the teletypewriters are in operation only a comparatively small part of the time. Since several carbon copies, printed forms, tabulating devices and other special features available on the No. 15 page teletypewriter are rarely needed in exchange service, the Teletype Corporation was asked to develop and supply a page teletypewriter of simplified design and lower first cost for this service and for certain types of private-line service.

The new machine, coded No. 26, is somewhat smaller and quieter than the No. 15 page teletypewriter and also more pleasing in appearance. It types on individual pages or on a long continuous supply from a roll or superfold pack. A single carbon copy may be made in any case, but typing on printed forms requiring accurate positioning has not been provided. The model illustrated in Figure 1 is a sending-receiving machine, but others without keyboard are available where "receiving only" service is required.

The keyboard mechanism of the new teletypewriter operates like others of modern design. Depressing a key releases a cam assembly which allows one or more of five contacts to close

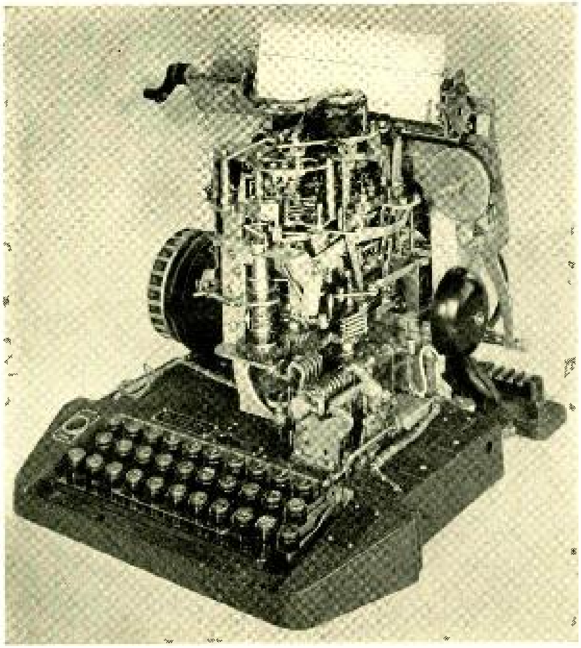


Fig. 1—The No. 26 teletypewriter types the message on individual pages or on a continuous roll or super-fold pack. It can make one carbon copy

in sequence and in various combinations depending on the key pressed, thus sending over the line signals composed of different combinations of five current-on or current-off intervals of equal length. Thirty-two different signals are obtained in this way, of which twenty-six are used for the letters of the alphabet and the others for functions such as feeding the paper, returning the carriage, and shifting. The shift signal brings into action a second row of type with numerals, fractions and punctuation marks.

In the receiving mechanism, the five component impulses of each selection are sorted out by a timing mechanism and transmitted to five code discs (Figure 2) mounted concentrically one above the other on a vertical spindle. The edge of each disc is slotted to conform to the signal code. One or more of the discs rotates through a small angle on receipt of the different signal combinations and this brings the slots in the edges of the discs into line at one point. Pins are mounted around the edges of the discs like a crown and press against them so that each pin spans all five discs. For each combination of impulses some pin enters a line-up of slots. A stop arm which is continuously seeking to rotate over the discs is then brought to rest as it strikes this pin. Fastened to the stop arm is a vertical shaft on the upper end of which the typewheel is mounted. The typewheel has two rows of characters facing outward and one of these characters is presented to the platen when the stop arm and typewheel come to rest. A printing hammer which extends into the inner part of the typewheel then operates and strikes the type pallet from the rear. This drives an inked ribbon against the paper and types the character.

As soon as the typing has taken place, the printing hammer retracts so that the typewheel may assume a new position for the next character. The spacing mechanism moves the paper carriage to the left one space after the typing of each character. To allow the last characters typed to be seen, the typewheel is raised into position immediately before typing and lowered immediately afterward by sliding up and down on the stop-arm shaft. When a shift or upper-case signal precedes a character the typewheel rises higher and the printing hammer strikes the lower level of characters on the wheel.

To feed the paper for a new line and

return the carriage, the stop arm and its shaft assume the selected position in the same manner as to type a character but at these points in the typewheel no type pallet is provided and no typing can take place. However, at the lower end of the stop-arm shaft, a spider arrangement similar to spokes on a wheel but on different levels is provided. The different arms or spokes are presented to a co-acting mechanism arranged to perform the desired functions. Spacing of the carriage is prevented when non-spacing functions are selected by disengaging the spacing mechanism. The ribbon feeds and reverses automatically.

The bell near the rear of the machine at the right may be operated from a distant machine to attract attention when an important message is to be received or as a special signal for other purposes. In front of the two ribbon spools is a graduated "range finder." Its arm may be unclamped and repositioned over the graduated scale to select the best portion of the signals being received. At the front of the machine to the left of the keyboard is a key labeled "break." This is used to open the line circuit when a station which has been receiving wants to take control of the circuit. Opening the line by operating the "break" key interrupts the sending from the distant machine. The sending operator, noting this, ceases sending so that the distant station takes control.

Arrangements are provided for using a small roll, containing about fifty feet of paper, mounted on the platen carriage inside the cover of the machine. Where the service requires a larger supply of paper a regular five-inch roll may be mounted in the table below the machine. The table on which the teletypewriter rests is especially adapted to handle paper for a moving carriage machine. The roll of paper is kept in the lower part of the table and fed through a slot near the top of the rear panel. The roll mechanism is carried on the front panel which may be swung down to replace the paper.

To reduce noise the machine has rubber supports; a cover encloses it almost completely and rubber flaps are provided at the necessary openings. The transparent curved plate through which the typing can be viewed is made of a tough non-shatterable composition.

The No. 26 teletypewriter incorporates some mechanisms which have been used successfully in earlier machines. The teletypewriter has been tested thoroughly, and has proved to be fit not only for intermittent use, for which it is primarily intended, but also for continuous service.

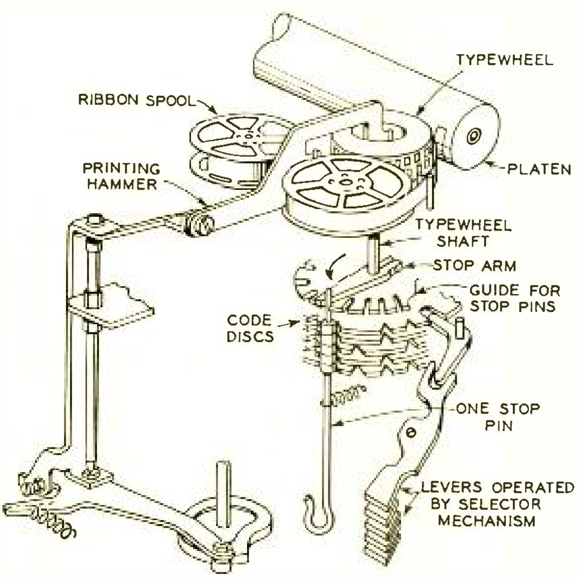


Fig. 2—Receiving mechanism of the teletypewriter

A Small Pre-Mixing Amplifier

By E. L. OWENS
Commercial Products Development

ONE of the requirements for modern high-quality broadcasting systems is the ability to handle programs with wide volume range. Since the lower limit of the volume range is restricted by the noise in the system, it is essential for best results to maintain noise levels as low as possible. Their lower limit in any amplifier system is set by the thermal-agitation noise at the input of the amplifiers, and the maximum signal-to-noise ratio obtainable is the difference in db between the output level of the microphone and the level of the thermal-agitation noise.

In radio broadcasting the standard procedure is to employ a number of microphones, and to combine their outputs by mixer circuits at the input of an amplifier system* that raises the microphone output to the proper level for the program line. The mixer circuits, which consist of resistance networks, have a fixed minimum loss depending upon the type of circuit and the number of microphones accommodated, and an adjustable loss in each channel is used, in addition, to set the output level to the desired value. Under some operating conditions the loss through the mixing circuit may be as much as 25 or 30 db. Until the last few years, the outputs of the microphones have been fed directly to the mixer without amplification, with the result that the microphone sensitivity, and thus the signal-to-noise ratio, has been reduced by the amount of the mixer loss. By inserting an amplifier between each microphone and its associated mixer, however, the signal-to-noise ratio is not seriously impaired so long as the mixer loss does not exceed the gain of the associated amplifier. The reason for this is shown graphically in Figure 1, using representative values for a signal-to-noise ratio and the thermal-agitation noise. At the left the conditions are indicated for no pre-mixing amplifier. At the out-

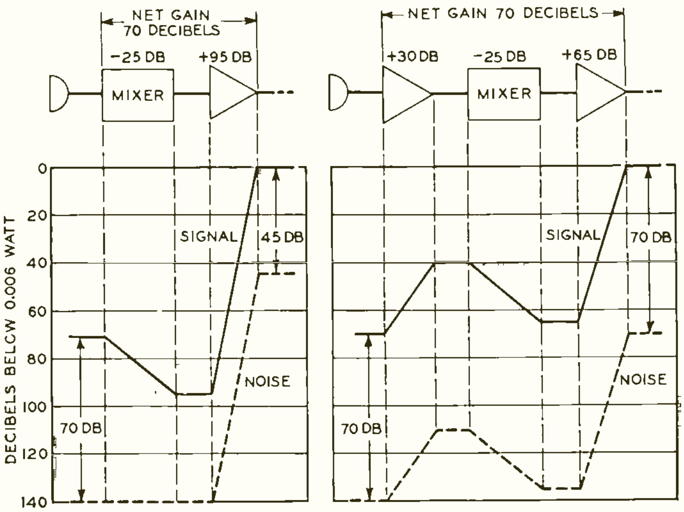


Fig. 1—*Effect of pre-mixing amplifier on the noise level at the output of an ideal system*

*Record, *December,* 1938, *page* 125.

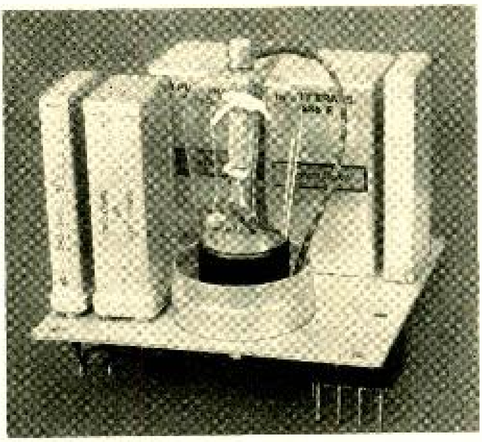


Fig. 2—The 104A amplifier with tube shield removed

put of the microphone the signal-to-noise ratio is 70 db, but a 25-db loss in the mixer reduces this to 45 db, which is maintained through the rest of the system. At the right are the conditions for a pre-mixing amplifier. The gain ahead of the mixer, as long as it is greater than the mixer loss, maintains the initial 70-db signal-to-noise ratio.

The above description assumes an ideal system. In actual practice noise components other than those due to thermal agitation at the input of the amplifier system are present and tend to decrease the signal-to-noise ratio. The magnitude of improvement with pre-mixing amplifiers, however, remains essentially the same in a well-designed system.

Because of the large number of pre-mixing amplifiers required in a typical broadcasting installation, it is desirable that they be small, inexpensive, and economical in operation. When they first began to be used, however, the only Western Electric amplifier available was the 80A*, which although entirely satisfactory so far as maintaining the signal-to-noise ratio was concerned, was larger and more expensive than was desirable. This situation has now been changed by the development of the Western Electric 104A amplifier, which is shown in Figure 2 with the vacuum-tube shield removed to expose the 262-B vacuum tube.

The component parts of the amplifier are assembled on a steel plate approximately five inches square and arranged so that three amplifiers can be accommodated on a mounting plate requiring only slightly over five inches of relay-rack space. Figure 3 shows the rear view of such a mounting plate equipped with three 104A amplifiers. The transformers, condensers, and vacuum tube are located on this side of the panel, and the terminals, resistances, and wiring are located on the front, where they extend within the recessed section of the mounting plate, and are protected by a front mat after installation. Figure 4 shows the front view of the mounting plate equipped with mat; the rotary switch is used to connect an external meter for measuring the plate

*Record, *October*, 1933, *p.* 60.

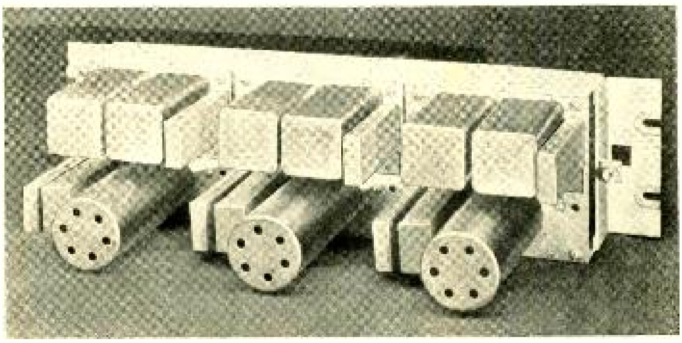


Fig. 3—Three of the 104A amplifiers mount on a relay-rack mounting plate

currents of the three vacuum tubes.

The 104A amplifier is a single-stage amplifier employing a Western Electric 262-B vacuum tube, and has a gain of approximately 29 db. It is designed to operate with microphones of either 30 or 250 ohms impedance and into impedances of 30 or 500 ohms. The transmission characteristic is substantially uniform over the frequency range from 30 to 10,000 cycles. For high-quality transmission the single-frequency output level should not exceed 20 db below 6 milliwatts, which is considerably higher than would normally be obtained with broadcast-quality microphones.

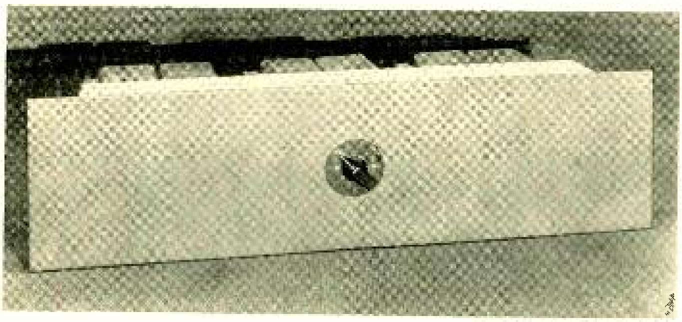


Fig. 4—The front mat of a panel mounting three 104A amplifiers carries only a switch for connecting an external plate-current meter to the three amplifiers

The amplifier is designed for operation with alternating current on the filament, and direct current on the plate obtained from an external rectified and filtered alternating-current supply. The filament requires 0.32 ampere at 10 volts, and the plate requires 0.6 milliampere at 375 volts. The plate current is fed through a resistance, which in combination with a condenser in the amplifier acts as a plate circuit filter. By changing the value of this resistance the amplifier can be made to operate with plate supply voltages as low as 200 volts.

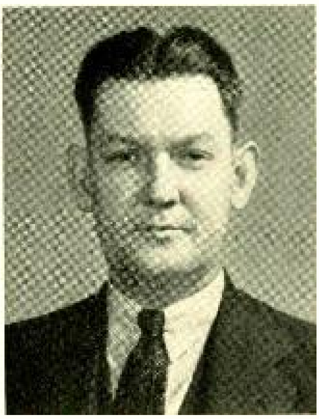
The 104A amplifier was intended primarily as an addition to the Western Electric 701A speech-input bay, and was designed to obtain its power supply from the power equipment in the bay. When used in more modern installations, in conjunction with the Western Electric 105A and 106A amplifiers, its power supply is obtained from one of these amplifiers. For other applications a rectifier is required for the plate voltage and some provision must also be made for supplying a-c for the filament. The Western Electric 15-A rectifier is available to perform these functions.

In addition to the 104A amplifier, the Western Electric 104B amplifier has also been made available to perform the same functions. The two amplifiers are interchangeable, the difference being that the 104B has a better shielded input transformer, making it less susceptible to disturbance from electro-magnetic pick-up, and is provided with terminals for operating from plate voltages of 200 and 250 in addition to the 375 volts required for the 104A amplifier. It also has a more uniform response characteristic at the upper end of the frequency range. The 104B amplifier has a gain of about twenty-eight db.

Contributors to this Issue

After four years in the Army, which included World War service, and a year's instruction in the Enlisted Specialists' School, J. B. Newsom entered the Systems Development Department of these Laboratories in 1920. For several years he was in the local circuit laboratory, and then transferred to local circuit development, where he worked on panel A-boards and call-distributing B-boards for panel systems. In 1931 he engaged in panel sender and decoder development, and with the advent of the crossbar system took part in the development of crossbar markers and senders.

After receiving a B.S. degree in mechanical engineering from the University of New Hampshire in 1923, H. H. Spencer joined the Technical Staff of the Laboratories. With the power group of the Systems Department, he has since then been associated chiefly with the development of power plants for toll systems.



J. B. Newsom

E. L. Owens graduated from Virginia Polytechnic Institute in 1924 with the B.S. degree in Electrical Engineering. He then entered the Engineering Department of the Western Union Telegraph Company and remained with them for some five years. In 1929 he became a member of the Technical Staff of the Laboratories. Here, with the Radio Development Department, he has been engaged in the development of speech-input equipment for radio broadcasting transmitters.

Testing apparatus and methods, described in this issue, for determining the effect of electric railway currents on nearby telephone lines are K. L. Maurer's personal contribution to the technique of inductive coördination. Mr. Maurer has been concerned with coördination studies for every railroad electrification since he en-

H. H. Spencer

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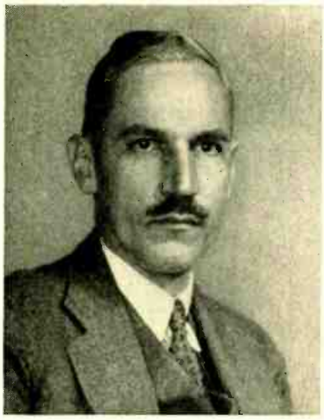

A. W. Horton, Jr.

Henry Kahl

B. S. Swezey

tered the D. & R. in 1925. As preparation for that work, he had had three years' experience in electrolysis studies with a firm of consulting engineers, together with undergraduate work at Amherst (A.B. 1917) and electrical engineering at Yale (Ph.B. 1921).

ARTHUR W. HORTON, JR., received the B.A. degree from Princeton in 1920, and the E.E. degree in 1922, having spent the summer of 1921 as an engineering student in the Physical Laboratories of the Western Electric Company. On leaving college he returned to West Street, associating with the Transmission Department, and with the organization of Bell Telephone Laboratories in 1925, he joined the Research Department. For the most part he has worked on transmission problems connected with telegraph, picture transmission, and television, and on voice-operated equipment, such as the transatlantic radio terminal and echo suppressors. At the present time, as Circuit Research Engineer, he is in charge of groups working on local and toll signalling and switching circuits, and on precision high-frequency generators.

HENRY KAHL joined the Research Department of the Laboratories in 1928 at which time he was graduated from the State College of Washington with the degree of B.S. Fundamental studies of noise and its effects and the design of equipment for noise and transmission studies engaged his attention until 1938. Since then his work has been on problems relating to open-wire crosstalk.

B. S. SWEZEY interrupted his engineering course at the Brooklyn Polytechnic Institute in 1917 to join the U. S. Naval Service. Two years later he returned to the same institution and received there the E.E. degree in 1920. For a time he instructed in electricity at the New York Edison Company and later at the Brooklyn Y.M.C.A. In 1920 he joined the Department of Development and Research of the American Telephone and Telegraph Company, where he was associated with the development of teletypewriters, including tests of some of the early machines used in the Bell System. When teletypewriter exchange service was initiated, he was concerned with the station equipment required as well as with teletypewriters for stations and central offices. Since the consolidation of the D. & R. with the Laboratories that occurred in 1934, he has continued the same type of work as a member of the Telegraph Facilities Department.