Telephone Equipment for Long Cable Circuits [1]

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SYNOPSIS: Some of the important developments contemplated in the apparatus and equipment for long toll cable circuits are described. The large number of equipment units per station in the cable plant and the greater number of stations in a given length of cable than in an open-wire system have made the economic importance of the equipment design such that a comprehensive program of development, affecting many types of equipment, has been undertaken. The outstanding features of some of the more important of these, including the telephone repeater equipment, test board equipment and signaling equipment, are described. The necessity for compactness in the dimensions of equipment units, uniformity in assembly arrangements, and simplicity in design, together with the need of careful correlation of the electrical and mechanical requirements, are emphasized. The methods proposed for meeting these requirements generally, are described.

INTRODUCTION

THE use of lead covered cables in place of bare copper wires for long distance telephone lines has been an important development and much interesting information on this subject has already been presented to the Institute. The engineering and construction features involved in a cable system of this sort were described by Mr. Pilliod [2] in his article on the Philadelphia-Pittsburgh Section of the New York-Chicago cable, while the transmission characteristics of such a system were brought out in the recent paper by Mr. Clark.[3] It is the purpose of the present paper to deal with some of the important developments in apparatus and equipment which are contemplated for the cable plant.

A cable system requires repeater stations at more frequent intervals throughout its length than an open-wire line, because of the much smaller gauge conductors which it employs and the increased electrical capacity due to closer proximity of the wires. Consequently, in such a system, a greater proportion of the plant investment is represented by the equipment within the offices than is the case with open-wire construction. Furthermore, the number of equipment units per station in a cable system is ordinarily much larger than in an open-wire office, due to the fact that the chief advantages in the use of long cable circuits, in place of open-wire construction, have occurred on routes carrying heavy traffic where many circuits are

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[2] Journal of the A. I. E. E. for August, 1922; and *Bell System Technical Journal*, July, 1922.

[3] Transactions of A. I. E. E., Vol. 38, part 2, p. 1287; and *Bell System Technical Journal*, January, 1923.

needed. Thus, the requirements of the cable plant have been such as to emphasize the economic importance of the equipment design.

To meet these requirements it has been necessary to undertake a comprehensive plan of development affecting many types of equipment. This has involved careful consideration of both the electrical arrangements and the mechanical design, which are being closely coordinated with the purpose that both should contribute to the highest degree of efficiency in the functioning of the system.

It is not possible in this paper to give many details concerning these developments, but it is desired to present some of the principal features as applied to typical cases. Among the more important of these are the telephone repeater equipment, the testboard equipment and the signaling equipment. These are closely associated with each other in their operation, as well as in their physical location, and it has been necessary, in the design of all units to have due regard to the system as a whole.

Telephone Repeater Equipment

The function of the telephone repeater as an amplifier in long distance lines is well known. The telephone repeater in its present form has been the chief factor in making long distance cable telephony practicable, and it is probable that the developments in connection with telephone repeaters have been among the most rapid and comprehensive of any in the toll equipment. It will, therefore, be very interesting to note, in the illustrations which follow, the principal

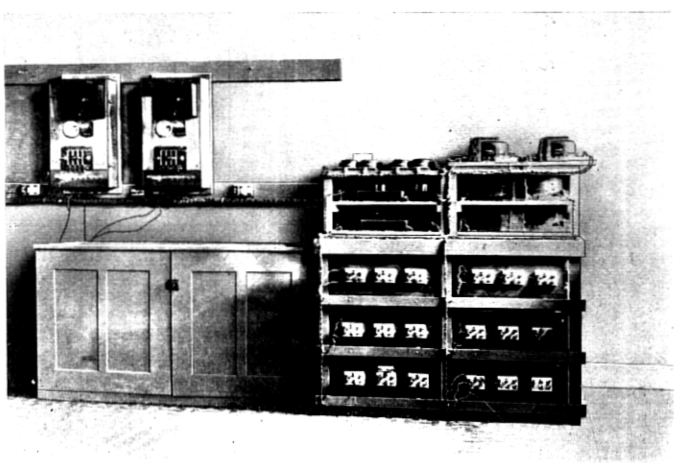

Fig. 1—Box Type Repeater Installation

steps which have been taken in working out the form of the equipment to the degree of efficiency now required for the cable plant.

In Fig. 1 is shown one of the original forms of repeaters, a number of which were installed as early as 1914. In this case the repeater apparatus was assembled in boxes designed to mount on the wall, each box containing a one-way amplifier. Two such one-way units would

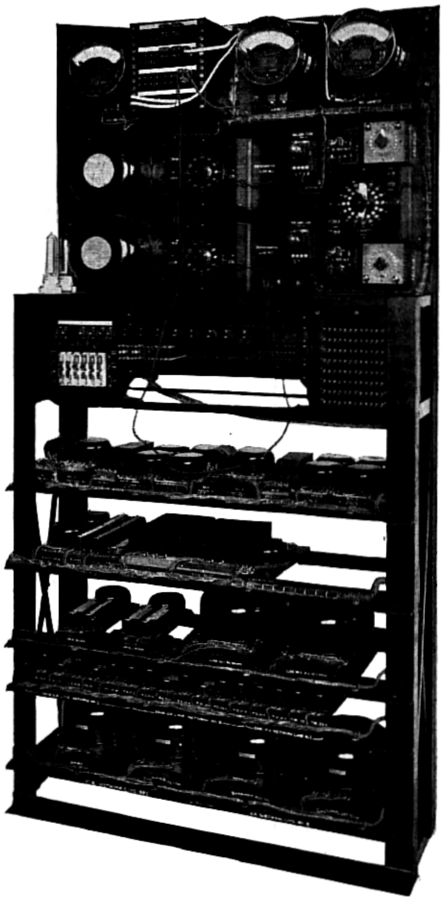

Fig. 2—Wide Rack Through Line Repeater

be required to form what is now known as a two-way, two element repeater. Although the particular amplifiers shown in the illustration were actually used for one-way operation only, they are typical in their general form, of the units employed for two-way operation. The balancing networks, associated coils, etc., were mounted on separate racks while the plate batteries for the vacuum tubes were mounted in an adjacent enclosed cabinet. The floor space required for a two-way repeater employing this type of apparatus was in the neighborhood of 15 square feet per unit, including the usual allowances for aisle space and associated apparatus.

Fig. 2 shows the first type of vacuum tube telephone repeater designed for commercial manufacture. The particular unit shown is a single "through line" set, that is, one which remains connected

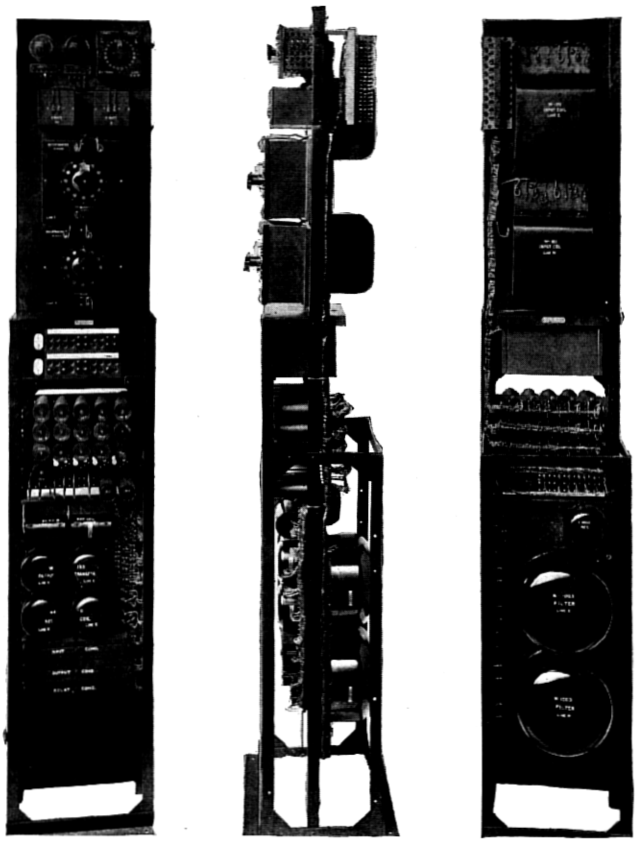

Fig. 3—Standard Through Line Repeater for Open-Wire Use

to a through circuit at all times instead of being used at a switching point to establish built-up connections at the will of the operator, as a "cord circuit" repeater is used. The "cord circuit" repeater of the same type was similar in arrangement and dimensions to the "through line" repeater shown. In this type of repeater, all of the apparatus for a two-way circuit was mounted together on one rack. The testing equipment and signaling apparatus were duplicated in each repeater set. This apparatus, as well as the balancing networks and other miscellaneous apparatus were mounted on the same rack as the repeater. A unit of this type required about 10 square feet of floor space.

Fig. 3 shows the type of "through line" set which was standardized in 1917 for use on open-wire lines. Fig. 4 shows a group of cord circuit

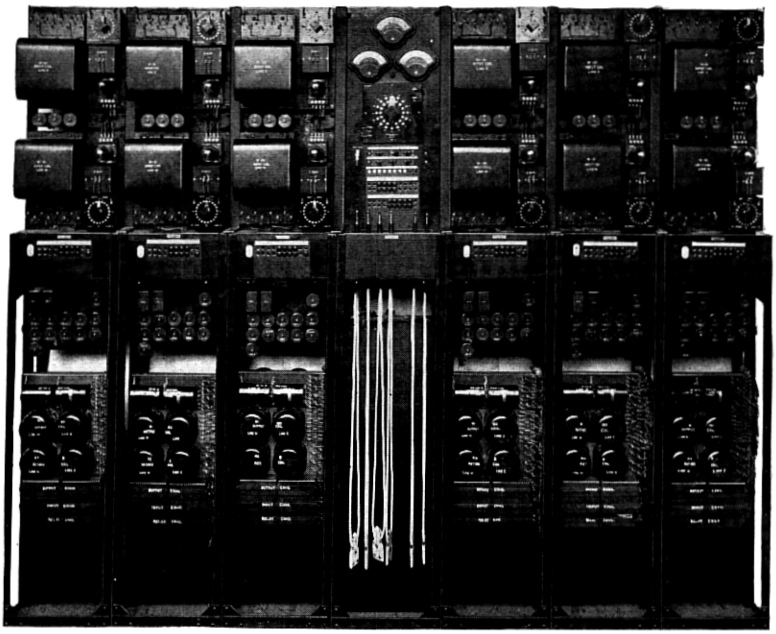

Fig. 4—Group of Six Cord Circuit Repeaters and Associated Testing Unit

sets of the same type of design, together with the testing unit. This form of set was a great improvement over the earlier types. It employed, however, many of the same large types of individual pieces of apparatus as were used in the former sets and the testing equipment, which was mounted on the middle rack of the group, was required to be duplicated for each group of 6 repeaters. This type of set has been used in many of the smaller installations, but it has not met the requirements for large cable installations. The average floor space area required was about 6 square feet per set.

Fig. 5 shows the proposed assembly of the type of telephone repeater which is now being developed for all classes of installations employing the two-way, two-element circuit. Fig. 6 shows the general arrangement proposed for a group of sets of this type in a large installation, as in a cable office. This set is expected to have

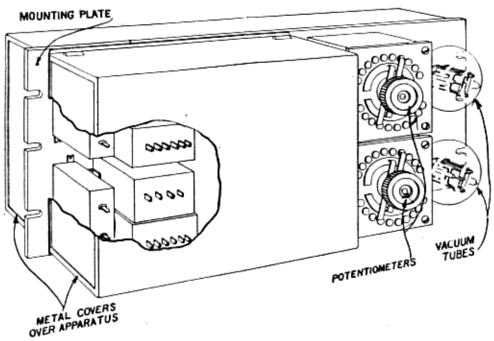

Fig. 5—Typical Assembly of Panel Mounted Repeater Set

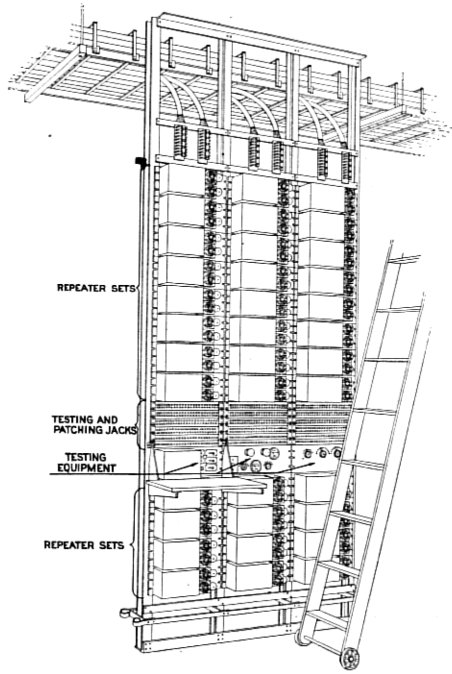

Fig. 6—Group of Panel Mounted Repeaters as Arranged in a Large Installation

many advantages adapting it particularly to cable installations. When mounted as shown in Fig. 6 it will occupy but 1.5 square feet of floor space per unit. Fig. 7 shows how this set may be arranged in small installations where it may be desired to be mounted on a low rack.

By the uniform use of these general mounting arrangements for all of the new repeater equipment, including the accessory apparatus as well as the repeater sets themselves, it will be possible, where desired, to serve a large number of repeaters with a small amount of testing

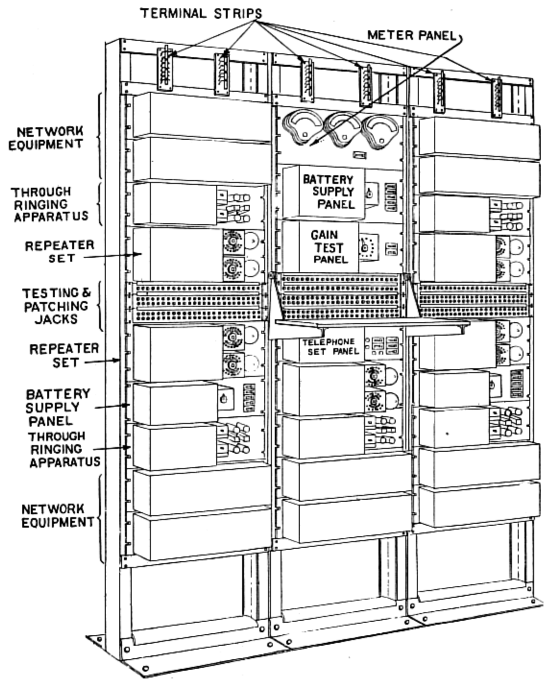

Fig. 7—Panel Mounted Repeaters as Arranged in a Small Installation

equipment. For example, in the case of the voltmeters and ammeters required, it will be possible to employ but one meter panel for as many as 120 repeaters. Thus, an economy in equipment as well as a saving in space will be effected.

Fig. 8 shows how some of the principal features of this proposed type of set, which distinguish it from the earlier types of repeaters, are related to the circuit arrangement, as well as to the mechanical design. Previously, the apparatus which it is now proposed to mount in distinct groups on separate panels, as indicated in this diagram, was assembled together in one repeater unit. Several types of sets were accordingly necessary to meet the various field conditions. This is to be avoided in the new design by separating from the basic repeater unit such apparatus as may be required to be different under different conditions of use. For example, the basic repeater unit in the new repeater is to be the same for both "through line" and "cord circuit" use, and for large installations as well as for small ones. The signaling apparatus which may have different features in different

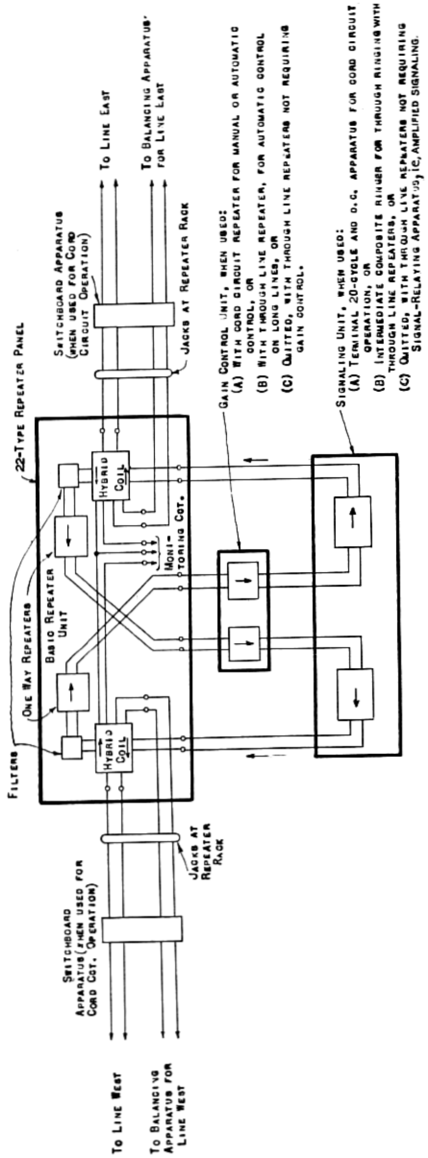

Fig. 8—Schematic Circuit Diagram Showing Two-Way Two-Element Repeater Arranged to Employ One Type of Basic Repeater Unit for all Classes of Service

types of offices, and which may not be needed with "through line" repeaters in some cases, will be furnished as a separate panel from the basic repeater unit. The apparatus which will permit the repeater to be used for cord circuit operation is also to be furnished as a separate unit and may be used in place of the through signaling unit, without changing the basic repeater. The filter which will determine the cut-off frequency of the repeater will also be furnished as a separate piece of apparatus mounted on the repeater set, thus the repeater may be suited to any desired type of line by providing the proper filter.

Another interesting phase of repeater development has been that in connection with the power supply for the vacuum tubes. This includes (1) a source of filament current (2) a source of plate potential and (3) a source of grid potential. In meeting the requirements of cable installations the principal improvements desired have included the use of batteries common to as many repeaters as possible, in place of individual batteries, closer regulation of potentials and the elimination of dry cells where practicable.

In some of the earliest installations a separate six-volt storage battery was used to supply the filament current for the vacuum tubes of each repeater set. Later, the filament current supply was taken from an 11-cell central office storage battery through a rheostat. As the potential of the 11-cell central office battery, normally 24 volts, varied from 20 to 28 volts during the operation of a charge and discharge routine, it was necessary to adjust the rheostat at frequent intervals to maintain constant current in the vacuum tube filaments. With the greatly increased number of repeaters per station which has occurred in cable systems, the maintenance involved in readjusting the filament currents would have become prohibitive on this basis. Accordingly, for the larger installations, duplicate 11-cell batteries normally floated from generators and provided with an emergency cell to maintain voltage during an emergency discharge are proposed. By this improved arrangement it is expected to be possible to maintain the filament voltage within one volt up or down from its normal value, even during an emergency discharge, until the batteries are almost completely discharged. This improved regulation will entirely eliminate adjustments of the individual repeaters during operation to secure proper values of filament current.

For the plate voltage supply dry cells have sometimes been used in small installations. These are now being displaced to a large extent, by small storage cells, two groups being used so that one group may be charged while the other is in service. In the large cable installations, the current drain on the 130-volt plate batteries has sometimes reached values as great as four or five amperes, so that it is now planned to float these batteries also, instead of operating on the charge and discharge basis. It is expected by this means to obtain regulation of the plate voltage within plus or minus five volts from the normal value of 130, at all times.

Consideration is being given to another possible improvement in the power arrangements for large repeater installations. This involves the proposal to use a storage battery common to all of the repeaters for supplying the grid potential. If it is found that this arrangement is practical, it will permit the elimination of the individual dry cell batteries which have been employed, with a consequent saving

Fig. 9—Typical Storage Battery Room for Cable Repeater Station

in maintenance that might be appreciable. It seems likely that a very small storage battery would serve for this purpose since the current drain is negligible.

The amount of power required to operate the vacuum tubes in a large telephone repeater installation is considerable. Each filament requires a current in the neighborhood of one ampere and, while the filaments are connected in series in such a way as to utilize as efficiently as practicable the full potential of the central office battery, the load on this battery sometimes amounts to several hundred amperes.

Fig. 9 gives some idea as to the size of the storage batteries for a typical office of this kind. The large cells in wooden tanks are those making up the filament batteries, each of which is an 11-cell battery of 24-volt nominal rating. These two batteries in parallel are large enough to carry the office load for at least 12 hours in the event of a complete failure of charging equipment.

Fig. 10 shows the charging generators and power switchboard for a typical cable repeater office. The gas engine drives emergency generators to float the filament and plate batteries in the event that

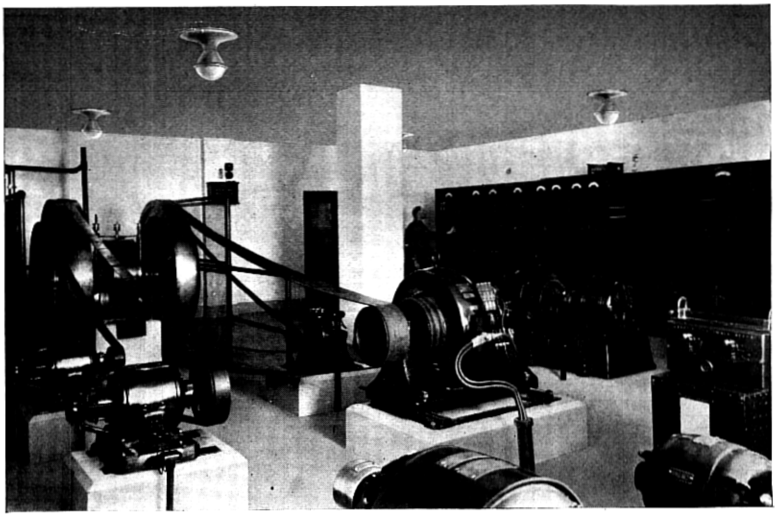

Fig. 10—Typical Power Room for Cable Repeater Station

the regular electric power supply service fails. Alarms are provided to indicate any abnormal condition such as a voltage higher or lower than normal, a blown fuse, etc. These are grouped in an annunicator cabinet on the wall.

Test Board Equipment

The test board forms an important part of the cable plant equipment, since it is the one point in the office where all of the lines and the equipment as a whole may be reached readily for purposes of testing or re-routing, in cases of line trouble or changes in layout. The form and arrangement of the test board equipment consequently have an important bearing on the effectiveness with which the facilities are handled by the maintenance forces. This is particularly true in the cable plant where the number of circuits involved is large.

In general, all toll line conductors are brought into a central office, from the outside, through a cable and first appear at a rack called a "distributing frame" where they are soldered to exposed terminal lugs so that they may be reached for the purpose of connecting them to apparatus within the office. This arrangement is well suited to the permanent connections but is not intended to permit frequent changes or the ready removal of the apparatus for line testing.

The necessity for rearranging the connections between the apparatus and the lines in cases of line trouble makes it desirable at times to be able to make such changes quickly, and the means which have been provided for this purpose are located at the "test board." Here both the line conductors and the apparatus units are wired to "jacks" which are arranged to permit the transfer of the normal connections by the insertion of plugs wired to flexible cords. A temporary connection made in this manner through a conducting cord wired to two plugs is called a "patch." The apparatus for determining the location of line trouble is also located at the test board and is wired to cords and plugs so that it may be connected to any line in the office readily, upon the occurrence of line trouble, without necessitating changes in soldered connections.

The test boards used for the open-wire plant have been designed to take care of 40 to 80 line conductors in one position, that is, in a board three feet long. The amount of testing and patching work required on open-wire lines has been such as to make this a convenient number of circuits to handle within this space. In cable installations, however, the amount of testing and patching per line conductor is less, while the number of circuits in such an office is much greater. Consequently, in cable offices it is possible to concentrate a larger number of wires within a given test board space. This is desirable from the standpoint of economy in space as well as from that of convenience in operation.

One of the first steps considered in the development of efficient test board equipment for cable installations has been the reduction of the number of jacks per circuit. In open-wire installations it has been the practice to equip each line circuit and each equipment unit, such as a composite set or phantom coil, with a full complement of jacks suited to provide the maximum degree of flexibility in "patching," thus permitting the ready interchanging of individual equipment units, lines and drop circuits. In cable installations, where the circuits are more likely to be uniformly equipped with the same types of associated apparatus and where the line troubles are less frequent, it is expected to be possible to eliminate certain of the jacks,

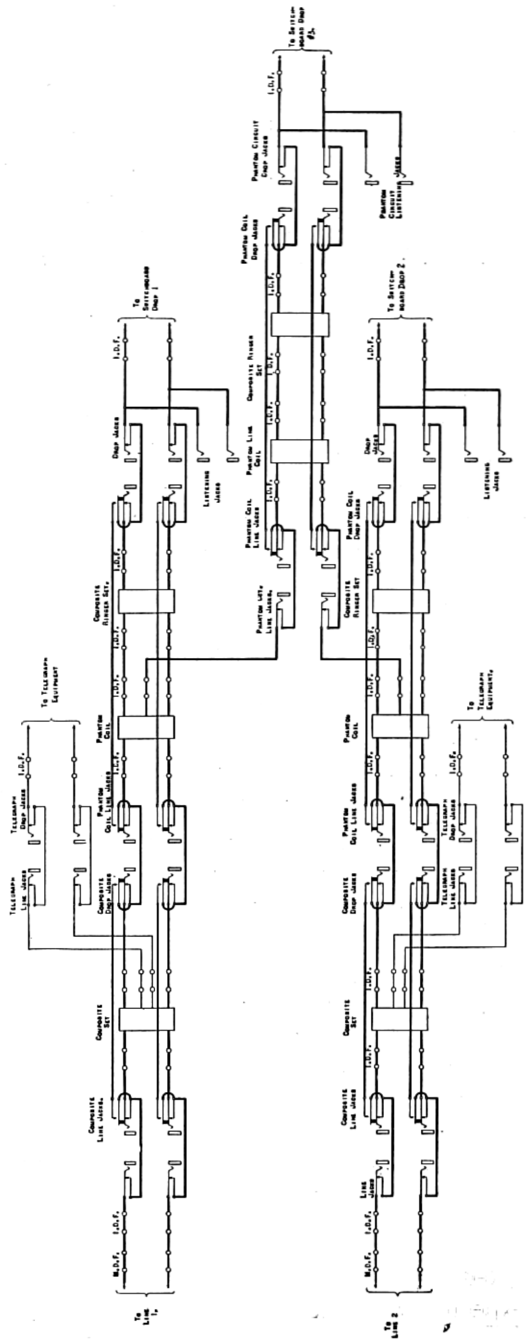

Fig. 11—Typical Phantom Group Circuit for Open-Wire Installations

such as those associated with the composite sets and phantom sets, thus simplifying the equipment for terminating the toll lines. Fig. 11 shows the typical open-wire arrangement for a terminating phantom group circuit in which the maximum number of jacks is furnished. This requires a total of 46 jacks. Fig. 12 shows the arrangement of a terminating phantom group circuit as planned for a cable installation. In this case a total of but 30 jacks is required.

Another important development expected in the test board arrangements to suit them to cable use is the grouping together of the jacks serving similar functions. Considerable improvement in

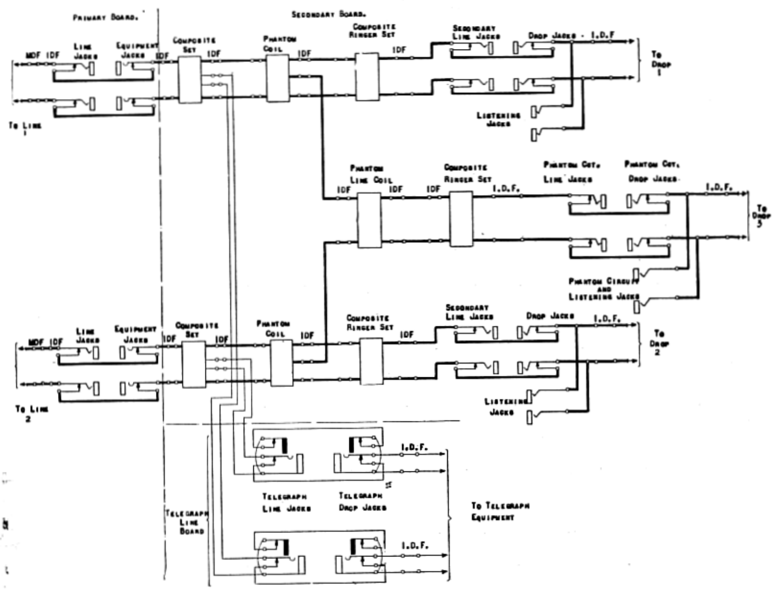

Fig. 12—Typical Phantom Group Circuit for Cable Installations

operation is thought to be possible with the jacks having different functions located at different test board positions. In this way all of the line conductor jacks, for example, may be assembled together in consecutive order, and since several hundred of these may be involved in a single installation, this should greatly facilitate the identification of the desired circuits by the attendant in the process of patching and testing. This grouping of the jacks will also effect a saving in testing equipment, since it will eliminate the need of the line testing apparatus, such as the Wheatstone bridge, at positions where the line conductors will not appear.

Fig. 13 illustrates both the open-wire and the proposed cable methods of grouping the jacks. In the arrangement for open-wire circuits the jacks associated with both the lines and equipment are located adjacent to each other in the same test board panel. In cable installations the jacks having similar functions are to be grouped

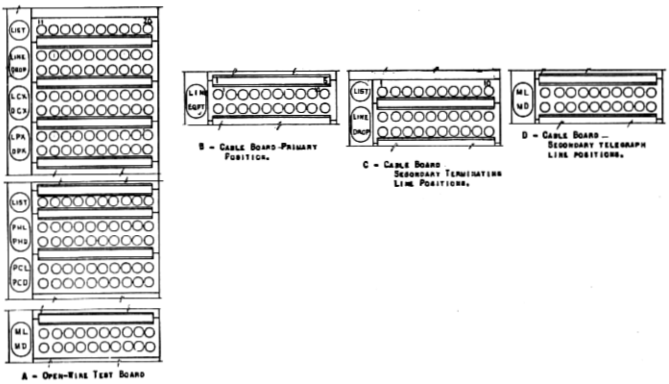

Fig. 13—Typical Jack Assembly Arrangements at Test Board

together, the groups having different functions being mounted in different panels which may be located in different test board positions. These various groups, in the latter case, are planned as follows:

1. Primary line testing position for testing and "patching" toll lines only. This position to be used for locating faults in the cable circuits and equipped with a Wheatstone bridge and voltmeter, to permit the necessary electrical measurements for this purpose. This position is also to be used for making temporary changes in the assignments between the lines, and the equipment as a whole, but is not to be arranged to permit changes in individual equipment units, such as composite sets, phantom sets, etc. The jacks to be located at this board are to include those designated as "line jacks" and "equipment jacks," in Fig. 12.

2. Secondary terminating line positions for testing and "patching" the lines between the "drop" side of the equipment and the toll switchboard circuit. This position is to be used for determining the general nature of a trouble and its general location, i.e., whether it is in the direction of the line or in the direction of the "drop," and for clearing troubles not requiring line tests. This position is not to be equipped with Wheatstone bridge testing

apparatus as at the primary board. The jacks to be located at this position are to include those designated as "secondary line jacks," "drop jacks" and "listening jacks," in Fig. 12.

3. Secondary telegraph line positions for testing and "patching" the telegraph line circuits. This position is to be used solely for interchanging telegraph lines and telegraph equipment, in cases of temporary changes in assignment and is not to be equipped with the line testing apparatus. This position will permit changes to be made in the telegraph assignments without interfering with the telephone circuits. The jacks to be located at this position are to include those designated in Fig. 12 as "telegraph line jacks" and "telegraph drop jacks."

A further and more extensive improvement in test board design is anticipated as a result of development work whereby it will be possible to employ panel mounted keyshelf equipment units, jacks and testing apparatus, which in the standard board are now housed in a

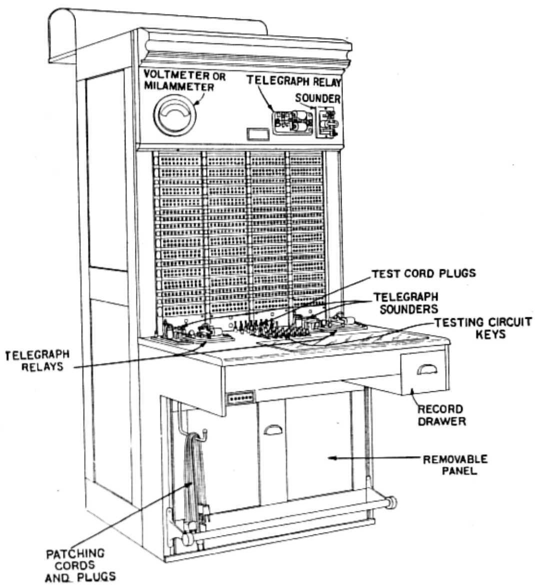

Fig. 14—Typical Assembly of Floor-Mounted Test Board—One Position

large wooden section. This will have the advantage of uniformity with the other toll equipment, as well as requiring less space. It will also permit flexibility in the use and installation of the various combinations of keyshelf equipment, jack equipment and other testing apparatus which may be required to suit each case. While this arrangement will have its chief advantages when applied to large cable installations, it will also be well suited to open-wire use and small installations, since its design will permit the highest degree of flexibility with respect to both the amount and type of equipment.

These points may be illustrated by comparing the general features of the two types of boards. Fig. 14 shows the assembly of a one-position section of the present type of board employing a wooden

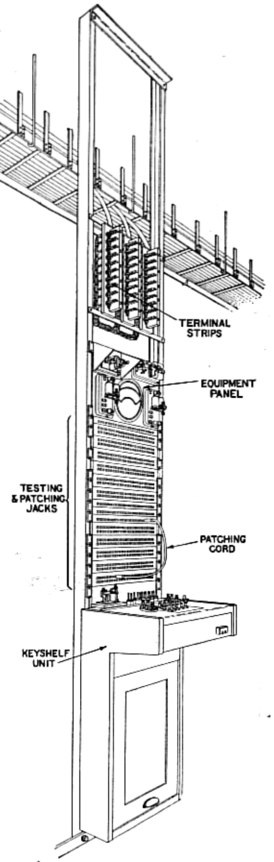

Fig. 15—Typical General Assembly of Panel Mounted Test Board

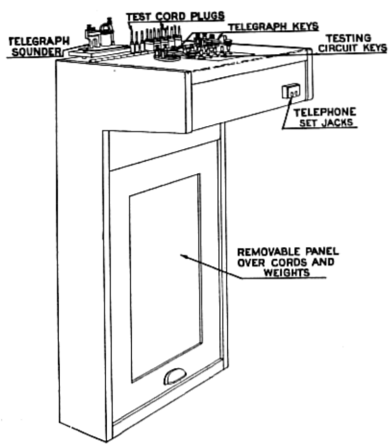

Fig. 16—Typical Assembly for Keyshelf Equipment Unit for Panel Mounted Test Board

framework. This board, with the necessary allowances for aisle space, requires a floor area amounting to about 24 square feet, while it houses a maximum of about 1000 jacks corresponding roughly to about 40 jacks per square foot. Fig. 15 shows a typical position employing the proposed panel mounting method. Such a board will occupy a floor space of about 10 square feet and will take care of about 600 jacks, corresponding roughly to a capacity of 60 jacks per square foot.

This latter type of board is to be made up of a number of panel units which are to be assembled on two vertical supports. The principal types of units to be provided for the purpose are the keyshelf units, the jack mountings and the equipment panels which may be combined together as desired to give the necessary facilities.

Fig. 16 shows a typical keyshelf unit designed for the panel type board. By constructing the keyshelf unit as a separate piece of apparatus, it is expected to be possible to standardize the necessary types of keyshelves to fit all ordinary field conditions and to specify the desired type of keyshelf to go with any particular arrangement or number of jacks. The number of keyshelf units of any given type may be as desired for each installation, thus the proportion between the jacks and the keyshelf equipment may be suited to each type of office.

Fig. 17 shows a typical arrangement of the jack equipment and the mountings which are to be employed for the jacks. This type of jack mounting will make it possible to mount the jacks on the same sup-

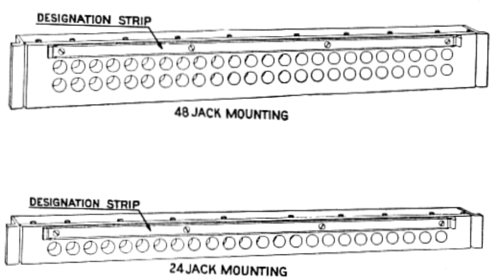

Fig. 17—Typical Assembly of Jack Mounts for Panel Mounted Test Board

ports as the testing equipment. The mountings are to be attached to the supports by fasteners, each occupying a vertical space of 1¾ inches and drilled to fit the usual drillings in the supports. This will permit the close association of the jacks with the desired testing apparatus. It will also be possible, by this means, to use for the jacks only such of the available vertical space as may be desired, the remainder being used for other equipment, thereby effecting economy in the use of the space. The arrangement is thus expected to be advantageous both in large installations, where the various groups of jacks are desired to be arranged at separate primary and secondary positions, and in small installations in which but a few jacks may be required for all purposes.

Fig. 18 shows the proposed assembly of a typical panel equipped with voltmeter, telegraph relay and sounder, such as are usually mounted above the jack field. The advantage of using the panel

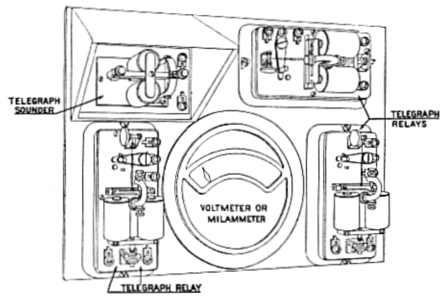

Fig. 18—Typical Assembly of Apparatus Panel for Panel Mounted Test Board

mounting for this equipment is expected to be the same from the standpoint of convenience and economy as that obtained from this method of mounting the keyshelves in relation to the various jack fields. It will permit the location of this equipment at any desired position and eliminate duplication at positions where this apparatus is not necessary. It will also permit flexibility in regard to the type of panel associated with a given jack field.

Signaling Equipment

The principal purposes of the signaling equipment in telephone lines are (1) to permit a subscriber to signal the central office operator, as he does automatically in removing the receiver from the switchhook, (2) to permit the central office operator to ring the subscriber's bell and (3) to permit the operators at different central offices to signal each other. At repeater stations this equipment serves to pass the signals around the telephone repeaters which might otherwise interfere with their transmission.

The switchboards in both the local and toll central offices have been provided with a source of 20-cycle current for signaling, as current of this frequency is suited to operate the subscriber's bell directly. This frequency has also been satisfactory for operating the signaling apparatus in the various local trunk circuits and in short toll lines without superposed telegraph. The introduction of superposed telegraph and telephone repeaters, however, has prevented

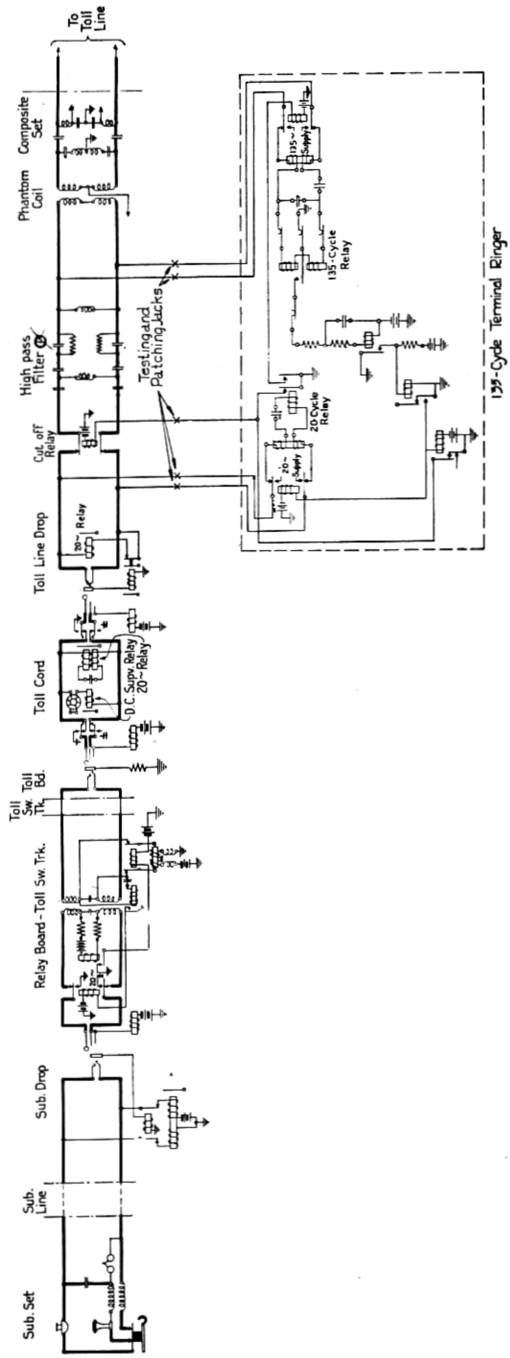

Fig. 19—135-Cycle Ringdown Toll Signaling System—Simplified Diagram

the use of 20-cycle signaling on many toll circuits. It has accordingly been expedient to use a higher frequency for the majority of these circuits, and the one which has been most generally used for this purpose has been 135 cycles. It is desired, therefore, to bring out here some of the more important features of the 135-cycle signaling arrangements which are being developed for cable systems.

The signaling equipment for cable systems has been required to meet more severe conditions than those ordinarily encountered on open-wire lines. In order not to interfere with the direct current telegraph system used on the cables, it has been necessary to limit the signaling current to a few milliamperes. Furthermore, the characteristics of the cable apparatus have been such as to attenuate the signaling currents to a greater extent than in open-wire systems. It has accordingly been necessary to undertake the design of signaling equipment of greater sensitivity, as well as to provide a source of supply of signaling current possessing a high degree of freedom from harmonics and capable of being closely regulated.

The desired increase in sensitivity of the signaling system is expected to be obtained through the use of a highly selective circuit in conjunction with a very sensitive 135-cycle relay. Fig. 19 shows the general scheme of the circuit which is being developed for the purpose.

It is seen that this includes a filter which may be inserted in the line circuit between the signal-receiving apparatus and the switchboard "drop" to give the desired terminal impedance at the signaling frequency, thus preventing the low impedance shunt on the signaling relay which would otherwise be caused by the "drop" circuit at a frequency as low as 135 cycles. The filter is arranged so that it need be inserted in the circuit only in such cases as may require the increased signaling range obtained in this manner, thus, it may be omitted on the shorter circuits where it is usually unnecessary.

The general circuit arrangement shown in Fig. 19 will permit the ready interchange of different types of signaling apparatus. With this arrangement of the apparatus, any "ringer" of any desired frequency combination such as 20–135 cycles, 20–20 cycles, 135–135 cycles, etc., may be connected temporarily to the system when desired. by means of "patching" cords, without requiring any changes in the permanent wiring.

Much of the sensitivity and selectivity which may be obtained with this signaling system are due to the design of the 135-cycle relay, As shown in Fig. 20, the relay is designed to make it capable of close and accurate adjustment. Both the magnetic air gap and the contact spacing may be adjusted, about 0.0015 inch or 0.038 millimeter being used ordinarily for the latter. The relay is mechanically tuned, the natural period of the reed with its adjustable weight corresponding closely to the frequency of the signaling current. A stop

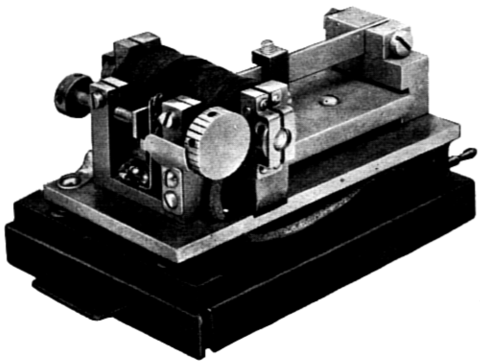

Fig. 20—Assembly of 135-Cycle Relay

pin is provided which prevents undue vibration of the reed due to transient impulses or excessive currents. Also, the relay circuit is electrically tuned by a shunt capacity and a series inductance and capacity. It is thus very selective and is relatively free from the ordinary sources of interference such as those caused by mechanical vibration, telegraph signals, switchhook impulses, voice currents, etc. The sensitivity of the relay is such that it will operate on as little power as 30 microwatts, corresponding to a current in the neighborhood of 0.25 milliampere.

This relay is to be mounted so that it may be inserted in the circuit or removed from it in the manner of a plug and jack, without requiring changes in the permanent wiring and without affecting the circuit operation, except to interrupt the signal-receiving system, while the relay is removed. Thus it will be very convenient to make the necessary adjustments of the relay separate from the circuit with which it may be associated in service. The relay will be well protected from mechanical interference, such as building vibration, by padding in the mounting which prevents rigid mechanical connection between the relay and its external support.

The assembly arrangements proposed for the new signaling apparatus are such as will fit in closely with the panel mounting methods designed for the remainder of the toll equipment in cable installations. Fig. 21 shows the assembly proposed for the new composite ringer set. This method of mounting the composite ringer

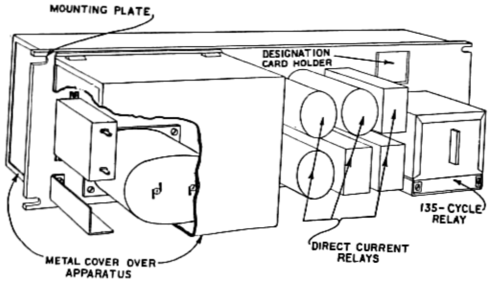

Fig. 21—Typical Assembly of 135-Cycle Composite Ringer Set

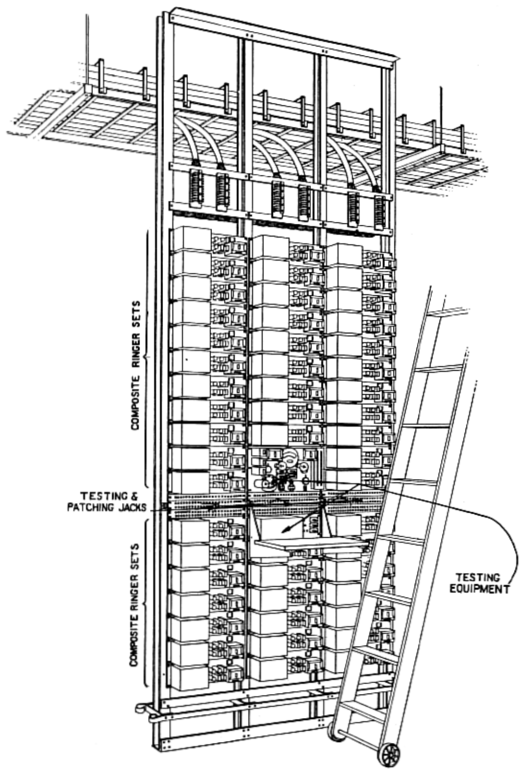

Fig. 22—Typical Assembly of Group of Composite Ringer Sets

set is a very desirable one since it permits a complete set to be manufactured as a unit and installed as such.

Fig. 22 shows the manner in which a number of these composite ringer panels are planned to be mounted together with the associated testing equipment in a large installation. This close association of the composite ringers with the jacks and testing equipment is expected to be of considerable advantage in facilitating the maintenance of the apparatus.

The need in cable systems of a particularly well-regulated source of 135-cycle signaling current, with sufficient capacity for a large number of lines, has made it desirable to undertake the development of both a special type of interrupter and a motor-generator for this purpose. Close frequency regulation is also very desirable in signaling over cable circuits, in view of the increased sensitivity in receiving which may be obtained by the use of very selective receiving apparatus.

Fig. 23 shows the circuit arrangement of the interrupter which is expected to be provided for this purpose. This includes a vibrating

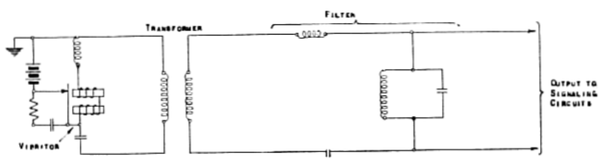

Fig. 23—135-Cycle Interrupter Circuit—Simplified Diagram

reed actuated by an electromagnet when direct current is applied. The contacts on the reed being in series with the battery circuit, intermittent operation is secured in the manner of an ordinary buzzer, the speed of operation for a given applied voltage being de-

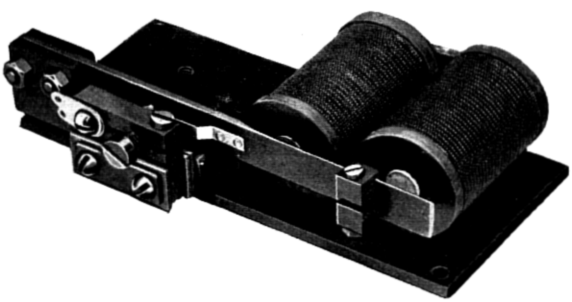

Fig. 24—Assembly of Vibrator for 135-Cycle Interrupter

termined by the natural period of the reed. The actuating circuit of the vibrator also includes the primary side of a transformer, the secondary side of which is connected to a filter for suppressing harmonics in the output. The maximum output capacity of the interrupter is about three-fourths of a watt.

Fig. 24 shows the vibrating element to be employed in this interrupter. This is equipped with an adjustable weight so that the frequency of the output may be regulated. For an input voltage variation of 20 to 28 volts, the output frequency will vary about 5 cycles.

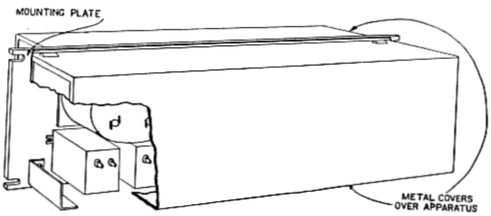

Fig. 25—Assembly of 135-Cycle Interrupter

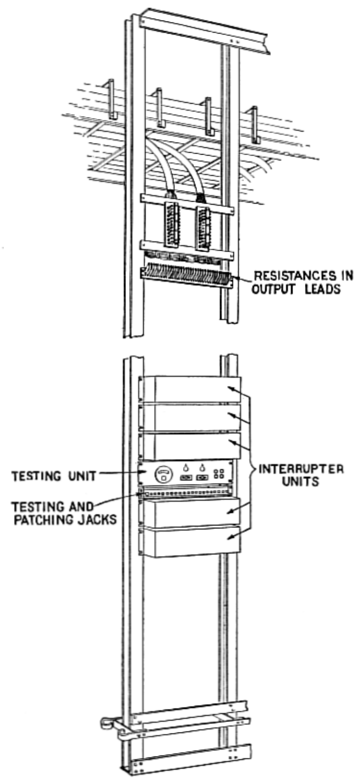

Fig. 26—Typical Assembly of Group of 135-Cycle Interrupters

Fig. 25 shows the assembly proposed for the complete interrupter unit. This includes the vibrator, filter, transformer, etc., mounted on a panel under metal covers. Fig. 26 shows a typical arrangement of a group of interrupters with the associated testing equipment. These assembly arrangements are uniform with those previously described for other types of equipment.

The 135-cycle motor-generator developed for signaling purposes is shown in Fig. 27. This outfit includes two motor-generators, one for regular service and one for reserve, on one panel, the control

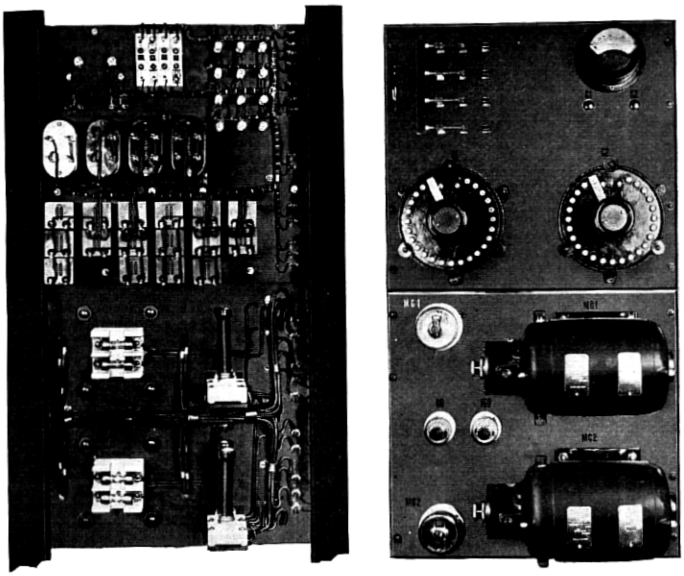

Fig. 27—Assembly of 10-Watt, 135-Cycle Motor-Generator Set and Associated Apparatus

equipment being mounted on a second panel. The output of the motor-generator, which is provided with a filter, is practically free from harmonics. Its voltage range is from 30 to 40, while its frequency range is from 133 to 137 cycles, including full load to no load conditions. The output capacity of this machine is approximately 10 watts.

General Assembly Arrangements

In the preceding descriptions some mention has been made of the panel assembly method which is expected to be used with much of the cable equipment. It might be well to speak briefly here of some of the features of this mounting method which are expected to have general application.

The large number of equipment units per station in the cable plant has been one of the principal factors in determining the requirements for efficiency in the design of the equipment. These requirements have been mainly (1) compactness in dimensions (2) uniformity in assembly arrangements and (3) simplicity in design.

To make possible the housing of the equipment for a cable installation within a building of reasonable dimensions, it has been necessary to economize carefully in space. Fig. 28 shows in a general

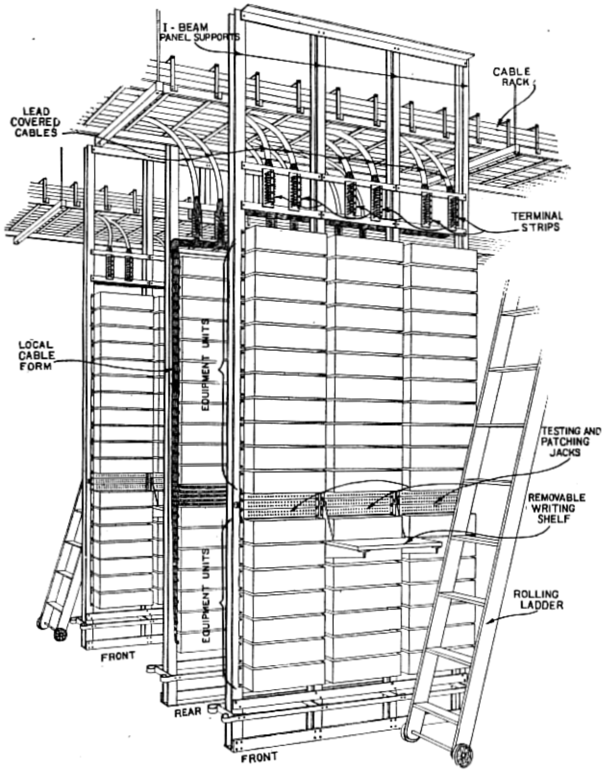

Fig. 28—General View Showing Typical Group of Equipment Units Employing Panel Mounting Method

way how the panel assembly method may be employed to accomplish this. As seen from this view, the equipment panels are assembled on vertical supports consisting of I-beams or channels which extend from the floor to the ceiling, rolling ladders being employed to reach the apparatus above when necessary. As has been shown in the preceding views of individual equipment units, all of the adjustable apparatus is mounted on the front of each equipment panel and the material not requiring adjustment when in operation is mounted on the rear, since by this means the rear aisles can be made narrower than the front aisles. Thus, all available space is utilized to the extent that the floor area required per equipment unit in a cable installation will be as small as the maintenance, manufacturing and installing requirements for the apparatus will permit.

In view of the many different types of equipment units having a variety of special functions which are required to make up a complete cable installation, a high degree of uniformity in design is necessary to permit efficiency in their use. It is expected that this will be accomplished effectively by applying the panel assembly method in a uniform manner to practically all types of equipment units. All panels are to be of a uniform length, designed to mount on vertical supports spaced 19½ inches between centers. The height of the different panels will vary, according to the amount of apparatus in each unit, but this vertical dimension is in all cases to be a whole multiple of 1¾ inches. By applying these specifications widely, it will be possible to secure interchangeability between panels and to employ uniform methods in grouping the different units, thus facilitating their installation and use.

The simplicity of the design of the equipment units comprising the various panels is also of great importance. This has necessitated careful attention to the forms of the individual pieces of apparatus, in order that these might fulfill their specific functions efficiently while at the same time fitting in well with the general equipment arrangements. To this end, new types of apparatus, such as repeating coils, retardation coils, etc., are being developed especially for cable use. Much will also be accomplished toward the simplification of the panels by carefully avoiding duplication in the accessories to the different types of equipment and by dissociating from the individual units of all types any pieces of apparatus capable of being made common to a number of units, or subject to different methods of application in different types of offices.

Other important advantages are anticipated in the panel assembly method. One of these is that it will permit the assembling together on one panel of all of the pieces of apparatus of different types which may be desired to form a distinct equipment unit. In large installations, completely equipped racks including a number of equipment units with the associated testing apparatus may be assembled in the factory on the supporting uprights and wired to the terminals at the top of the rack, thus simplifying the installation work. The location of the testing apparatus on the same rack with the equipment panels has the further advantage that it will place the apparatus to be adjusted within easy reach of the testing facilities. Furthermore, the testing apparatus will serve for the maintenance of a greater number of equipment units when all of the space between the floor and ceiling is utilized, thus reducing the amount of testing equipment required.