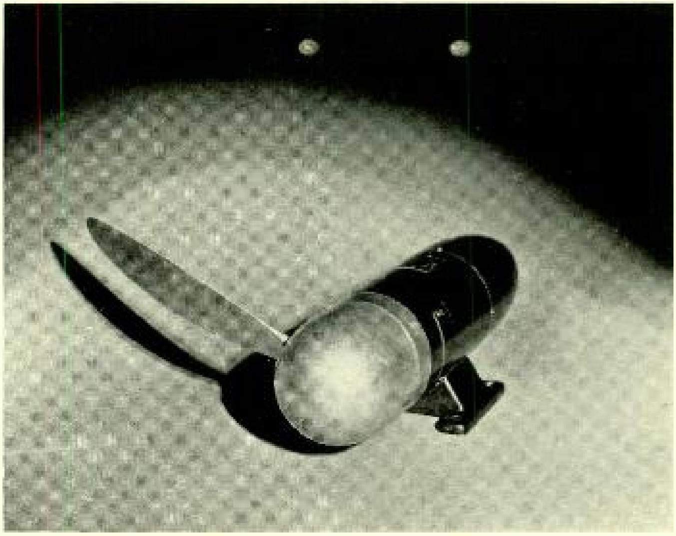
BELL LABORATORIES RECORD



Wind-driven generator used with Western Electric aircraft radio transmitter

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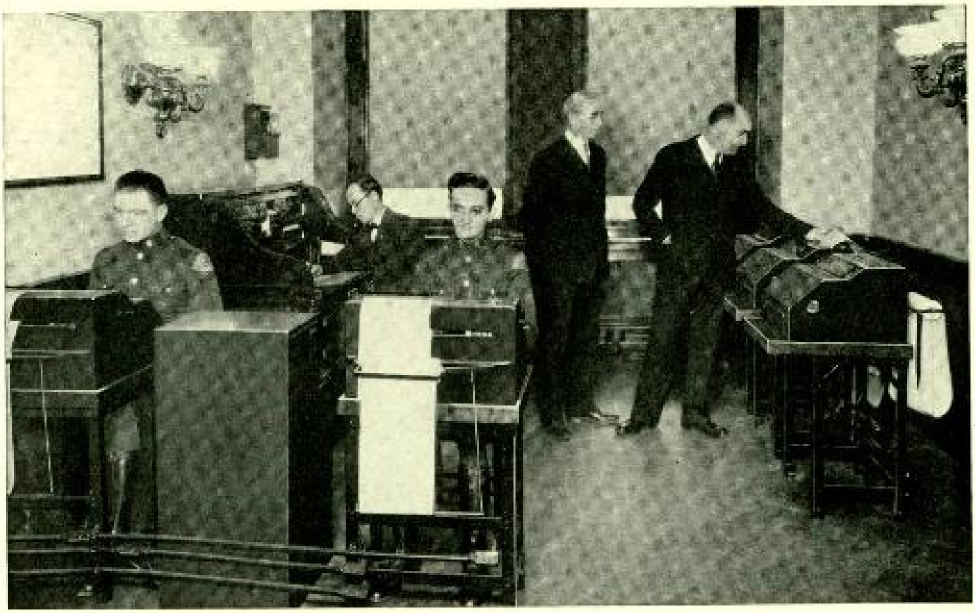


Telephone-Typewriter PBX Systems

By G. A. LOCKE
Toll Systems Development

PRACTICALLY all the leased-wire telegraph service provided by the American Telephone and Telegraph Company has been long distance business between two stations for a definite number of hours each day. Until a few years ago such service was exclusively Morse operated. Recently, however, a large amount of it has been converted to the telephone-typewriter system, and now to meet the demand for greater flexibility and wider scope telephone-typewriter PBX systems have been designed.

Two types of telephone typewriters are available and both have the transmitting and receiving elements contained in a single unit. The number 14, shown in Figure 1, prints the characters on a paper tape ⅜ inch wide; the number 15 type prints on a standard letter size sheet of paper. Each has its distinctive advantages and use. The tape from the number 14 type may be gummed on one side, and to put it in the ordinary message form it is cut into strips and fixed to a blank sheet of paper. Any errors may easily be cut out during this process. The page typewriter, on the other hand, although not requiring this cutting up and arranging procedure, also does not permit the ready correction of errors, and requires additional signals for feeding the paper up and for returning the carriage when it has reached the end of the line. Either may be operated by any typist after a brief training.

Telephone-typewriter systems of the Bell System have been rapidly growing in popularity during the last few years. Recent developments have made the instruments smaller in size, and easier and less expensive to operate; all of which has stimulated the demand that arises from the very substantial service they are able to render. Banks, brokers, and manufacturing concerns as well as Press Associations, and Police Departments, which have found very valuable the rapid communication by the printed page which they permit, are now asking for still further extended service possible through PBX systems.

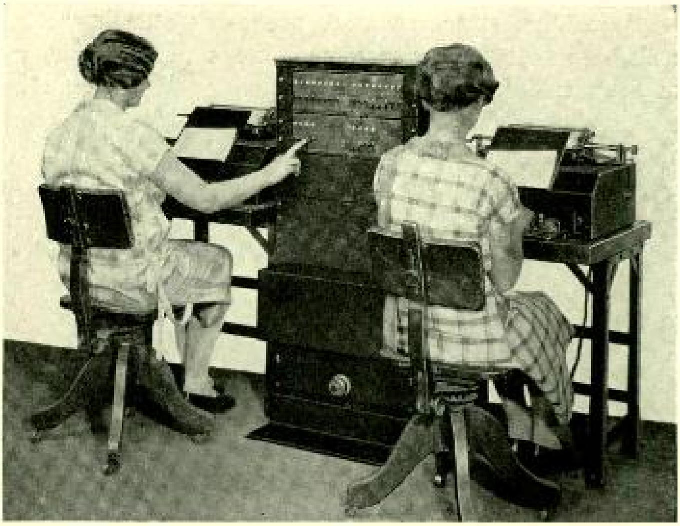


Fig. 2—A broadcasting PBX for printer service with two operators and keys for 24 radial lines

The first requirements were comparatively simple. Means were asked for transmitting simultaneous communications from the headquarters of an organization to some or all of its departments. This method is known in police phraseology as broadcasting. The first standard equipment for the purpose is shown in Figure 2. This is a 24-line radial switching system for one-way transmission from a central point to outlying stations equipped for receiving only. Two operators may be employed to transmit simultaneously to different groups of stations. A second switchboard can also be added to increase the number of outlying terminals. The typewriter at the PBX operates one or more master relays each of which in turn operates a number of sending relays. Each sending relay may be associated with a line by the operation of a key on the switchboard, two of which are provided for every line—one for each operator.

Fig. 1—The number 14 printer writes its message on a narrow strip of paper just visible above the keys

The next step in printer PBX development was made for the police of New York City. Each borough headquarters is equipped with a switchboard for broadcasting both to its own local precincts and to the other borough headquarters. The arrangement at police headquarters in New York City is shown in Figure 3. Two features are incorporated that are not included in the earlier systems. One is an acknowledgement signal. When a key is depressed at one of the precinct offices, where the typewriters are arranged for receiving only, a lamp is lighted at headquarters to indicate the receipt of the message. The other feature makes it possible to broadcast to all stations by the operation of a single key at the switchboard.

A later development provides for intercommunication between outlying stations. This cannot be accomplished merely by connecting the two lines together at the PBX because typewriter operation requires that the line current be held to approximately a constant value. A simple connection of two lines would change their impedance and thus the current flowing, so that the insertion of a single-line repeater is required at the PBX.

An experimental installation in a large industrial concern was found to be satisfactory. With this system the outlying stations are equipped for sending as well as receiving, and the PBX may be called by operating a key at the outlying station which lights a lamp at the PBX. The operator then connects the calling station to any other desired. Broadcasting is also provided for as with the older installations.

After this a switchboard in various sizes was developed which would embody practically all the features required in the past. The first board, a ten line unit, is shown in Figure 4. This switchboard has had a satisfactory trial with a Credit Bureau in Detroit and a number are being manufactured for service.

In a number of these PBX systems, it is very desirable to be able to send a message to a station when no attendant is present. This can be accomplished by providing means at the PBX for starting the motors at the outlying stations. A number of methods are available for doing this; either

Fig. 3—PBX for printing telegraph system in headquarters' office of the Borough of Manhattan

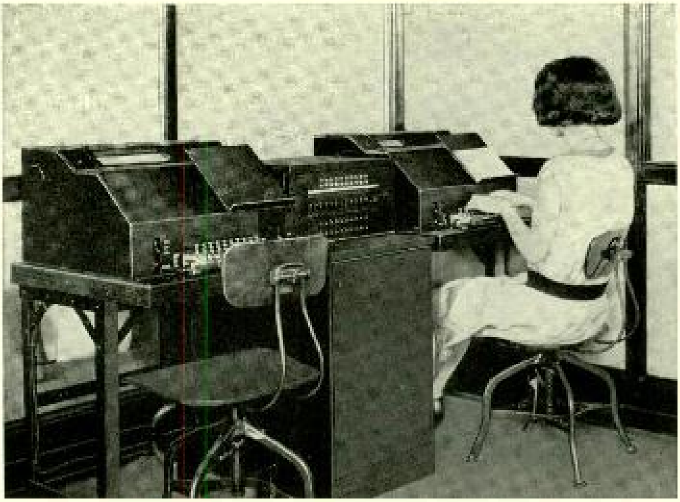


Fig 4—A standard ten line PBX with printers of the page type

the transmitting circuit or a second channel may be used.

There are very likely to be special conditions, however, that cannot be met by a standardized board so that modifications are often required. One such is the state-wide installation for the Pennsylvania State Police. Its extent is shown by the map of Figure 5. Four modified ten line boards in conjunction with a large number of receiving stations are installed in the four administrative sections whose headquarters are at Pittsburgh, Harrisburg, Philadelphia, and Wyoming. Each headquarters' office is equipped to broadcast to all the typewriters in its division. At times it is desirable to be able to broadcast from the general headquarters at Harrisburg to all typewriters, and to make this possible the three other headquarters are tied to Harrisburg with full duplex lines, and the operation of a key at Harrisburg is all that is required. The office at Harrisburg is shown in the headpiece.

Telephone-typewriter PBX systems constitute what is practically a new art. The aim in development work

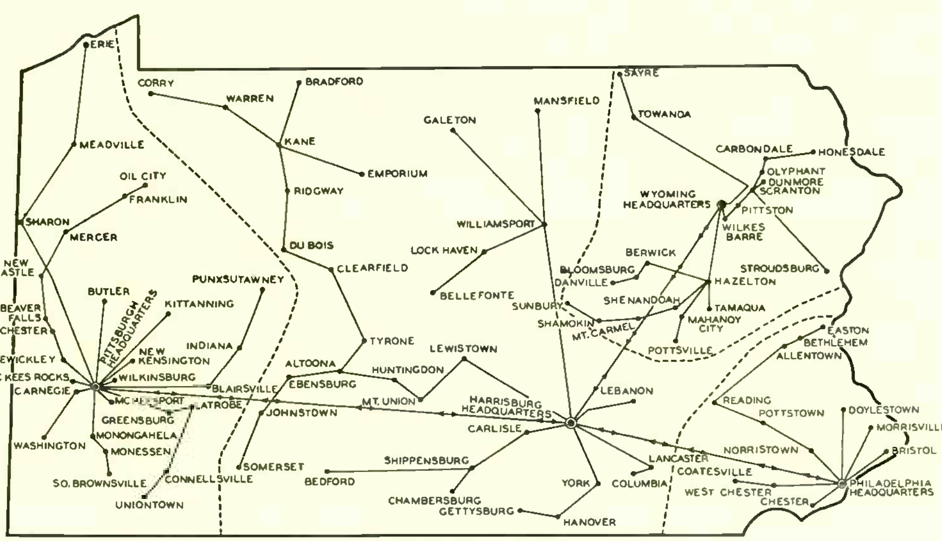
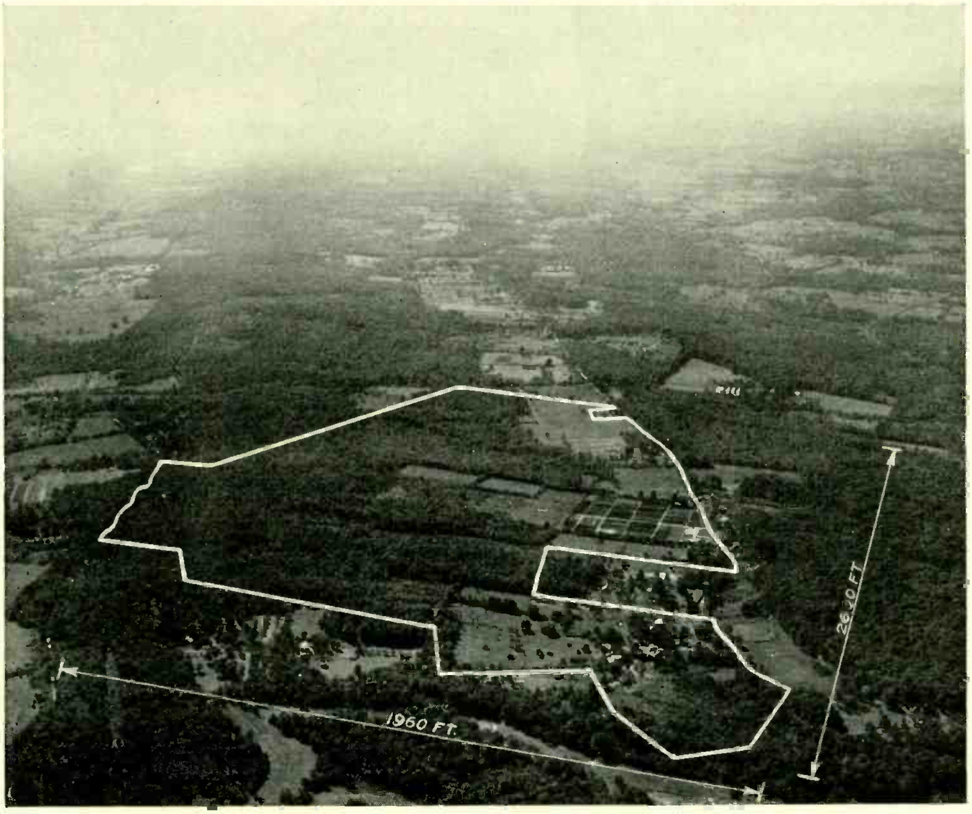


Fig. 5—Map of printer telegraph system of the Pennsylvania State Police

will be to make use of those features which experience in telephone switching has shown to be desirable, and to add others that are peculiar to telegraph. The value placed on the service by those who have it in operation would indicate that the present demand would greatly increase.



An airplane view of the new Bell Laboratories property at Murray Hill, New Jersey

Selector-Connectors for PBX Service

By J. B. DRAPER
Local Systems Development

WHEN private branch exchanges of the step-by-step type have one hundred or more extensions, it is necessary to use three-digit designations for the stations, and both selectors and connectors are required for the completion of a call. The functioning of the apparatus and circuits of these larger PBX's is similar to that of a central office and has already been described in the RECORD.* With fewer extensions, requiring only two-digit designations, it is frequently possible to simplify the system, and economize on the amount of apparatus employed, by using connectors alone. Each extension is connected to one terminal of the connector bank, and is reached by dialing two-digits. The first steps the brush rod up to the proper level, and the second rotates the brush horizontally to the desired terminal.

When even a small PBX, however, has a group of trunks to a central office, or a group of tie lines to another PBX, selector action is required. Movement horizontally around the levels on which trunks or tie lines are located must be automatic, and must cease when an idle trunk or tie line is reached. Under these conditions it has been necessary in the past to use both connectors and selectors even for the small PBX, and as a result the station numbers must contain three digits, which is necessary when both types of switches are employed. To avoid the use of this additional apparatus, a selector-connector has now been developed: a step-by-step switch which on its lower levels acts as a connector and on its upper, as a selector.

As has already been noticed a selector differs from a connector in having its horizontal motion controlled automatically by relays in its circuit which automatically step the brush around to an idle trunk or tie line. When this is found, a simple direct connection is made. The connector,

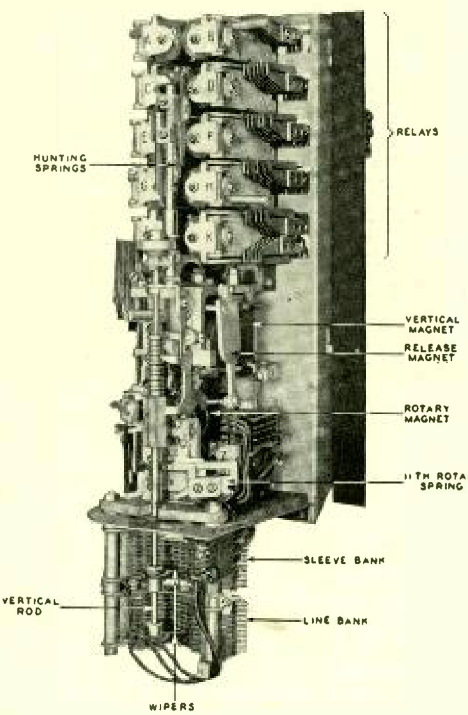


Fig. 1—A selector-connector showing the various operating elements

* *An Outline of Step-by-Step Operation.* BELL LABORATORIES RECORD, *Dec.,* 1929, *p.* 174.

on the other hand, in addition to having the horizontal motion controlled by the dial, includes in its circuit relays that connect talking battery, and

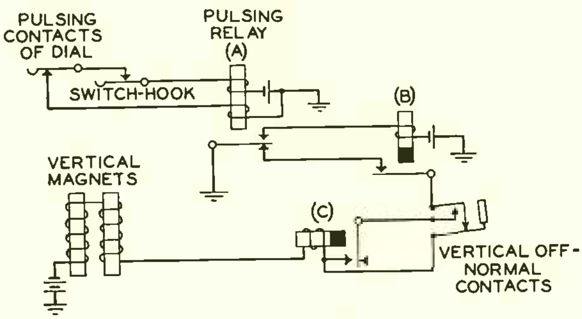


Fig. 2—Essential elements for controlling the up motion of the brush rod

apply and disconnect ringing current. The selector-connector, therefore, must include relays for both types of operation, and in addition an arrangement must be provided for changing from one type of operation to the other at some predetermined level.

This transfer action is accomplished by adjustable hunting springs which are operated when the brush rod has reached the predetermined height. Their position and method of operation may be seen in Figure 1.

Assume, for example, that a certain PBX has sixty-five extensions (numbered 21 to 85), eight trunks to a central office, and six tie lines to another PBX. Selector-connectors could be used for the installation, which on their first eight levels would act as connectors and on their top two, as selectors. Levels one to eight inclusive would be used for calling any of the extensions; level nine could be used for central office calls; and the tenth or zero level, as it is called, for tie-line calls. If a station dialed 53, the switch—acting as a connector—would move up to the fifth level and then, still controlled by the dial, around to the third terminal on that level. If the line were not busy, connection would be made to it and ringing current applied in the regular connector manner.

If 9 were dialed, to obtain a central-office connection, the switch would step up to the ninth level, and in passing from the eighth to the ninth level the hunting springs would operate and convert the switch to a selector. At the ninth level, therefore, the brush would start stepping around automatically till the first idle trunk was found. A tie line on the zero level would be obtained in a similar manner by dialing zero.

The action of a step-by-step switch is controlled chiefly by the dial and by a group of relays mounted at the top of the switch itself. In Figure 2 are shown the relays essential to vertical

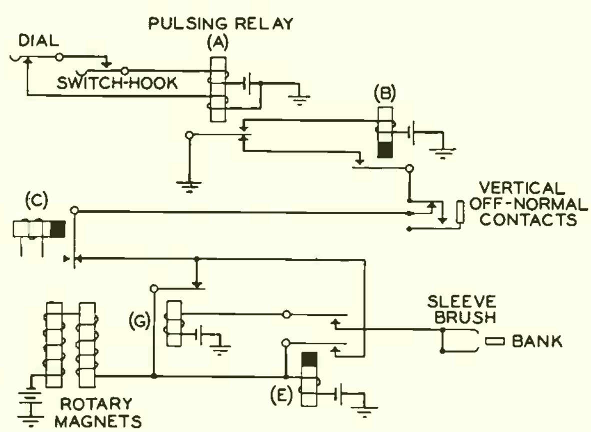


Fig. 3—Rotation of the brushes around the contacts of one level are controlled in a similar manner by the rotary magnet

motion of the brush rod, and the designating letters correspond to the markings on the relays of Figure 1. Relays A and B are in the circuit for all operations; A acts as the pulsing relay to transmit the pulses to the apparatus, and B as a control relay to hold the various switches operated by contacts not shown. A heavy copper band gives the B relay a slow releasing characteristic so that it does not release during the short open-circuit period of the pulse.

Lifting the receiver from the hook closes the switchhook contact and operates successively the A, or pulsing relay, and the B relay. As the dial is released for the first digit, its pulsing contact is opened successively a number of times corresponding to the digit dialed—assumed in this case to be eight or less. Each brief opening of the circuit during pulsing drops the pulsing relay which in turn closes the circuit of the C relay and the vertical magnet, and moves the brush rod up one step. The C relay has slow release characteristics and remains operated during the pulsing.

The pulses pass through the vertical off-normal contact—shown at the right of Figure 2—which is opened as the vertical magnet operates, but the circuit is not broken because the front off-normal contact is shunted by the front contact of relay C and the back contact of the off-normal springs. After the last pulse the A relay remains operated so that C releases and opens the circuit to the vertical magnet.

The next digit dialed acts through A and B in a similar manner but through the back rather than front contact of C, and thus operates the rotary instead of the vertical magnet—as indicated in Figure 3. Each line that is busy has ground on its sleeve terminal in the bank so as the sleeve brush moves around, the G relay operates each time a busy line is reached. Operation of G would open the circuit to the rotary magnet except for a shunted circuit through E, which is also "slow release" and remains operated during the pulsing. When the terminal is reached that corresponds to the number dialed, the circuit of E is opened. If the line is busy, G operates and through contacts not shown, returns a busy signal to the calling subscriber. If the line is not busy G remains unoperated, and ringing and talking battery are applied.

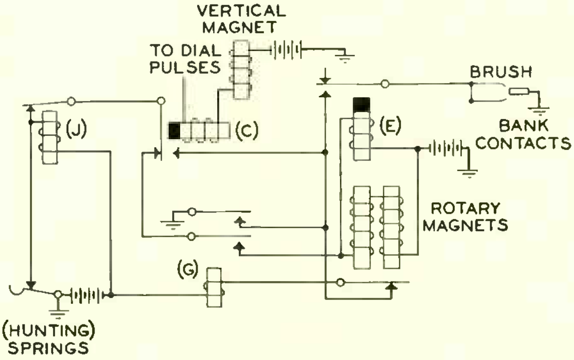


Fig. 4—Circuit arrangement for hunting

When a central-office trunk or a tie line is dialed, the action proceeds as described for Figure 2 until the eighth level is passed. Between the eighth and ninth levels, the hunting springs are operated and in turn operate J, and after pulsing ceases for the first digit, the circuit is as shown in Figure 4. Before C releases, the front contacts of C and J are closed so that ground from the hunting springs is extended through C and J and a contact on the rotary magnet, and operates G which locks under control of the rotary magnet. When C releases, ground from the hunting springs then operates the rotary magnet and E through the contact of G.

A rotary step-by-step motion is now

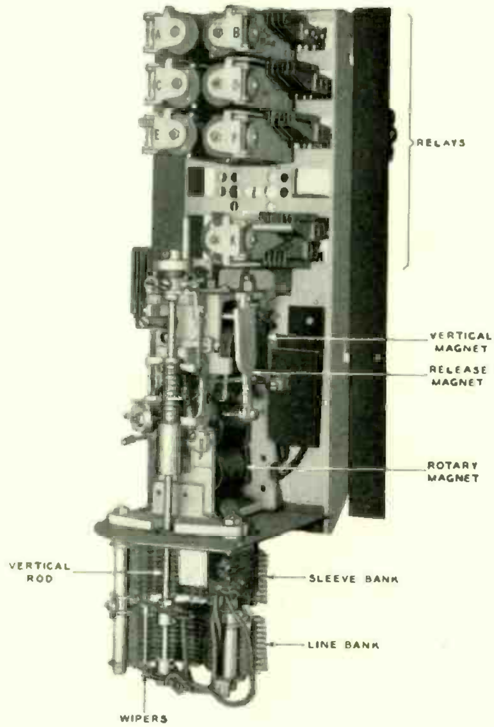


Fig. 5—A step-by-step connector

automatically maintained by the action of G and the rotary magnet and grounds on the hunting springs and sleeve bank, as long as there is ground on the contacts of the sleeve bank. When the springs on the rotary magnet operate, G is released and in turn releases the rotary magnet. The release of the rotary magnet again operates G through the ground from the sleeve-bank contact through E which is slow releasing and does not release during the brief opens. The alternate operation of G and the rotary magnet continues until a trunk is reached that is not busy. This idle condition is indicated by absence of ground on the sleeve lead so that G is not operated after the rotary magnet releases. When this occurs the circuit is cut through and connection is made to the trunk or tie line. Should all trunks be busy, the eleventh rotary spring is operated which returns a busy signal to the calling party.

There are, of course, other relays that act which are not shown on the diagrams, and also other springs and contacts on the relays shown that perform additional functions. Only relays and connections essential to the

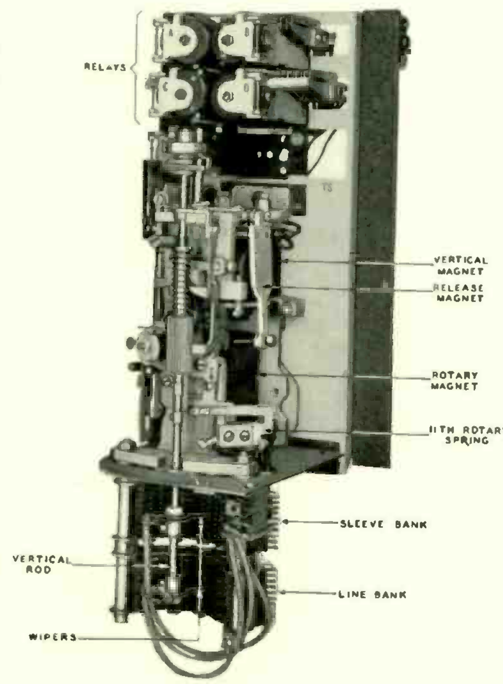
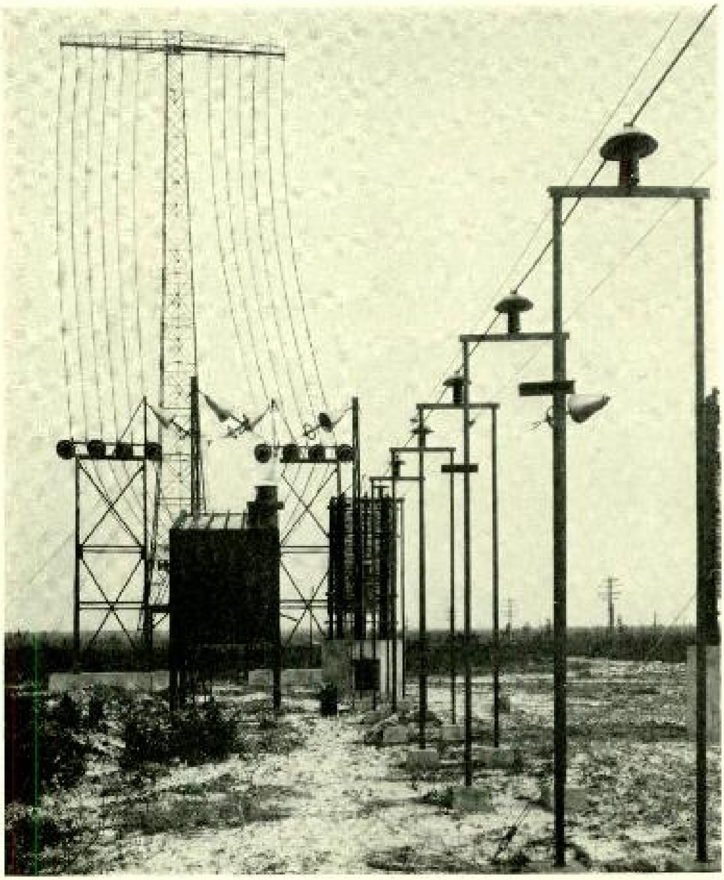


Fig. 6—A step-by-step selector

three main types of operation of the selector-connector are shown.

The effect on the switch itself of this double duty it performs may be gauged by comparing the photograph of the selector-connector with those of a regular connector and selector respectively. A connector, Figure 5, requires seven relays — A, B, C, D, E, F, and K — and has no eleventh-step rotary spring. A selector, Figure 6, has only five relays — A, B, C, D, and E — but requires an eleventh-step rotary spring to act when all trunks are busy. A selector-connector requires the full equipment of ten relays as well as the eleventh-step rotary spring, and also a "hunting" spring to change from connector to selector action.

Although the selector-connector is thus a more expensive switch than either the selector or connector alone, it makes possible less expensive step-by-step operation for the smaller PBX's. It avoids the use of two types of switches and their connecting trunks and thus more fully uses the capacity of the equipment employed as well as making unnecessary the use of three digits for calling stations.



Transmitting antenna of the Bell System's long-wave trans-atlantic radio-telephone transmitter at Rocky Point, Long Island

Economics of the Application of Relays to Telephone Circuits

By W. W. WELLS
Local Systems Development

IN the matter of the selection of relays for telephone circuits, the cost of the individual relay is not great, and its current consumption in service is so small that the saving to be obtained by close calculation for the most suitable design might seem to be almost negligible. The number of relays used, on the other hand, is very large; the relay production of the Western Electric Company in 1929 was upwards of 9,000,000. Because of this enormous production, economic factors are of prime importance, and possible savings — both in the initial and operating cost — reach considerable magnitude.

Due to the almost innumerable circuit conditions under which relays must operate, however, a practical point of view must be maintained. It is obviously impossible to design an ideal relay for each particular condition that may arise. Such a procedure would frequently require the design of a different relay for each application, and would ultimately result in the manufacture of an excessive number of types. The development of new relay structures, therefore, is not frequently advisable. Because of this, the economic application of existing relay structures only will be considered here. The development of new windings and spring arrangements as required will be discussed but not the design of a new structure.

Many relays, as used in telephone circuits, are energized only a very short time and current consumption therefore is so small as to be actually a negligible factor. The resistance, therefore, may be as low as is consistent with keeping within safe temperature limits. Others are energized during an entire conversation and may be in continuous service for from twenty to forty minutes or more during each busy hour of the day. In some instances relays are so connected in a circuit as to be in practically continuous operation twenty-four hours a day, being released occasionally for momentary intervals only.

As the number of relays in a 10,000 line office of the dial type amounts to more than 50,000, a large proportion of them energized for considerable periods, it is evident that the total current drain is a very important factor. Unless care is exercised in the selection of favorable resistances for such relays, not only will the cost of the current consumed be excessive, but the size of batteries required may be appreciably increased, and a costlier plant required than would otherwise be necessary. There would thus be added to the expense of maintaining the office not only the excess current consumption but also the additional cost of the larger battery-plant. In choosing relays for use in telephone circuits, therefore, efficient circuit design requires that proper attention be given to the traffic conditions, so as to determine the most suitable resistance from the standpoint of the current drain, as well as the capability of the relay to handle the load.

This increase in power cost, however, is not the only factor affecting relay economy. The cost of the winding of a relay varies with the size of wire and the number of turns used, and, in view of the large number of relays employed, may definitely affect the question of economic choice. If a relay is in circuit for only a few seconds per busy hour, it is quite probable that the cost of a high resistance winding to save current consumption would more than offset the current saving.

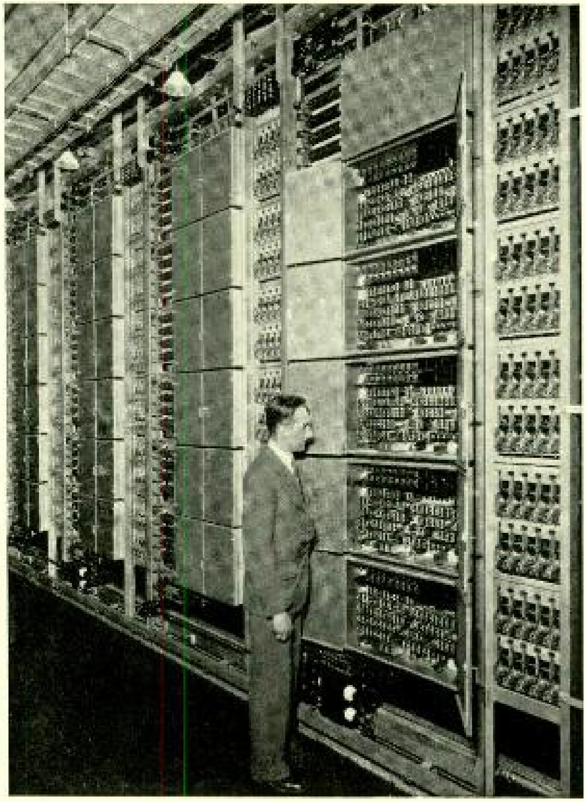


Fig. 1—The large number of relays in a dial office is indicated by this row of sender frames. Behind all of the closed doors are groups of relays like the ones being inspected by W. D. Mischler

The economic balance that must be obtained between the operating and fixed charges on a relay has already been discussed in the RECORD*, but additional conditions may affect the choice of design ultimately made. The necessity for keeping the relay from overheating under normal service conditions, or under trouble conditions in which the relay winding becomes accidentally connected across the battery, imposes some limitation on the design of windings. Each path from battery to ground must, under service conditions, be sufficiently high in resistance to prevent the overheating of the magnet coils, and under trouble conditions the magnet coil must either be high enough in resistance to prevent overheating or sufficiently low to insure the blowing of the circuit fuse. This means that for each type of relay there is a band of resistance values, ranging from a few ohms to several hundred which if adopted would cause the relay to become a hazard in the system. Such windings are therefore not usable though for other reasons they might be the most economical.

Another factor which enters into the choice of a relay is the pressure between contacts. The "B" relay, for example, has a low contact pressure due to its light construction, and it responds to currents of the order of a few tenths of a

* BELL LABORATORIES RECORD, *Feb.*, 1930, *p.* 274.

milliampere. It is not suitable where strong contact pressure is required such as for contacts forming part of the transmission circuit. Because of the relative unstability of its contacts, therefore, the application of the relay is not considered for certain conditions regardless of its advantages even though otherwise its use could be justified on a basis of relay cost.

Another factor affecting economy in design is the speed at which a relay may be required to function. For many conditions it is necessary that a relay operate or release very slowly or very quickly and the service gains to be obtained are of greater importance than relay cost and current consumption, so that a more expensive structure may be warranted. One instance of this is the pulsing relay in dial systems which must respond quickly to the dial pulses. Here, again, the current consumption and relay cost are not factors to be primarily considered; the relay must be designed with resistance and inductance characteristics that will enable it to follow the dial pulses as faithfully as possible over a station loop of established characteristics. The gains to the system are in relative speed and sensitiveness. Occasionally the use of permalloy as the magnetic material provides a more satisfactory release than is obtainable with magnetic iron. The relatively high cost of permalloy is offset, under these conditions, by improved circuit performance and a decrease in maintenance charges.

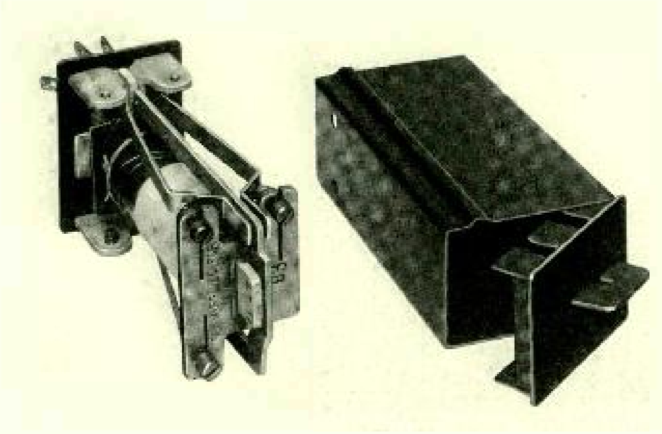


Fig. 2—A light but relatively expensive relay is the "B" type which is used only when great sensitivity is required

Some relays, such as the "B" type already mentioned, are much more sensitive than others; they require less operating current than the "R" type, for instance, which is a heavy-duty relay, and may be used advantageously where only light spring pile-ups are required. On the other hand, the "B" type relay is more costly than the "R," and this added cost can very easily offset the saving due to the smaller operating current. Because of the additional cost of the "B" relay it is never used except where the additional cost is compensated by the service gains due to its greater sensitivity.

An instance of this is the supervisory relay in manual cord circuits. The lower sensitivity of an "R" type would make inter-connection between subscribers impossible over any but the shortest lines. Here the question of economy is not one of current consumption, or wire and relay cost, but of service possibilities. It is obvious that the longer the loop over which a relay will work, other things being equal, the greater is the gain to the system, since a wider area can be served or smaller gauge wire used.

Another feature of design to be kept in mind is the severity of the mechanical and electrical adjustments that must be applied to the relay. Close and severe adjustments increase both the cost of the relay in the factory and its maintenance in service. A point may easily be reached where these costs would be excessive for the service obtained. For some special conditions, however, close adjustments may be warranted. This is true of the No. 231 type polarized relay, for instance, but it has only a comparatively limited application and the service given would generally be unobtainable by other means.

Relays inserted in the transmission line or bridged directly across it, give rise to transmission losses. Certain definite loss values have been established beyond which the relay should not, in general, be allowed to go, and the inductance characteristics of relays so used must also be considered.

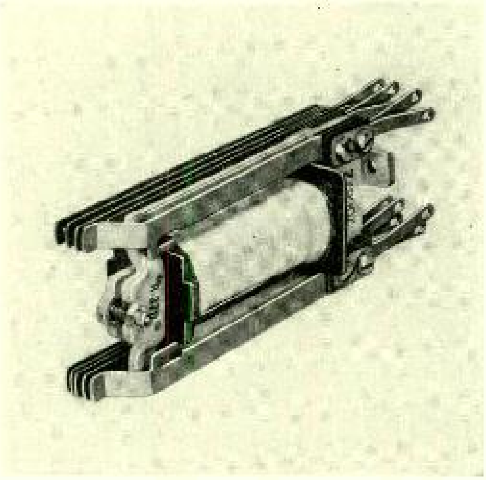


Fig. 3—One of the less expensive relays is the "R." It is employed widely in the Bell System where special requirements do not make its use undesirable

Fig. 4—An early general utility relay that still finds use in the Bell System is the No. 122 type

Under certain conditions a cover must be provided that will avoid voice interference between adjacent circuits. The question of wire and current economics does not enter to any great extent into cases of this kind as service factors are controlling.

It must be borne in mind, however, that, although it is always desirable to have the most capable relay to meet a given condition, it would not be economical to design a new winding for every condition and a new design is not developed, therefore, unless the probable demand is extensive enough to justify the cost of its development and introduction into the system. The question of coding a new relay of a standard type—with a coil, springs, or adjustments different from any existing relay—is an important item to be considered because of the expense in placing and maintaining such information in the shop and field. It is necessary, therefore, in the selection of a relay for a new circuit to compare the expense of a new code with the additional cost of using an existing relay which does not most economically fit the circuit from a design standpoint. If the annual charge due to the use of a relay not most economically suitable to the circuit is less than that due to the cost of a new code, it would, in general, be sounder policy to specify the existing relay. In fact, there should be a substantial yearly demand expected for the new relay before establishing a new code.

The history of relay development is, in a sense, one of development economics. The original general utility relay capable of carrying a considerable load was the No. 122 which gave satisfactory service for a number of years. As the telephone art developed, however, the need became imperative for a more economical relay: one more economical in first cost, in current consumption, in capability, in load possibilities, and in mounting space. The result of this need was the design and development of the A, E, and R types in the order named.

The manufacture of these relays is essentially a punch-press operation and they are therefore more cheaply produced than the No. 122 type, various parts of which are machine formed. Owing to their structure they are capable also of carrying more springs and thus permitting more circuit switching per relay. They also can be mounted on from ¾″ to 1⅛″ centers, depending on the number of springs and windings, which is more favorable than the 1¾″ required for the No. 122 type.

It is evident from this brief review that the design and selection of relays for telephone circuits is playing and will continue to play an important part in the economic operation of the telephone system.

Electrical Delay Circuits for Radio Telephony

By R. T. HOLCOMB
Telephone Apparatus Development

On the transatlantic radio telephone circuits elaborate echo and singing suppressing equipment is required which has already been described in the RECORD.* A short circuit is normally maintained across the outgoing channel which is removed by voice operated relays at the beginning of outgoing conversation. Although these relays are sensitive and fast operating, they would not always remove the short circuit in time to pass the very first part of the initial speech signal if delay circuits were not inserted between the point of connection of the voice-operated relays and the point of the short circuit.

Delay of alternating currents is usually measured in degrees. A single complete cycle occurs in 360 degrees and the time required for a cycle is the reciprocal of the frequency. Thus the time for a cycle of 60-cycle current is 1/60 of a second and for a 1000-cycle current, 1/1000 of a second. The delay measured in degrees is called phase shift and if there is to be the same delay in seconds for all frequencies the phase shift should thus be made proportional to the frequency.

For the first delay circuits used with the transatlantic radio telephone, this condition was approximated by employing a low pass filter with a cut-off point well above the highest frequency to be transmitted. The phase shift characteristic of such a network, together with one of the component sections, is shown in Figure 1. Along its low-frequency end the curve is straight, the phase shift varying directly with frequency, but the deviation from linearity rapidly increases with rise in frequency. Although the maximum phase shift is 180° per section, less than half of this can be used

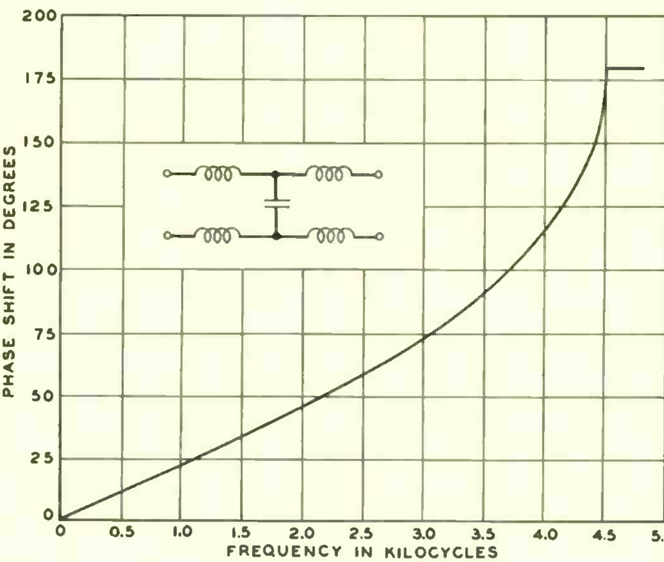


Fig. 1—A single section of the delay circuit used for the first transatlantic installation together with its phase-shift characteristic

*BELL LABORATORIES RECORD, *Nov.*, 1927, *p.* 80.

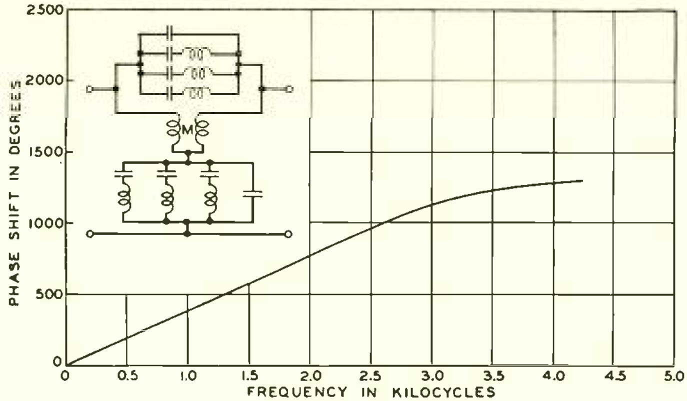


Fig. 2—A section of the new delay network is much more complex but produces a greater phase shift with less deviation from linearity in the relation between phase shift and frequency

hundredths of a second is large. A non-loaded line of No. 8 BWG wire would have to be 3500 miles long to produce it.

In seeking possible types for the new delay circuits, acoustical equipment was considered and tried out. In its present state of development, however, it does not offer the dependability of operation that can be readily obtained with an electrical circuit.

if the deviation from linearity is to be kept within moderate limits.

With the growth of the transatlantic traffic since 1927, the performance of the original delay networks, although fairly satisfactory, has shown that improved networks would be desirable which would have less distortion and which would occupy less space as well as being less costly to manufacture. It also seemed desirable to provide enclosing covers to give protection to the terminals, which had not been arranged for with the original networks.

The amount of delay desired is about two hundredths of a second, and although almost any electrical circuit will produce a delay of some sort, the attainment of adequate delay sufficiently constant for all frequencies requires a very carefully designed network. The amount of circuit required to give a delay of two

An investigation of the various electrical networks available resulted in a selection of the circuit shown in Figure 2, which also shows the phase-shift characteristic of a single section. For this more complex section the maximum phase shift is 1440° and because the curve is straight over a greater range of frequency, it is possible to use 75% of the maximum value and still have only 5% variation between the maximum and minimum delay over the range of frequencies employed. For the same deviation only 20% of the maximum delay of the earlier type could be employed.

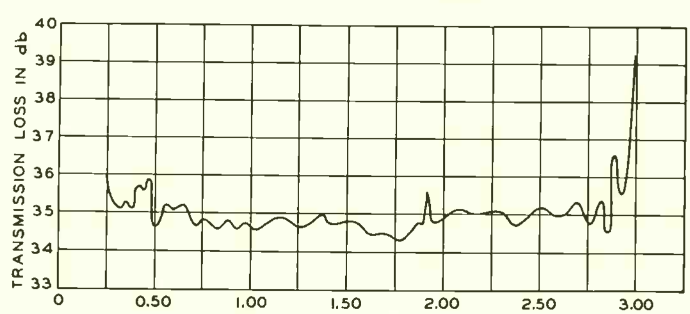


Fig. 3—Overall transmission characteristic of the new transmitting delay circuit and equalizer together

Besides shifting the phase of the currents passing through them, these delay networks also produce an attenuation which varies with frequency. Since for satisfactory transmission any attenuation introduced should be the same for all frequencies, it is necessary to use equalizers which have attenuation characteristics complementary to those of the delay networks. The overall attenuation of the new delay network and equalizer is substantially constant with frequency as shown by the curve of Figure 3.

The extent to which the old and new delay circuits maintain a constant delay over the operating frequency range is shown in Figure 4. The delay referred to in this illustration is the slope of the phase-shift frequency curve, which gives the delay when steady state conditions do not exist. From these curves it is seen that while the maximum variation for the old curve was nearly 25% over the operating range of from 250 to 2800 cycles, that for the new circuit is only about 5%. The variation in delay with frequency is quite different for the two circuits. The older has a characteristic that rises from a maximum deviation in one direction at the lower frequency limit to a maximum in the other direction for the higher limit. It crosses the axis of zero deviation but once. The deviation for the new circuit, on the other hand, crosses the axis of zero deviation eight times and never rises more than 2.5% in either direction.

On the mechanical side—the reduction in size and the changed appearance—the new delay circuit differs perhaps even more markedly from the earlier one. Nine sections of the earlier network were mounted on a single relay-rack panel seven by nineteen inches—five sections on one side and four on the other. Sixteen of these panels held the transmitting delay circuit and five the receiving.

As described in the article already referred to, reflection occurred at the

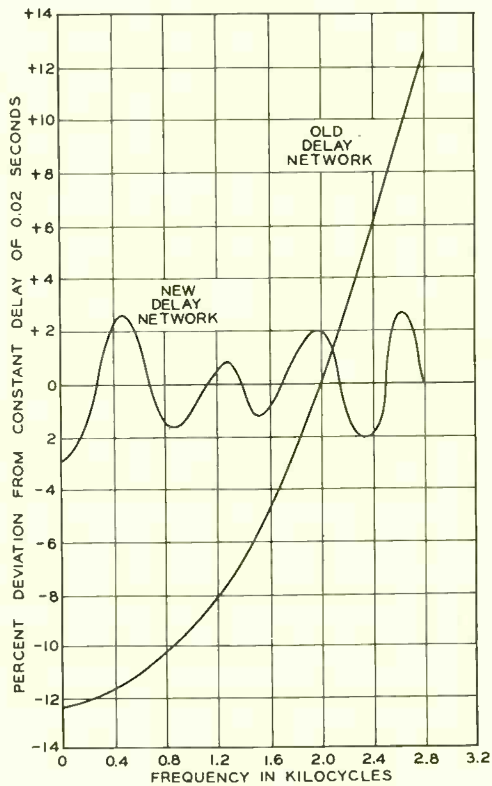


Fig. 4—Comparison of the constancy of delay with frequency for the old and new delay networks

remote end of the circuit so that the voice current travelled over the delay circuit twice: once out to the end where it was reflected, and then back. By this means the delay obtained was double what it would have been had reflection not been employed. Certain distortion is introduced, however, by this method of operation which it seemed desirable to avoid. For this reason the new delay networks are made to operate on a straightforward

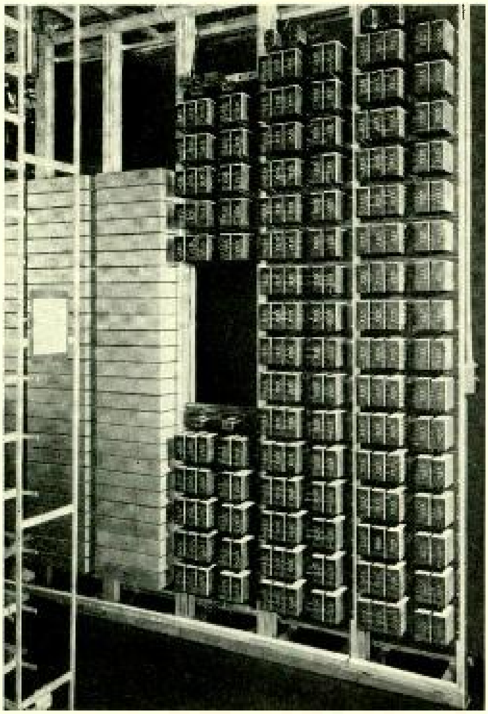


Fig. 5—Forty-two panels of the old circuit, with black finish, give the same delay with straightforward operation as 24 panels of the new, shown in the adjacent bay in light finish

or non-reflection basis. In Figure 5 are shown two of the old circuits, consisting of 42 panels on three bays. If reflection had not been used with the old circuit, the entire 42 panels would have been required for the desired delay. Mounted beside them is one of the new circuits, which requires less than a single bay, so that this figure illustrates the relative effectiveness of the two circuits. Each section of the new circuit is mounted on the two sides of a panel three and a half by nineteen inches. This panel is arranged for covers on both sides. Twenty of these panels are required for the transmitting and four for the receiving circuit. The transmission equalizers provided for each delay circuit are mounted on panels of the same size and equipped with similar covers. Compared on the basis of straightforward, or non-reflection, operation this new circuit is a marked improvement. Only 11.1 square feet of relay rack space is required against 38.7 for the old, and the corresponding total weights are 552 lbs. against 3230. Also in cost, the new delay network makes a favorable showing. On the basis of regular production in the shops of the Western Electric Company, the new circuit costs about one quarter as much as the old.

In addition to an improved design, which gives a better performance with only about half the number of elements, many other factors—better and cheaper coils and the improved paper condensers—have contributed to the recent accomplishment. With their enclosing covers finished in aluminum varnish the new delay circuit makes a very favorable appearance which is well brought out by Figure 6 showing the new delay circuits for six transoceanic channels.

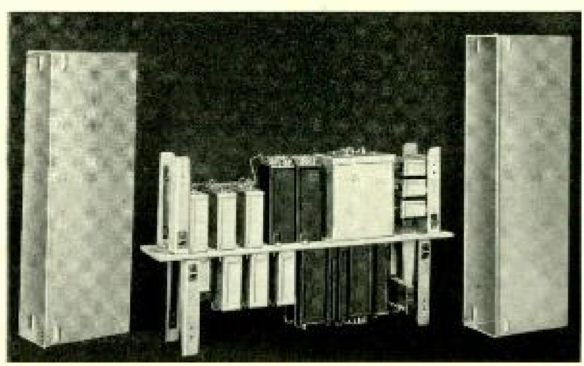


Fig. 6—Each section for the new circuit is mounted on a separate relay rack panel. For manufacturing reasons some of the condenser units are built up of more than one condenser

Circuit Equipment for Program Transmission

By R. A. LECONTE
Toll Systems Development

WITH the development of radio broadcasting, there arose a demand for facilities to link together several broadcasting stations by wire networks so that the same program could be broadcast simultaneously from widely spaced centers. As a result, certain long-line circuits of the American Company have been made available for this service and are known as program networks. Six open-wire systems are in use at present and over more than 30,000 circuit miles link upward of 150 stations together. Cable circuits are also being added to the existing open-wire chains, thus putting the long-lines facilities of the Bell System still more fully at the disposal of national broadcasters.

Technical problems encountered in designing repeater equipment and loading for program circuits are similar in general nature to those met in designing channels for ordinary telephone purposes. For each of these types of facilities the circuit of course must be designed so that an electrical impulse impressed at one end will be reproduced sufficiently well at the other to serve the purpose of the circuit. When the signal is considered as composed of sine waves of various frequencies and amplitudes, the requirements for ideally faithful transmission may be stated as follows. First, the component waves must be of the same magnitude relative to each other at the receiving as at the sending end. The overall attenuation, in other words, must be independent of frequency. Second, the components must be in the same time relationship at both ends: that is, the speed of travel over the circuit must be the same for all frequencies. Finally, only the components present at the sending end should be found at the receiving end. This means that the transmitting system should be free from outside interference, and that it should not give rise to new components—

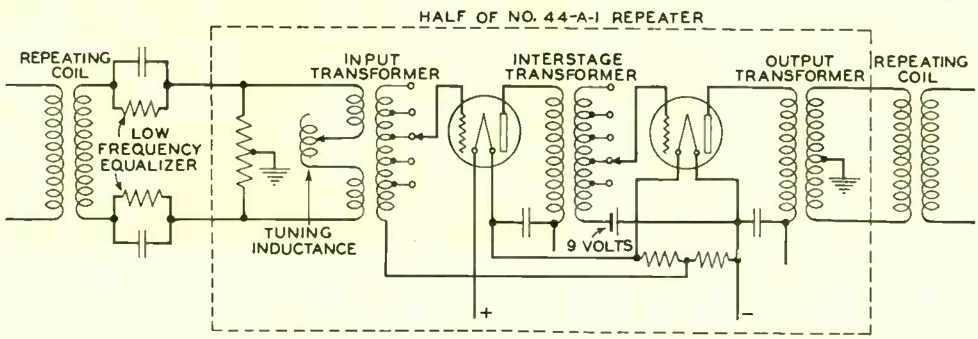


Fig. 1—Repeater and associated apparatus for program transmission on open-wire circuits

either harmonics or combinations of the original frequencies.

It is, of course, not possible nor necessary to provide ideally faithful transmission for either telephone or program circuits. For the former type of facility the object is to convey a spoken message which may be interpreted clearly and easily and with a reasonable amount of naturalness. For this purpose it has been found satisfactory to transmit a band of frequencies of about 2500 cycles, this band being from about 250 cycles to 2750 cycles for present standard designs.

For program transmission, on the other hand, more is required of the circuit than for message transmission for here naturalness is considerably more important and it is necessary to transmit a wider band of frequencies: first, for the reason that increased naturalness requires the wider band and second, that the energy of musical instruments is not as likely to be habitually restricted to a given part of the possible frequency range as is that of speech. In listening to transmitted music one wants to receive the same impression that comes from listening directly to the music. It is desirable to recognize the various musical instruments with their different tone qualities, caused by the overtone combinations which accompany the fundamental notes. Even when the program is speech, more than intelligibility is wanted, since it is desirable to transmit the speaker's personality, as conveyed by the intonation and warmth of his voice.

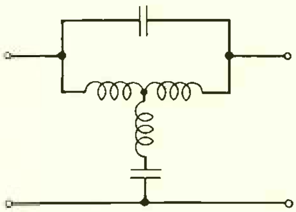


Fig. 2—A delay equalizer network for B-22 cable circuits

For program circuits which make use of open wire conductors, this wider frequency band is obtained by providing the necessary amount of equalization for the wire line and making use of repeaters and associated equipment normally used for message circuits but modified to transmit the wider band for program use. Open wire circuits, now almost universally operated on a non-loaded basis, have inherently such transmission characteristics that by means of a small amount of attenuation equalization they may be made to transmit uniformly a fairly wide band of frequencies. Phase distortion has been found to be serious only for the longer circuits and is introduced chiefly by the repeaters and other equipment in the circuit. This effect has been reduced to a tolerable degree in the latest type of open wire program equipment by changes in design rather than by the use of phase correctors, as discussed below in the case of cable circuits. Modulation effects are likewise not experienced for the wire lines themselves, but are of course, present to a small degree in the loaded entrance and intermediate cables and equipment.

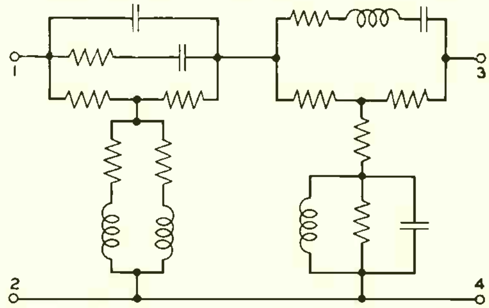


Fig. 3—Attenuation equalizer for B-22 cable circuits used for program transmission

The four-wire repeater, consisting of two independent one-way amplifiers mounted on the same panel, can readily amplify a band sufficiently wide for program transmission. It is normally provided with a tuning arrangement of the input transformer so that its frequency-gain characteristic can be adapted to the frequency-loss characteristics of the various circuits with which the repeater is used. An adjustment of this tuning was made which increased the gain of the repeater at frequencies above a thousand cycles in correspondence with the increase in line loss. Below a thousand cycles the gain of the repeater more than compensates for the line loss so that to meet the requirement of equal overall gain for the entire transmitted band, additional loss was required for the lower frequencies. This was obtained by inserting a network in series with the repeater, which consists of a condenser shunted by a resistance. Figure 1, a schematic circuit of the repeater and associated apparatus for open-wire program circuits, shows this low frequency equalizer connected on the receiving end of the wire section.

As the cable networks became rapidly extended, their greater reliability made it desirable to use them also for the transmission of programs. Although the open wire circuits are readily adapted to this special use, cable circuits require more fundamental modification to make them suitable for the transmission of wide frequency bands. Cable pairs used for long distance telephony are loaded to reduce their attenuation by the insertion of inductance coils at regular intervals. This loading makes the transmission characteristic of the cable circuit somewhat similar to that of a low-pass filter, so that when a frequency approaching the nominal cut-off value is transmitted, its attenuation becomes very great. This cut-off point for the highest quality cable circuits used for message transmission, which employ H-44 loading (44 millihenry coils inserted every 6000 feet), is about 5500 cycles, and it is not practicable to equalize such circuits over long distance to transmit frequencies much above 4500 cycles. Since this frequency limit was not considered high enough for the expected future requirements of program transmission, the B-22 loading system was developed which uses 22-millihenry coils inserted every 3000 feet. This halving of the inductance, and of the capacitance of the cable between loading points, results in a doubling of the nominal cut-off frequency which becomes 11000 cycles and permits equalization for frequencies up to 8000 cycles.

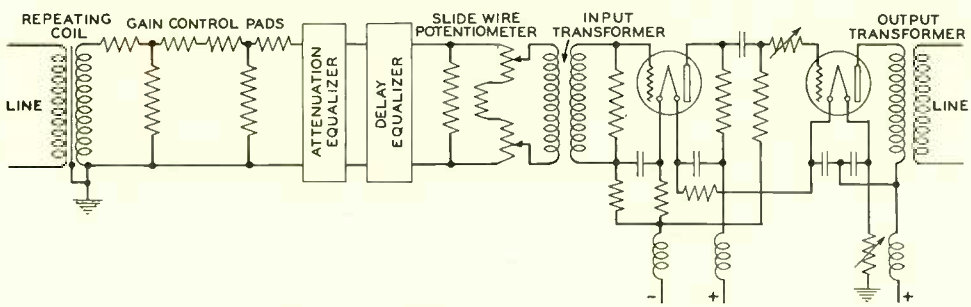


Fig. 4—Non-regulating repeater and associated apparatus for B-22 cable circuits used for program transmission

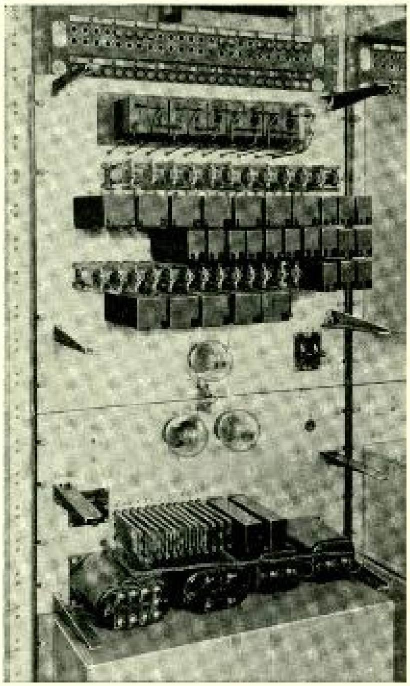


Fig. 5—Regulating network and repeater for B-22 cable circuits

The transmission of a wide frequency band over cable circuits is also affected by the speed of transmission, which is considerably lower for loaded cable circuits than for open wire. Were the speed the same for all frequencies no troubles would arise, but unfortunately the higher frequencies are delayed more than the lower, and over long distances the differences can be detected by the listener. The high frequencies, which arrive last, also remain after the lower frequencies have died out and give rise to a transient effect which at times may be seriously damaging to the quality of the program.

It is necessary, therefore, to introduce correction, not only to compensate for attenuation distortion but for the unequal speeds of propagation as well. To accomplish this, a phase corrector is associated with the repeater, which introduces a greater delay at the lower frequencies. Figure 2 shows the nature of the network employed. Component frequencies transmitted over the line and network together are delayed the same amount to within a few milliseconds for a 2000 mile circuit.

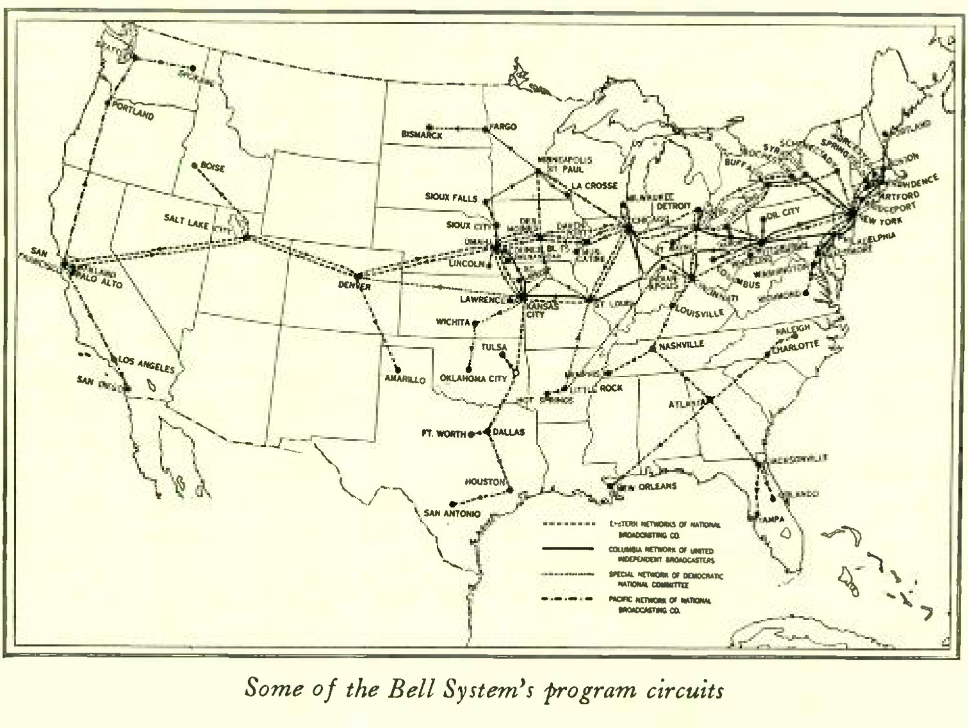
Because of the greater attenuation of cable circuits, repeaters must be used at much closer intervals than for open wire circuits, and are located about every fifty miles. There are a greater number of repeaters, therefore, and equalization of each repeater must be made with greater accuracy. Instead of attempting to shape the repeater characteristics to compensate for the line attenuation-distortion, the repeater is designed to give a constant gain over the desired frequency range, and a special equalizing network is associated with the input of the repeater, to equalize the line characteristic. This network is shown in Figure 3, and the repeater circuit in simplified form, in Figure 4.

As may be seen from this diagram, the repeater itself introduces both shunt inductances, in the form of transformers, and series capacitances, which decrease the speed of propagation for the low frequencies more than for the high. Fortunately the ear is less sensitive to low-frequency delays than to high and perfect equalization does not appear necessary. There is a maximum value of delay which may not be tolerated, however, and a delay for each repeater of not more than one millisecond at fifty cycles has been found unobjectionable. This low delay is obtained by the use of a repeater circuit of high grade coils with permalloy cores and high inductance values. In addition the series capacitances are made large in comparison to the impedance of the circuit in which they are inserted, and a pure resistance coupling is employed between the two stages, which avoids the additional shunt inductance which would be present were the plate of the first tube fed through a retardation coil.

Because of the high attenuation of cable circuits, the variation of attenuation with temperature is considerable, and occurs at a rapid rate which requires automatic correction. The method employed has already been described in the RECORD.* When such regulation was considered for program transmission it was found that the wide frequency band transmitted introduced a peculiar attenuation problem. For frequencies up to about 5000 cycles an increase in temperature caused an increase in attenuation due to the increase in the resistance of the line. Above 5000 cycles, however, the effect was reversed. An increase in temperature caused a decrease in leakage conductance which became predominating at the higher frequencies. Such a reversal of effect, of course, greatly complicates the problem of equalization since the gain of the repeater must be varied in opposite directions in different parts of the transmitted band.

To obtain suitable equalization a network is attached to the ordinary repeater at regulating points as shown in Figure 5. Here the repeater is shown surmounted by the regulating network which includes an additional tube and, inserted as an interstage coupling, a shunt-type potentiometer together with variable resonant shunts.

* BELL LABORATORIES RECORD, *Jan.*, 1929, *p.* 183.



Some of the Bell System's program circuits

Step-by-Step Pulse Repeater

By P. T. SLATTERY
Local Systems Development

THE length of loop over which dial pulses will operate step-by-step equipment is limited. In a community of a size requiring only a single central office the loop lengths are not ordinarily too great, but when two or more offices are required the operating paths over which the pulses must travel are considerably increased. Under these conditions it becomes necessary to provide some means of relaying the dial pulses at the originating office. This requirement is met by the use of apparatus capable of receiving pulses from the subscriber's dial and sending out new ones which will successfully operate the switches in the distant office. Such a piece of apparatus is known as a pulse repeater.

In completing calls in multi-office areas, however, conditions are met which allow additional valuable features to be incorporated in the pulse repeater. It is to meet these conditions that the present pulse repeater has been designed. It performs three functions.

The first is the primary one of increasing the subscriber's dialing range by repeating the pulses.

The second function, of considerable economic value, reduces the number of conductors required between offices. Lines to subscribers have only two wires, used for both dialing and talking. Within a central office, however, a third wire — known as the release wire — is used to hold the various switches operated for the duration of the call. In multi-office areas this third wire would have to be run between offices if a method had not been incorporated in the pulse repeater which made it unnecessary.

The third function is to obtain certain supervisory features by the use of additional relays. Just what these relays accomplish need not be considered in detail here but their manner of operation will be briefly discussed later.

The operation of the dialing feature of the pulse repeater may be followed from the simplified diagram shown as Figure 1, on which the main pulsing

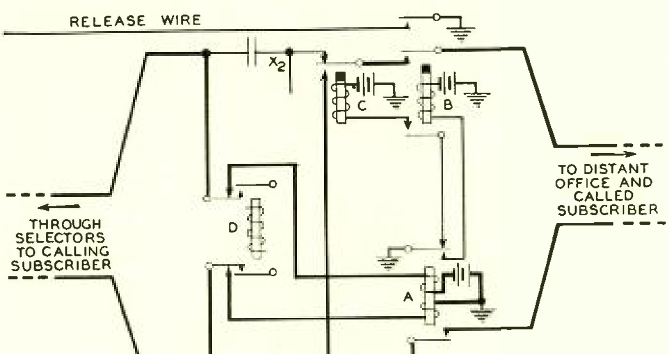


Fig. 1—Diagram showing operation of the pulse repeater during dialing

circuit is drawn in heavy lines. The supervisory relays referred to are D, only partly shown in the illustration, and two others connected between X_1 and X_2. At the calling subscriber's end, the line is shorted through the dialing contacts which open and close the circuit to cause the pulses. Battery and ground are supplied through the windings of relay "A" which follows the dial pulses and sends on a new set of pulses through the opening and closing of its lower contacts. Relay "A" operates when the calling subscriber seizes the repeater in the process of completing a call, and through one of its contacts operates relay "B." This relay is designed to be slow releasing so that it will remain operated during the dialing which, of course, rapidly opens and closes the contacts of "A."

Relay "C," also of the slow release type, is operated through the bottom contacts of "B"—which remains closed all the time the call is in progress—and, in series with it, the top contact of the "A" relay. It is operated, therefore, at the first opening of the subscriber's dial, which momentarily de-energizes "A" and allows its top contacts to close. On account of its slow-release characteristic, "C" remains operated during the dialing of each digit but opens during the longer period between digits when "A" is operated. Its function is to close the path of the outgoing dialing circuit, bringing about a condition in the outgoing circuit corresponding to the conditions existing at the subscriber's station during dialing; that is the outgoing line is short-circuited and the bottom contacts of the "A" relay take the place of the impulse contacts of the dial. Without this arrangement the outgoing pulsing current would have to pass through the impedance of the circuits connected between X_1 and X_2.

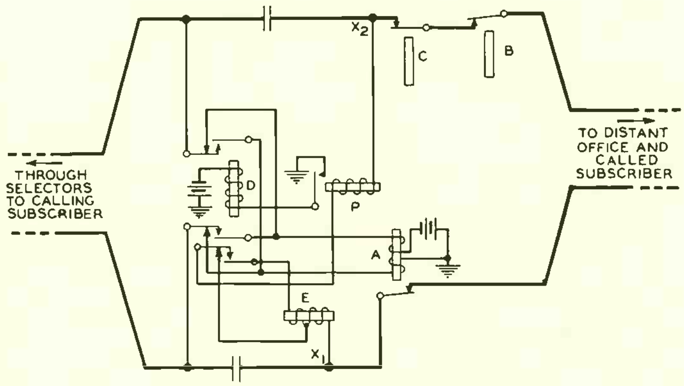


Fig. 2—Diagram showing connections of the pulsing circuit after dialing has ceased

The operation of "B" also grounds the release wire and so holds the selectors between the pulse repeater and the subscriber operated. When the calling subscriber hangs up, thereby opening the line at the calling end, "B" releases—as a result of the release of "A"—and removes the ground from the release wire, thereby allowing the selectors in the calling office to release. Another contact of "B" opens the circuit to the distant office which releases all the operated equipment there.

A schematic of the supervisory features of the pulse repeater is shown in Figure 2. In this figure the talking path is drawn in heavy lines and the supervisory circuits in light lines. Ringing of the called subscriber is done by the connector in the distant office after the proper number of digits has been dialed. When the subscriber answers, the connector in the distant office also reverses the current on the line back to the calling office, and this current reversal operates the polarized relay "P." The operation of "P" actuates "D" which in turn reverses the current to the calling subscriber's line. This is necessary for metering if the calling subscriber is receiving service on a message-rate basis, and for supervisory purposes if the call originates at an operator's position. The operation of relay "D" also removes the short circuit from the number 2 winding of coil "E," cutting additional impedance into the circuit to improve the transmission.

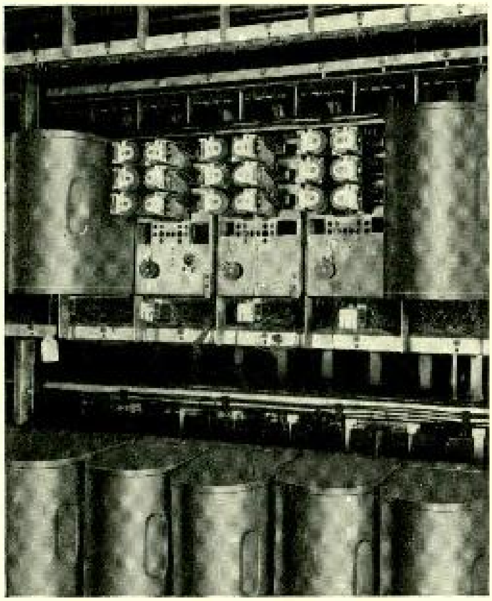


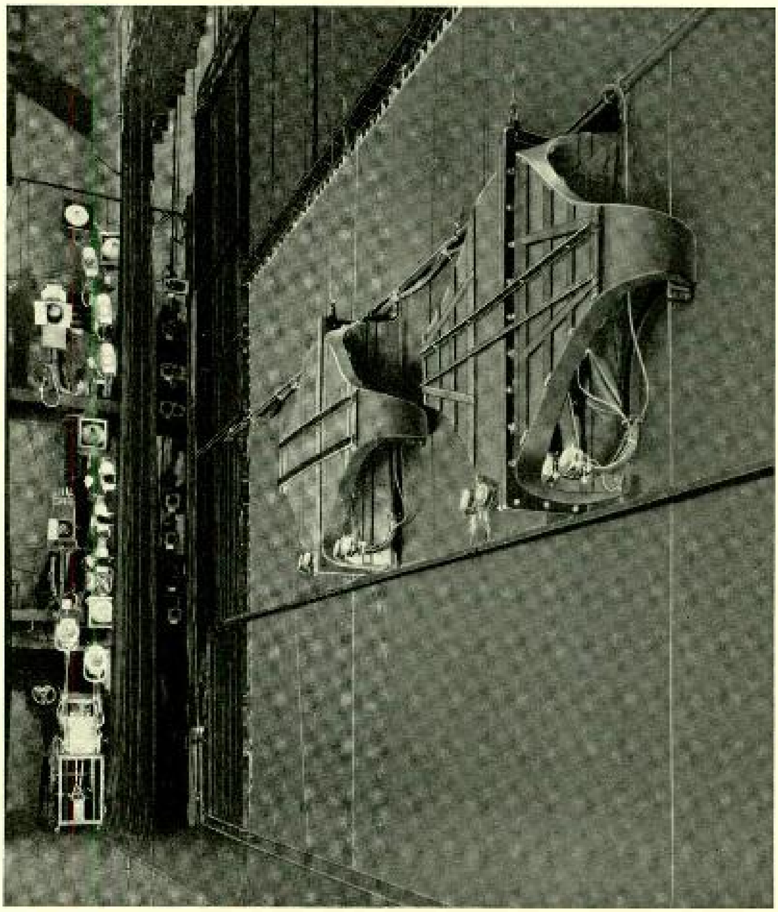
Fig. 3—Standard impulse repeater with electrically polarized relay

Not only would it be impossible, without pulse repeaters, to operate selectors and connectors over the long inter-office trunks in multi-office areas, but the talking current, if fed from only one office, would be too weak for satisfactory transmission. The impulse repeater, therefore, in addition to its other functions, serves to divide up the talking current— allowing each office through which the call is passed to furnish part of it. Relay "A" feeds battery to the originating office and the calling subscriber while the current for the distant office and the called subscriber comes from the battery at the distant office. The condensers, shown in both the illustrations, prevent the steady battery current from passing between offices but readily pass the voice currents.

The simple impulse repeater described above is capable of operating over 1200 ohms of loop resistance which is the equivalent of approximately fourteen miles of standard nineteen gauge cable and so is suitable for most requirements. Many special repeaters are made, however, to meet special conditions. One of these is the pulse-correcting repeater* which receives distorted pulses and sends on new corrected pulses.

The ever increasing distances between offices require the development of repeaters which are sensitive enough to follow the weak pulses received over long loops but still rugged enough to withstand the rigors of constant operation, and stable enough to prevent false operation by unavoidable line surges encountered in the process of completing calls.

* Bell Laboratories Record, *May*, 1929, *p.* 361.



A Shallow Horn for Theatre Use

By H. B. ELY
Transmission Instruments Engineering

BECAUSE of their greater efficiency compared to direct radiators, loud speakers used for Western Electric sound-picture systems have been of the horn type. After considerable experimental work the horn shown in Figure 1, known as the 15-A, was finally adopted. The sound field of this horn for satisfactory reproduction is approximately 15° on each side of the axis so that a single horn is suitable only for a long narrow auditorium. For wider auditoriums it is necessary to use two or more horns, properly flared, that is, pointed towards the sides of the auditorium; and this increases still further the depth occupied.

While the 15-A horn is satisfactory and economical for use in the majority of theatres, there are some cases where limited space would make its employment difficult. In many theatres, the space between the screen and the back wall of the stage is not sufficient to accommodate this horn, which has a depth of 52 inches. Sometimes the screen is painted on the rear wall itself. Evidently a shallower horn would in many such cases, avoid or

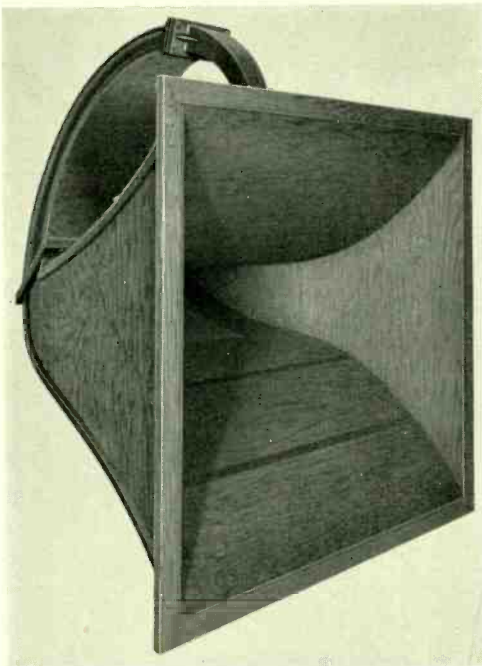


Fig. 1—The 15-A horn is of the logarithmic type with a mouth 52 inches square

minimize structural changes, such as recessing the rear wall or moving the screen forward and possibly encroaching on the seating space.

Another limitation is sometimes presented by houses where stage shows or vaudeville are given, as well as pictures, and it is desired to hang a back drop close behind the screen. Such a situation existed at the Roxy, one of Broadway's largest theatres. The space between the screen and the nearest scenic drop behind was too small to accommodate the 52-inch horn.

A horn designed for these special cases should not only be shallow, but should also have a relatively wide angle of sound distribution, so that it can generally be used flat against the screen.

It was essential, of course, that while obtaining wider distribution and a horn depth under thirty inches, the performance characteristics should be as good as for the 15-A horn. A good response characteristic for the entire band of frequencies requires a fixed rate of taper from the small end to the mouth, and a certain minimum mouth area. Also any bends in the horn must have a radius of curvature large compared to the width of the sound passage along the radius of curvature. The wide sound passage of the 15-A horn makes it necessary to start the bend some distance back from the mouth and is thus largely responsible for the 52-inch depth.

The new horn, shown diagrammatically in Figure 2 and in actual photograph in Figure 3, attains its small depth of 26 inches by two major design features. While maintaining the same mouth area possessed by the 15-A, the opening of the new horn, which is known as the 16 type, is made oblong — 44 by 60 inches — and the air column is divided into two equal branches a short distance back of the mouth. As a result, the divided air columns are much narrower and may thus be curved around shorter radii.

The two halves of the horns are curved in opposite directions around a 90° bend starting 14 inches back from the mouth, and then, after running straight for a short distance, make a 180° bend back on themselves, and then another 180° bend at right angles as shown in Figure 3. The rate of taper for each half remains the same as in the 15-A air column but the cross-sectional areas at equal distances from the mouth are only half as large. These smaller areas permit the sharper bends without detriment.

Experimental models of the new 16 type horn were made of wood, fabric, and metal, and each was found to have practically the same performance characteristics. For practical reasons 1/16 inch sheet steel was used for the final form and all seams are welded to prevent rattling. Each throat section may be arranged for either one or two receivers of the 555 type. When two are used, as shown in the illustrations, the 36-inch single receiver section is replaced by a bifurcated section only 23 inches long. Here, too, halving the areas of the sound passages permits shorter length with the same taper.

At low frequencies, where the wave length of sound is comparable to the dimensions of the mouth, radiation is more or less non-directional. At the higher frequencies, on the other hand, where the wave lengths are relatively short, the radiation usually takes more the form of a beam. As a result the high-frequency radiation is likely to cover a smaller area than the low-frequency and the quality along the beam tends to be high pitched. With the 16-type horn this effect is largely over-

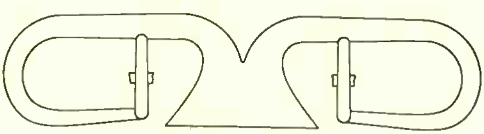


Fig. 2—The new horn, known as the 16-type, has a divided sound passage which permits shorter radii of curvature

come by the divided opening which projects a double beam of high frequency radiation which more completely covers the field of low-frequency radiation. The divided mouth

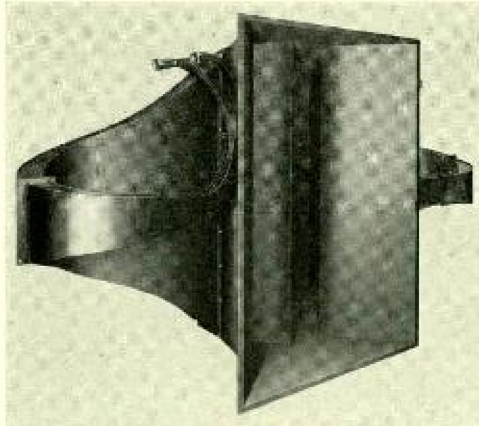


Fig. 3—Either one or two receivers may be connected to each sound passage of the 16-type horn

section acts as a single radiator for low frequencies and as two radiators for high frequencies. This permits the 16-type horn to be used satisfactorily where two or even three of the 15-A horns would be required since its sound field is approximately 45° on each side of the center axis.

One of the first installations of the new horn, shown in the headpiece, was made at Roxy's theatre. Two of the experimental models of the 16-type horns are mounted on the trussed steel frame carrying the screen, and because of their small depth may be raised without interfering with the other drops. A heavy, dark material is used to cover the back of the screen to prevent light, and to some extent sound, from reaching the audience from "back-stage." This may be seen in the photograph where the covering is cut and folded back to allow the horn mouth to lie flat against the perforated sound screen. The receivers are here shown pointing to the rear of the horn instead of to the side as in Figure 3. Since the sound passage at this point is rectangular the most convenient position may be selected.

USHERED in by the collapse of a violent speculative era, 1930 has been a year of business uncertainty. For many people it has meant privation and hardship; for many others a radical curtailment of plans and desires; and for all of us a sobering review of the world we live in.

Because so much of our work is concerned with the future rather than with the immediate present, we of Bell Telephone Laboratories have been among the more fortunate. We have been able to carry on our work with a more thorough prospective and in more normal fashion than many less fortunately situated.

We have accomplished much that will help materially to solve the problems of the Bell System in the upbuilding years ahead. We are laying the groundwork for still other achievements while not failing to reappraise the several fields of our activity in the light of the changed conditions.

There has been a world depression, but there is every reason to believe that the crisis is passing and before 1931 is very old, we all hope, the patient will be clearly convalescing. We of Bell Telephone Laboratories have worthwhile work and a knowledge that despite the notable achievements of the past we are still a very long way from the time when we can write *finis* at the end of the chapter.

Frank B. Jewett

I WELCOME this New Year Day for the opportunity it affords to extend my personal greetings to all members of the Laboratories. For each, I wish that the coming year shall offer new or enlarged opportunities, that health and strength shall not fail, and that true happiness shall result.

In behalf of myself and my immediate staff, whose association has made my own work so pleasant, I wish to extend to every member of our organization our sincere appreciation of their efforts, for without the hearty cooperation of all the accomplishments of the past would have been less and the tasks more difficult. Our work is so highly interrelated that its success depends in a large measure upon the efficient and sympathetic cooperation of the group, as well as upon the individual abilities and contributions.

Accomplishments of importance have indeed marked the past year of the Laboratories' work. They have played some part in almost every extension and improvement of service which the Bell System is rendering to the public. We may, I believe, have just pride in our contributions to these advances, but I think they should be most satisfying to us as concrete evidence that by continued effort we may expect to make larger and even more important contributions in the future.

Another year is before us, and we anticipate with satisfaction its many opportunities. A Happy New Year to all.

General News Notes

Aircraft Communication in Police Work Demonstrated

That police officers patrolling the city from the air may be in closer contact with headquarters than the policeman on the street was demonstrated by a new use of the radio-telephone on November 26. Rodman Wanamaker, Aviation Aid to Police Commissioner Mulrooney, Arthur M. Chamberlain, Assistant Secretary to the Commissioner, Captain A. W. Wallender of the Police Air Patrol, and Captain Olley of the Imperial Airways of Great Britain, flew in the Laboratories Ford plane. They communicated with Police Commissioner Mulrooney in his office at Police Headquarters and described the waterfront stretching out under them and the motor traffic as it seemed to crawl slowly along the New York streets.

After making reports to the police commissioner's office, the police representatives in the Ford plane communicated with the Laboratories Fairchild plane flying above the Narrows. Through a three-way hookup the conversation was overheard by Commissioner Mulrooney and police officials assembled in his office. Excellent reception was reported in both the direct communication from the Ford plane and in the hook-up with the two planes in flight.

The practical application of this new use of aircraft radio-telephone was quickly seen by police officials and newspaper men attending the demonstration. The pursuit of criminals in high-powered automobiles, it was pointed out, can be more effectively carried on by an airplane flying overhead, keeping the fugitives in view and directing the activities of the land forces. The untangling of traffic jams from the vantage point of the air offers another instance of the utility in police work of an airplane in a position to relay reports to headquarters. Cooperating with the Fire Department in fighting large water-front fires, where the airplane from the broad perspective which its height gives it, may direct the attack of fire boats and the land fire-fighting apparatus, was seen as another role the police airplane equipped with radio-telephone might play.

A circuit from the Police Commissioner's office in New York City to the Laboratories' aeronautical ground station at Whippany enabled Commissioner Mulrooney to converse with his aides while they were flying over the city. Captain A. R. Brooks piloted the Ford airplane and D. B. McKey controlled the radio equipment. The Fairchild airplane was piloted by P. D. Lucas with D. K. Martin in charge of the radio equipment. The transmitting equipment at Whippany was operated by J. M. Henry and J. P. Dolbear. Special receiving points were established at Mendham, New Jersey, and in the Radio Development laboratory at 180 Varick Street, New York City. The receivers at these points were operated respectively by W. K. Caughey and R. H. Herrick. J. W. Greig coordinated the operation

A police report to headquarters by radio. Left, F. B. Woodworth, B.T.L.; center, H. N. Willets, W. E. Co.; and right, Police Commissioner Edward P. Mulrooney

of the receiving circuits at the Walker-Lispenard Building and F. B. Woodworth attended the operation of the equipment installed in the Police Commissioner's office.

The demonstration was made at the instance of the Western Electric Company, and H. N. Willets of that company acted as master of ceremonies in the Police Commissioner's office.

Brooklyn Municipal Club Sees Television Exhibit

The Municipal Club, composed of men prominent in business and civic life in Brooklyn, were shown how synchronized voices and images are transmitted by television on November 25. The club members were divided into two groups, one assigned to the 195 Broadway terminal of the system and the other to the Laboratories terminal in the auditorium, and talked over the television circuit in pairs. The demonstration was arranged by J. S. Kennedy, secretary of the General Employees Benefit Committee of the New York Telephone Company and chairman of the State Department of Correction. G. F. Fowler of our Bureau of Publication was one of the guests at a dinner tendered by the Telephone Company in its headquarters building.

Colloquium

At the meeting of the Colloquium on November 24, R. L. Peek gave a paper on the subject *Theories of Elasticity*. He discussed the deformation of matter under conditions wherein neither the elastic theory nor the theory of viscous flow applies. Examples he cited included extrusion of lead sheathing and of rubber insulation, the wiping of joints, the cold flow of asphalts and plastics. No satisfactory theory is available for such deformations, he declared, but numerous quasi-empirical relationships apply in special cases. Indicating the line of attack in theoretical studies of the problem, Mr. Peck outlined celebrated plasticity and plastic-viscous theories and asserted that while emphasis will be on the mathematical formation of these theories, some consideration will be given to possible physical mechanisms consistent with various hypotheses involved.

S. A. Schelkunoff spoke on *Curvature of Space* at the December 8 meeting. He discussed the concepts of dimensionality and curvature, which he elucidated by suitably chosen examples, and showed the way in which they enter the theory of relativity.

Administration

Bancroft Gherardi, a Director of these Laboratories, has been elected to the presidency of the American Standards Association. As president he will assume the direction of the standardization activities of the organization, a task in which are engaged representatives of about 500 trade, technical and governmental groups from all parts of the country.

At Summit, Dr. Jewett spoke at a meeting sponsored by the Rotary, Kiwanis, Civic and Lions Clubs and acquainted the residents with projects the Laboratories had in view with reference to Murray Hill. Three sound-picture films were shown: "Acoustic Principles," prepared by Harvey Fletcher in our Sound Picture Laboratory, "Business in Great Waters," and "The Home Team."

S. P. Grace spoke before the Washington Board of Trade in the main ballroom of the Willard Hotel on December 3. Fifteen hundred persons crowded into the hall to hear the talk. On December 12-13 he gave his lecture-demonstration in the Municipal Auditorium, Springfield, under the joint auspices of the Chamber of Commerce and the Western Massachusetts Engineering Society. His discourse was given on December 17-18 in Mechanics Hall, Worcester, under the auspices of the Worcester Engineering Society. In each of the talks R. M. Pease assisted him in the demonstrations.

Mecca Auditorium was jammed to its capacity at each of the four talks which Mr. Grace gave in New York on November 19, 20 and 21. The meetings were held under the joint auspices of the Science Forum of New York Electric Society, the A. I. E. E. and Museums of the Peaceful Arts through arrangement with the New York Telephone Company. New York marveled at the wizardry of Mr. Grace in exhibiting the scrambling of speech, the transmitting of sounds electrically into the brain, and the singing flame, all of them the outcome of organized research and development activities quietly carried on within its own borders. In several instances the New York newspapers, in view of the crowds milling about on the sidewalk at each meeting awaiting the opening of the hall, were unable to resist the temptation to point out that a lecture describing industrial research accomplishments competed with a Ziegfeld Revue in attracting crowds to its doors. It is estimated that as many persons were turned away as were present, and it is regretted that all persons desiring it were unable to hear Mr. Grace's talks.

Departmental News

Systems Development

A. F. Dixon delivered an address at Montreal under the auspices of the Northern Electric Engineering Society in which he described the work carried on in these Laboratories to further the development of telephonic communication.

W. A. Bollinger on December 1 completed twenty-years with the Bell System.

Local Central Office Development

P. L. Wright completed twenty-years of service in the Bell System on December 12.

On November 29, A. J. Busch attended the cutover of two new units of panel equipment at Evanston. Sixteen thousand subscriber's lines were affected. The latest developments of automatic zone and overtime registration are included in the newly-installed equipment.

W. J. Scully and R. C. Paine visited Philadelphia for a field trial of new contact protections on panel-sender circuits.

The operation of a test circuit of the panel incoming selector under field conditions was observed at Buffalo by C. H. McCandless.

Toll Development

H. I. Romnes is engaged on tests conducted in the Carolinas on the circuits and equipment required for the trial of the projected 4000-mile cable.

F. B. Anderson was at Norlina, North Carolina, to inspect an installation of an alarm circuit for detecting high-insulation leaks in cables. Mr. Anderson also visited the new No. 3 Toll Switchboard at Richmond.

F. A. Brooks spent several days in Washington to obtain data in regard to the performance of a type "C" carrier-telephone system modified for emergency operation over toll cable pairs, rather than open wire circuits.

Manual Equipment

The trial installation of cable carrier, in which shielded and sealed cable terminals are used at each end of a 25-mile loop of outside cable, required A. J. Weir's presence at Morristown, New Jersey.

A. C. Gilmore, accompanied by engineers of the American Telephone and Telegraph Company, was in Roselle, New Jersey, studying an improved method of designating the subscriber's multiple in switchboards.

Special Equipment

H. W. Horney visited Allentown to assist in the installation of equipment for observing service on multiparty lines.

Various repeater stations on the New York-Charlotte toll cable were visited by E. W. Sullivan and J. R. Lafferandre to assist in the installation of the repeater equipment.

W. H. Bendernagel described the operating principles of trans-atlantic telephony before an out-of-hour class at Western Electric Company, 149 Fulton Street.

Power Development

F. T. Forster represented the Laboratories in a general conference on storage batteries at the Philadelphia factory of the Electric Storage Battery Company.

H. M. Spicer participated in a test on power-transfer switch equipment held in Buffalo.

At Fort Wayne C. W. Van Duyne attended a survey conference to consider changes in the handling of orders for General Electric equipment.

V. T. Callahan's work on power apparatus took him to Buffalo to discuss design of gasoline engines.

Dial Equipment

Of the mementoes produced at the luncheon for Reinhold Petersen, noted in the last issue of the Record, one has particular significance to the younger generation in the Laboratories. It is a list of the Equipment Engineering group at Hawthorne in 1910, of which Mr. Petersen was a member. Twenty-years later, this list shows that of those ninety-seven engineers, sixty-six are still in the Bell System. Two are Chief Engineers—F. M. Craft of the Southern Bell and J. R. McGregor of the Bell of Pennsylvania—and two are General Superintendents of the Western Electric Company—J. Danner, of Installation and W. G. Minich of Equipment. Four are Building and Equipment Engineers of Associated Companies. Our own Equipment Development Department is headed by one of the group—H. H. Lowry—and contains as well S. F. Butler, C. Borgmann, H. E. Marting, C. E. Boman, H. L. Bostater, R. P. MacLaren, O. E. Benson and B. M. Bouman. In other departments of the Laboratories are E. H. Clark, J. G. Dusheck, W. C. Kiesel, H. W. MacDougall, A. Raynsford, W. E. Viol, S. W. Shiley, H. N. Van Deusen, and F. S. Irvine.

In 1900 O. E. Benson of the Panel Equipment Engineering group entered the employ of the Central District and Printing Telegraph Company of Pittsburgh. He worked on switchboards, in both the shop and on installation, and a year later became wire chief. After two years in this capacity he left the telephone industry. In 1905 his youthful wanderlust took him to Chicago where the inducement to enter upon his former work on telephones was presented at the Clinton street factory of the Western Electric Company. On December 11, 1930 Mr. Benson finished twenty-five years of continuous association with the Western Electric Company and the Laboratories.

O. E. Benson

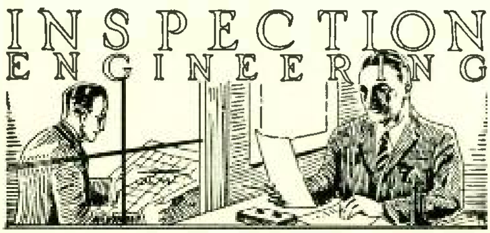
In the Clinton Street factory and Hawthorne, where the work was transferred in 1907, he wrote specifications and later was placed in charge of the analyzing of job specifications. In 1911 he was transferred to work on standardization of manual equipment practices. Shortly afterward he was assigned to the sales department as enginering adviser in connection with sales to non-associated companies and in 1915 came to New York and was placed on circuit development work. He was placed in charge of a group, then known as the methods-of-operation group, in 1917, and about two years later was transferred to his present work on panel equipment standardization.

S. F. BUTLER'S career in the telephone industry runs the gamut from

S. F. Butler

office boy to telephone equipment engineer. Thirty years ago he began as a messenger in the engineering department of the New England Telephone Company. His supervisors found him quite apt in picking up the essentials of telephone work and within a short time he was made an installer for subscriber's station and central office equipment. He was later advanced to maintenance man for central office and PBX and worked throughout the New England territory. In 1910 he left this work and came to Hawthorne. He was engaged on equipment engineering with the Western Electric Company and for several years, until coming with the Laboratories in 1919, he supervised a section of this work.

He came here at the start of the panel machine switching program and was assigned to the group working on the development of equipment associated with this project, the first units of which were installed in Kansas City and Omaha. In 1921 he was placed in charge of the Current Development and Trial Installation group. Development work on dial equipment, both on panel and step-by-step, was placed under his direction in 1926. His duties as dial equipment engineer include also common system engineering which takes in the development and standardization of practices and equipment common to all telephone systems.



DURING THE early part of November, P. S. Olmstead attended a quality survey on handset transmitters at the Hawthorne plant of the Western Electric Company. Later in the month, Mr. Olmstead was again in Hawthorne in company with P. H. Betts to attend a quality survey on amplifiers and transmitters used in radio broadcasting.

S. H. ANDERSON attended a quality survey on power machines at the General Electric Company factory, Fort Wayne.

H. L. KITTS recently completed a week of investigation work on sound-picture apparatus at the Hawthorne plant and the Chicago warehouse of the Electrical Research Products, Inc.

E. G. D. PATERSON and C. R. Brearty were in Pittsburgh at the Hubbard & Company plant attending a quality survey on outside plant line hardware. From Pittsburgh they went to Lebanon to attend a quality survey on the same type of equipment.

R. C. KOERNIG, Field Engineer at Omaha, spent a few days in Des Moines and Minneapolis to attend regular field review conferences. Mr. Koernig was also in Denver in connection with investigation work on position dial circuits and in Salt Lake City investigating transmission losses in cord circuits of No. 1 Toll Boards.

H. W. NYLUND, Field Engineer at San Francisco, was in Seattle and Portland during the early part of November, attending field-review conferences. Mr. Nylund also visited the recently installed toll office at Yakima, Washington.

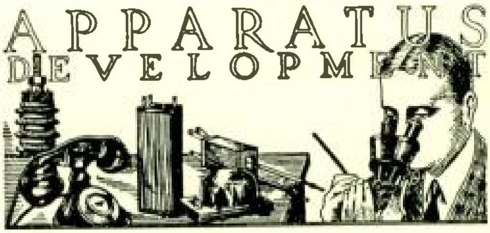
IN CONNECTION with a quality survey on multi-coin coin collectors, J. F. Chaney spent several days at the plant of the Gray Telephone Pay Station Company in Hartford.

INVESTIGATION WORK called W. E. Whitworth, Field Engineer at Cleveland, to Columbus and Cincinnati during November. E. J. Bonnesen, Field Engineer at St. Louis, visited Kansas City for the same purpose.

T. A. CRUMP, Assistant Field Engineer in Philadelphia, attended a field review conference at Harrisburg. T. L. Oliver attended a similar conference in Boston. He also visited Bridgeport and New Haven in connection with inspection matters.

GENERAL INSPECTION matters called L. E. Gaige, Field Engineer at Detroit, to Port Huron during the early part of November.

AT A meeting of the A. S. M. E. Committee on Graphical Standards, H. F. Dodge gave a talk on appearance factors in engineering graphs. Mr. Dodge summarized in his discussion the major characteristics of graphical illustrations which are essential in presenting engineering and scientific information in effective and attractive form. W. A. Shewhart presided at the meeting of the committee.



SPECIAL PRODUCTS

ON HIS return from Hollywood H. Pfannenstiehl stopped off at Hawthorne to discuss the studio reproducing machine.

A PAPER describing new sound-reproducing equipment for small theatres was read by George Puller before the Society of Motion Picture Engineers at the New York convention.

AT THE meeting of the Acoustical Society of America held at the University of California, Los Angeles, F. L. Hunt read a paper *Some Factors Which Affect Quality in Sound Pictures* and C. F. Eyring presented a paper on *Reverberation Time Measurements in Coupled Rooms.*

H. S. PRICE and R. M. Pease were in Washington during the week of December 1 in connection with the lecture and demonstration by S. P. Grace before the Washington Board of Trade on the evening of December 3. Mr. Pease also assisted Mr. Grace at the Springfield and Worcester meetings and spoke before the Rotary Club of Worcester at its luncheon December 18 on sound recording in connection with motion picture films. J. K. Beins was at both cities to assist Mr. Pease in setting up the apparatus.

N. R. Stryker supervised a sound-picture showing given in conjunction with a talk by Dr. Jewett before the Kiwanis Club at Summit. Mr. Stryker is author of the paper *Scanning Losses in Reproduction* in the November Journal of the Society of Motion Picture Engineers.

A talk on sound pictures was given by V. Subrizi before the alumni of Cooper Union on December 4.

Telephone Apparatus Development

W. Fondiller visited Hawthorne for conferences on station apparatus, cable sheath, and improved permalloy for loading coils. While on this trip he visited the Teletype Corporation.

Transmission Apparatus

W. J. Shackelton attended a meeting at Washington of the Electrical Insulation Committee of the National Research Council.

E. B. Wheeler was at Hawthorne to discuss enamelled-wire and switchboard-lamp problems.

A conference on master testing specifications dealing principally with bridge measurements was attended by J. G. Ferguson, S. J. Zammataro and H. T. Wilhelm.

Materials Development

On December 12, F. F. Lucas returned on the *Europa* from Germany where he visited the Carl Zeiss works at Jena to inspect the new high-power photographic equipment for use in his work in the Laboratories. During his stay, he also visited Paris and London and conferred with prominent metallurgical engineers.

Tests on carbon-dioxide fire extinguishers were made by C. H. Wheeler, J. M. Melick, and D. C. Hendrickson at Whippany. Mr. Wheeler also visited the Consolidated Gas Company at Astoria to arrange for tests on special sub-station apparatus for use in explosive atmospheres.

W. A. Evans attended a meeting at Washington of the sub-committee on Insulating Materials of the American Society for Testing Materials.

C. H. Greenall and V. P. Triolo have returned from Hawthorne where they spent five weeks in connection with lead cable-sheath investigations.

Manual Apparatus

C. F. Swasey visited the plant of the Weston Electrical Instrument Company on meter problems.

F. A. Kuntz, with I. L. Hopkins and G. M. Wiles, visited the Queensboro Works of Western Electric to observe manufacturing methods on flooring for telephone booths.

Dial Apparatus

J. R. Irwin visited the Trinity exchange in Philadelphia to study relay contacts in senders.

Transmission measurements on toll circuits equipped with new relay gain control apparatus were made by B. F. Runyon at the Chicago office of the Long Lines Department.

W. C. Slauson was at Harrisburg, on trial installation of 43-type signals.

D. H. Gleason with several engineers of the A. T. & T. Co. visited Hartford and Bridgeport to study the operating characteristics of traffic registers in step-by-step dial offices.

Radio Development

H. E. J. Smith visited Minneapolis to inspect and adjust the Western

Electric 400-watt radio telephone equipment owned and operated by the Police Department of that city.

B. R. Cole inspected station WDSU owned by the Uhalt Radio Company, New Orleans.

A survey for the installation of a 1 kw radio telephone broadcasting equipment was made at Albany by J. F. Morrison for Messrs. H. E. Smith and R. M. Curtis, co-partners in station WOKO. He also visited Milwaukee to supervise the installation of a 1 kw radio telephone broadcasting equipment and associated speech-input equipment for the Evening Wisconsin Company and to inspect station WTMJ owned by the Milwaukee *Journal*. Later Mr. Morrison inspected the 1 kw radio telephone broadcasting equipment recently installed for WKBH, Inc., at La Crosse.

J. C. Herber together with Mr. A. J. Eaves of the Graybar Electric Company recently visited Minneapolis and while there inspected the Western Electric 400-watt radio telephone equipment owned by the Minneapolis Police Department.

A. B. Bailey inspected the Outlet Company's 1 kw broadcasting station, WJAR, at Providence.

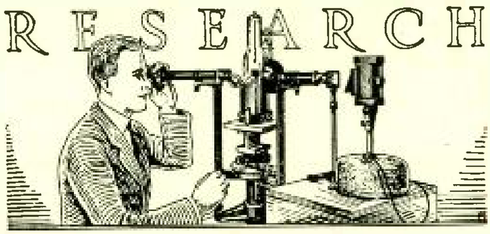
On an inspection tour of Western Electric equipped broadcasting stations in the Western States, O. W. Towner visited stations KOL, KOMO, KHQ, KVI and KFPY. He also directed the installation of a 1 kw radio telephone broadcasting equipment for the intermountain Broadcasting Corporation of Salt Lake City.

B. O. Browne conferred with officers of the Signal Corps at Wright Field, Dayton, regarding the development of Western Electric radio telephone equipment for aircraft applications in the U. S. Army.

W. P. Fisher inspected the station of the Shepard Stores, WNAC, at Boston.

Accompanied by Mr. H. V. Forster of the Publicity Department of the Western Electric Company, J. O. Gargan, W. J. Adams, and O. M. Hovgaard recently made an inspection trip on the U. S. Coast Guard Patrol Boats *Diligence* and *Pulaski* to observe the operation of their new Western Electric radio telephone equipment.

RESEARCH



H. E. Ives attended the American Physical Society meeting in Chicago and in an after-dinner address spoke on *Law of Diminishing Returns in Applied Physics*. K. K. Darrow was also at the meeting. Before returning to New York he made a visit to the University of Wisconsin at Madison.

A visit to the Loomis Laboratories at Tuxedo Park was made by W. A. Marrison, J. Bollman, W. L. Bond and G. Hecht in connection with work on standard frequencies.

Harvey Fletcher attended a White House Conference on Child Health and Protection held in Washington.

Transmission Engineering

H. A. Frederick and C. F. Wiebusch attended a meeting at Ann Arbor of the Standardization Committee of the Acoustical Society of America.

H. F. Hopkins was in Chicago for several days to aid Dr. Jacobson of

In the Acoustical Laboratories speech waves are analyzed by the tuned-reed harmonic analyzer which A. Grieco is using

the University of Chicago in the adjustment of apparatus he is using in connection with measurements of voltages developed in the body tissues due to psychological stimuli.

D. G. BLATTNER was in San Antonio, Texas, where he acted as technical consultant in patent litigation concerning sound pictures.

CHEMICAL RESEARCH

R. R. WILLIAMS addressed the November monthly meeting of the American Institute of Chemists on the contribution of chemistry to the telephone industry. He touched upon the diversity of problems under investigation by our chemical group.

R. M. BURNS and C. L. Hippensteel were at Washington where they participated in the soil corrosion conference at the Bureau of Standards.

IN CONNECTION with various problems on finishes, R. M. Burns, C. L. Hippensteel, H. G. Arlt and A. E. Schuh made a recent visit to Chicago.

B. L. CLARKE attended an A. S. T. M. meeting in Washington.

THE MEETING of the Dielectrics Committee of the National Research Council in Washington was attended by S. O. Morgan, W. A. Yager and A. H. White.

R. L. TAYLOR attended the committee meeting of the National Research Council on Insulation.

PROBLEMS CONNECTED with development of rubber-covered wire necessitated a recent visit by R. R. Williams, A. R. Kemp and J. H. Ingmanson to the Point Breeze plant.

G. M. BOUTON and J. H. Scaff have returned from Hawthorne where they were engaged on investigations of lead cable-sheath alloys.

L. A. WOOTEN and J. D. Struthers were at Hawthorne in connection with the analysis of calcium in lead cable sheath.

RADIO AND VACUUM TUBE

A DISTRICT meeting of the Institute of Radio Engineers held at Rochester was attended by H. A. Pidgeon, A. L. Samuel and J. O. McNally.

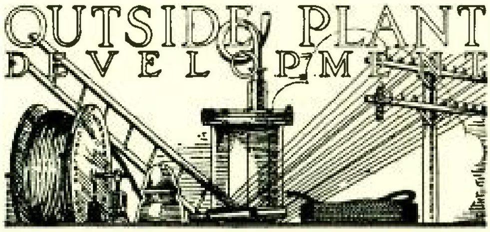
A. E. STAFFORD was in Detroit during the early part of the month to conduct field tests on ballast lamps used in new carrier-current equipment.

SUBMARINE CABLE

O. E. BUCKLEY returned from London on November 24 where he has been conferring on matters connected with the transatlantic telephone cable.

J. J. GILBERT has returned to this country following an extended stay at Nordenham, Germany.

ON DECEMBER 4, J. B. Johnson delivered a lecture before the Franklin Institute on the subject *The Cathode Ray Oscillograph.*



D. A. QUARLES, in company with J. R. Shea and H. Rossbacher of the Western Electric Company, recently visited the Point Breeze works to discuss manufacturing and development features of lead-covered cable and weatherproofed wire.

F. B. LIVINGSTON was in Pittsburgh to observe the installation of some trial orders of 1212-pair pulp-insulated 24-gauge cables. He extended his trip to Cleveland in order to investigate how cable in which textile insulation was treated with cellulose acetate withstood winding on cable reels.

FOR DISCUSSIONS of general cable development problems R. P. Ashbaugh came from Hawthorne to New York for several days.

C. R. MOORE was in Hawthorne in regard to the manufacture of sleeve-rolling tools.

IN CONNECTION with work on low-pressure contactors for gas-pressure testing, V. B. Pike visited several small places in Delaware.

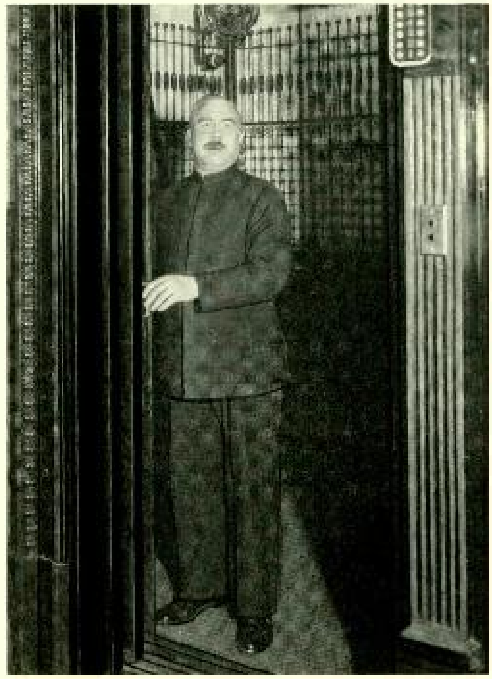
B. A. MERRICK attended survey conferences on outside plant hardware at Pittsburgh and Lebanon.

A. H. BLAKE was in Wallingford and New Haven, Connecticut, in connection with the manufacture of drop wire and attachments.

STAFF DEPARTMENT

THIRTY YEARS of service with the Western Electric Company and the Laboratories were completed by William Carroll, elevator man at the 463 West Street entrance, in December.

When Bill Carroll became a member of the Western Electric Company, the original sections of the present building had been occupied but a few months. For three years he helped



William Carroll

out in the shop, doing odd porter jobs and lending a hand here and there. He was strong, a willing worker, and in 1904 was assigned to the cable department removing cables from the drying ovens. And no one can tell Bill Carroll that it wasn't a hard and a hot job. In 1907 he was made a night watchman and a short time later was transferred to the operation of elevators.

In the thirty years he has been with the Bell System Bill Carroll has lost not more than a half-dozen days from his work on account of illness. At one time he was threatened with appendicitis and was already in the hospital awaiting the scheduled operation. But it happened that the surgeon forgot about the appointment so Bill put on his clothes, came home, returned to work losing only a half day, and carries the appendix that was to be removed to this day.

All of the notables of the telephone industry at one time or another have been passengers in his car and many of them he knows intimately. But Bill states his biggest thrill occurred about a year ago when the celebrated Irish tenor John McCormack visited the building accompanied by the late J. J. Lyng. As they were emerging from the car Mr. Lyng mentioned that Bill Carroll's home as a young man was in Kings County, Ireland, but a short distance from the McCormack's native city of Athlone, and the tenor turned back to shake Bill's hand and exchange brief reminiscences of their boyhood scenes.

PERSONNEL

G. B. Thomas attended the Winter Convention of the Middle Atlantic Section of the Society for the Promotion of Engineering Education held at Drexel Institute on December 6.

The annual Industrial Safety Congress held by the New York State Department of Labor at Syracuse was attended by J. S. Edwards.

PUBLICATION

L. S. O'Roark spoke on *Transmission of Personality* under the auspices of the Toledo Technical Society at the Chamber of Commerce, Toledo, early in December.

Current advances in television were described by P. B. Findley before the Men's Club, St. John's Church, Flushing. He also addressed the Civic Association of Manhasset on sound pictures.

PATENT

During the period from November 4 to December 3, the following members of the Patent Department visited Washington in connection with the prosecution of patents: H. A. Burgess, W. G. Crawford, S. B. Kent, E. C. Laughlin, G. C. Lord, W. C. Parnell, J. W. Schmied, W. B. Wells and F. H. Crews.

From July 1 to November 1, 1930, patents were issued to the following members of the Laboratories:

W. M. Bishop
C. Borgmann
E. Bruce
O. E. Buckley
G. W. Burchett
E. T. Burton
E. D. Butz
W. W. Carpenter
E. H. Clark
H. W. Dudley
L. A. Elmer
J. R. Fry
J. J. Gilbert
F. H. Graham
F. Gray (3)
H. M. Hagland
A. E. Hague
H. C. Harrison (3)
R. V. L. Hartley
J. R. Hefele (2)
R. A. Heising
J. B. Johnson
L. H. Johnson
B. W. Kendall
E. F. Kingsbury (2)
C. E. Lane
H. E. Marting
W. P. Mason
R. C. Mathes
P. Norton
A. A. Oswald
E. J. Pratt
T. E. Shea
C. A. Sprague
E. J. Sterba

Contributors to this Issue

G. A. Locke entered the Bell System in 1908 by way of the New York Telephone Company. In 1915, he transferred to the engineering department of the Western Electric Company where he engaged in the development of printing-telegraph apparatus. During the war he went to France as a member of the Signal Corps in a special unit dealing with printing and other telegraphic communication circuits. On returning to this country in 1919, he again became associated with the Laboratories, spending three years on printing-telegraph development in the Systems Department, and then transferred to the Research Department, where he worked on apparatus for high-speed transatlantic telegraph cables. During this period he received both a B.S. and an E.E. degree from Cooper Union. In 1928 he joined the toll development group where he has since been engaged in the design of telephone-typewriter systems.

After a year at the University of Michigan, H. B. Ely went to West Point and was graduated in 1917. For the next four years he served in the Engineer Corps of the Army, and from 1921 to 1928 in the Ordinance Department. For six years he was engaged in the development of aircraft detectors, and also during his service with the army he took post graduate work at the Massachusetts Institute of Technology and at the State University of Iowa. At the beginning of 1929 he joined the technical staff of the Laboratories where he has been engaged in loud speaker development work with the Research Department.

Before joining the Laboratories in 1918, J. B. Draper had spent thirteen years with the New York Telephone Company in their Plant Department, engaged in maintenance and engineering. His first work with the Laboratories was in the Toll group where he was associated with the development of start-stop signalling and of the Catalina Island radio telephone.

G. A. Locke

H. B. Ely

J. B. Draper

R. T. Holcomb

P. T. Slattery

R. A. Leconte

He later transferred to the Local Systems Group and took part in step-by-step development. For the last two years he has been engaged in PBX development.

R. T. HOLCOMB received an S.B. degree from Harvard Engineering School in February 1925 and immediately joined the Laboratories' technical staff. He was first associated with the Apparatus Development Department where he engaged in the design and development of transmission apparatus such as filters, equalizers, phase correctors, and balancing networks. During the past summer he transferred to the Patent Department where he is now working on radio transmission, modulation systems, and transmission networks.

AFTER SEVERAL years' service with the Navy during the War, Paul T. Slattery graduated from Rensselaer Polytechnic Institute with a degree of E.E. in 1922, and immediately joined the technical staff of the Laboratories, where he has been associated with the Systems Department. For about two years he was engaged in relay design but more recently has been associated with step-by-step development. At present he is a step-by-step-system testing engineer.

R. A. LECONTE was born in Grenoble, France, graduated from the Electrotechnical Institute of Grenoble, and later attended the University of that city. Previous to the war he had been employed by Jacquet Frères and later by the C^ie^ Française Thompson-Houston, with both of which concerns he was engaged in the design of direct and alternating current motors and generators. At the outbreak of the war he obtained an engineering commission and after a period at the front was sent to this country as a member of the French commission charged with the purchase and inspection of materials. In addition to his other duties here, he served as instructor in army camps, and, except for trips to France, has been here ever since. He has recently become an American citizen. In 1922 he joined the Laboratories and, with the toll group, has been engaged in the development of amplifiers for program broadcasting circuits, and of repeaters for four-wire toll circuits.

Club Calendar for January

FRIDAY, 2: Bowling, 5:45
MONDAY, 5: Bridge, Men, Room 277, 6:00
Basketball, Women, Carroll Club, 5:30
Bridge, Women, Rest Room, 5:15
TUESDAY, 6: Basketball, Men, Labor Temple, 5:30
Basketball, Women, Salvation Army, 5:30
Orchestra, Rest Room, 5:10
WEDNESDAY, 7: Glee Club, Rest Room, 5:15
THURSDAY, 8: Basketball, Men, Labor Temple, 5:30
FRIDAY, 9: Bowling, 5:45
MONDAY, 12: Bridge, Men, 6:00
Basketball, Women, Carroll Club, 5:30
Bridge, Women, 5:10
TUESDAY, 13: Basketball, Men, 5:30
Basketball, Women, Salvation Army, 5:30
Orchestra, 5:10
Classes in Rhythm, Noyes School, 5:30
WEDNESDAY, 14: Glee Club, 5:15
Women's Swimming, 5:30
THURSDAY, 15: Basketball, Men, 5:30
Women's Swimming, 5:30
FRIDAY, 16: Bowling, 5:45
MONDAY, 19: Bridge, Men, 6:00
Bridge, Women, 5:10
Basketball, Women, Carroll Club, 5:30
TUESDAY, 20: Basketball, Men, 5:30
Basketball, Women, Salvation Army, 5:30
Orchestra, 5:10
Rhythm Class, 5:30
Health Course for Women, 5:15
WEDNESDAY, 21: Glee Club, 5:15
Women's Swimming, 5:30
THURSDAY, 22: Basketball, Men, 5:30
Women's Swimming, 5:30
Health Course for Women, 5:15
FRIDAY, 23: Bowling, 5:45
MONDAY, 26: Bridge, Men, 6:00
Bridge, Women, 5:10
Basketball, Women, Carroll Club, 5:30
TUESDAY, 27: Basketball, Men, 5:30
Basketball, Women, Salvation Army, 5:30
Orchestra, 5:10
Rhythm Class, 5:30
Health Course for Women, 5:15
WEDNESDAY, 28: Glee Club, 5:15
Women's Swimming, 5:30
THURSDAY, 29: Basketball, Men, 5:30
Women's Swimming, 5:30
Health Course for Women, 5:15
FRIDAY, 30: Bowling, 5:45
Bridge and Dance, Telephone Club Rooms, 140 West St.