New Developments in Military Switching

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Plans for a new communication network for a military theater of operation were recently formulated. These plans include not only a number of presently available new facilities such as carrier and radio systems, but also a general switching plan together with means for its implementation. It is with these switching arrangements that this article is concerned.

A manual switchboard of advanced design is described in which many formerly manual procedures are mechanized. An orderly arrangement of switching centers and trunk groups provides for efficient usage of trunk facilities with alternate routes engineered as needed to minimize call delays.

The equipment design features considerable flexibility so that rearrangements to decrease or increase the size of a switching center may be accomplished with a minimum of effort. Rapid installation or dismantling is facilitated by limiting individual equipment packages to 250 pounds and by the use of patch cables which eliminate the need for soldering when an office is installed.

I. INTRODUCTION

Some years ago, following examination of the effectiveness of communication techniques and facilities employed in prosecuting World War II, plans were formulated for a new communication network for a military theater of operation. These plans comprise not only a number of new facilities, such as new carrier and radio systems now available and described elsewhere,* but also a general switching plan for a military theater together with means for its implementation. It is with these switching arrangements that this article is concerned.

* Bell Laboratories Record: G. Rodwin and G. H. Huber, New Military Carrier Telephone System, pp. 274–275, July, 1955; G. H. Huber, A Military Communication Network Using Wire and Radio, pp. 290–293, Aug. 1955; A. L. Durkee, New Military VHF-UHF Radio Set, pp. 382–384, Oct., 1955; and W. G. Hensel and Reinschmidt, AN/TRC-24 Radio Transmitter, pp. 428–431, Nov., 1955.

The problems involved in military switching, where mobility and adaptability are prerequisite, differ radically from those encountered in a commercial system. In a commercial system both central offices and stations remain comparatively fixed, thus permitting the use of a pre-engineered numbering pattern. A study of these problems and of available art indicated that automatic switching for a military theater would be difficult to realize at this time. Accordingly, development work was initiated on a manual switching system of advanced design which would to a considerable extent mechanize former manual procedures and provide many of the benefits of the automatic switching. At the same time the flexibility necessary of the shifting demands of military situations will be provided. Salient features of this switching system include:

(a) Adaptability to an orderly arrangement of switching centers and trunk groups so as to provide efficient usage of facilities with alternate routes as needed to minimize calling delays.

(b) Complete control and supervision of calls by the originating operator with automatic differentiation between the call status when the called party has not answered and when he has hung up. Through these and other features, the new switching equipment reduces operator time to about half that previously required.

This newly developed straightforward military switchboard has been designated "Manual Telephone Central Office". The switchboard, together with associated equipment developed on this and previous contracts, provides the necessary facilities for an integrated switching network for military theater communications.

GENERAL

II. FEATURES OF MANUAL TELEPHONE CENTRAL OFFICE

The central office is a universal, common battery switchboard developed for military use at both toll and local switching centers. It is arranged for use with a nominal 48-volt battery power plant. It is designed primarily for straightforward type trunking. However, special trunks are provided to connect to existing military switchboards. In addition, a combination line and trunk is provided to connect on a ring-down basis to magneto switchboards or lines. A special trunk is furnished which permits connection to a civilian local central office on a dial or manual basis.

The development model of this switchboard was subjected to military environmental and operational tests and was approved. While the development model was a three position, two hundred line board, the flexibility of the unitized equipment design permits a progressive growth to a maximum of twenty positions and fourteen hundred lines and/or trunks when using a four panel multiple.

III. SWITCHING CONSIDERATIONS

Civilian communications networks such as those used with the nationwide dialing switching plan of the Bell System are engineered with the assurance that the various centers comprising the network will be fixed as to location. The connecting trunk routes and the numbering plan will also remain comparatively fixed for some years.

A military theater of operations switching plan is difficult to establish with any assurance that the various centers comprising the network will remain fixed for any length of time. Accordingly the concept of a dial switching system for a military theater of operations was temporarily deferred in favor of an interim plan employing a manual system of advanced design.

The design requirements envisioned a manual switching system in which the straightforward mode of operation would provide the most desirable features of a dial system but which would be tailored to meet the needs of a fluid military situation.

The basic Military Straightforward Switching Plan is patterned after the Bell System Plan for nationwide dialing. The two plans are illustrated in Fig. 1 for ready comparison.

The basic switching plan for a military theater contains a complex arrangement of interconnected switching centers serving a variety of functions but integrated in an orderly sequence. Some of these switching centers serve important large areas and have trunk groups to all parts of the theater. Others cover more restricted and somewhat less important areas and depend upon centers higher in the chain of authority to reach points outside their own sectors. In diminishing order of rank or importance, the trunk switching centers in the military long distance network are zone centers, primary centers and secondary centers. Next below these are the local or end centers which are at the bottom of the long distance chain.

Magneto or tributary exchanges at which station loops terminate are next in order of rank below the local or end centers. They connect one loop to another or connect a loop to a tributary trunk which leads to the switching center for the area, or to a terminal trunk leading to another tributary exchange in the same local area.

From a systems engineering standpoint it is necessary to limit the number of switching points or links in a connection involving toll facilities. Reference to Fig. 1(b) shows that a call from the local center LC1 to the local center LC2 could involve six intermediate switching points and seven links. Such a call would be switched successively through secondary, primary and zone center and thence successively through a zone, primary and secondary center of the second area. This number of switches on a large number of calls would cause adverse reactions on service for two reasons. First, the number of switching points involving operators would increase the time required to establish the connection and, second, the over-all transmission loss which is the sum of the individual link losses would be too great for satisfactory transmission. Therefore, additional routes are provided for most calls of this type which bypass certain switching centers. The high-usage trunk group from secondary center SC1 to primary center PC2 in Fig.

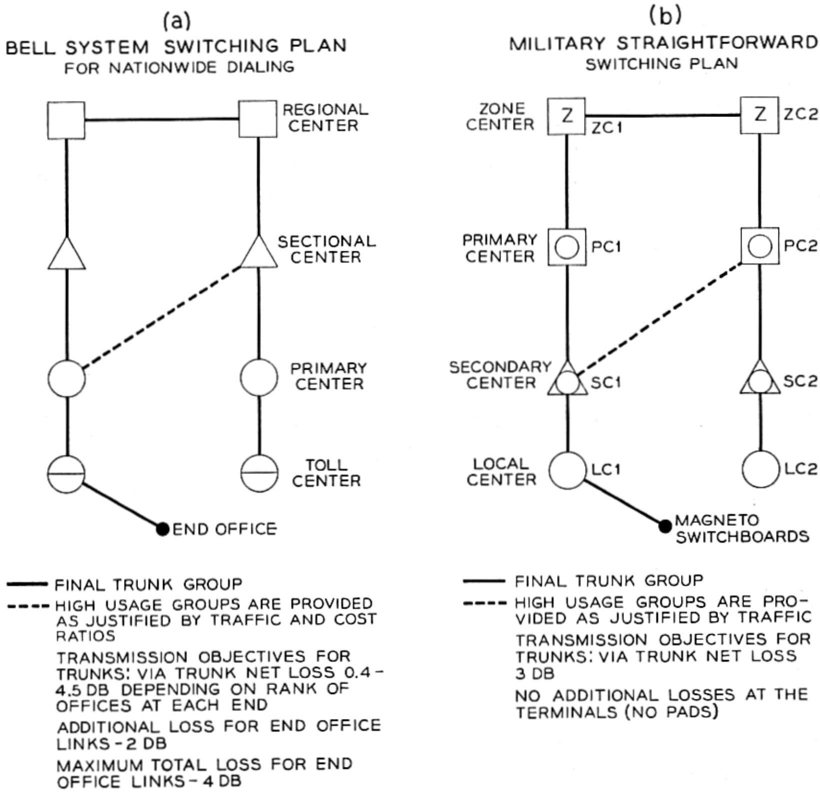

Fig. 1 — Comparison of Bell System Switching Plan for Nationwide Dialing and a new Military Straightforward Switching Plan designed to facilitate long-distance military traffic on an essentially "no delay" basis.

1(b) illustrates this type of trunk. Now a call from local center LC1 to local center LC2 would be routed successively through secondary center SC1, primary center PC2 and secondary center SC2. This routing over a high-usage trunk group reduces the number of switching points from six to three and the number of links from seven to four. This represents a 50 per cent decrease in operating time and almost a 50 per cent improvement in over-all transmission.

The example given above typifies the manner in which high-usage trunk groups are utilized. These trunk groups are provided on a tightly engineered basis. That is, they are engineered so that, during the busy hour, a considerable portion of the calls offered to them cannot be accommodated and must be diverted to different, alternate routes. The alternate route employs final trunk groups, and this may introduce one or more extra switches as compared with the more direct first choice routes. This method of trunk engineering results in a very efficient use of trunks in the high usage groups.

Final trunk groups shown in Figure 1(b) are engineered for low delay. That is, each group is provided with enough trunks to carry not only all of the first choice traffic offered to it, but also any overflow from high usage groups which may use it as part of an alternate route. The engineering objective is that, during the busy hour, an average of not more than three calls in 100 will find all final trunks occupied in any given group. With this low delay, it follows that the final trunk groups are used relatively inefficiently in the sense that many of the trunks usually will not be in use continuously during the busy hour. However, a combination of highly efficient high usage groups and relatively inefficient final groups results in an over-all plant with trunk efficiency comparable to that of a ringdown plant. While the number of switching terminations is increased, total network trunk mileage will be less than for ringdown plant giving comparable speed of service.

The type of long distance network described above must be evaluated from an over-all performance standpoint on the basis of the number of delayed calls during the busy hour. First choice routes for a large proportion of the total calls originated will consist largely of high-usage trunk groups. During the busy hour, these groups will be able to carry (with no delays) most of the the calls offered to them (in the order of 70 per cent). The remainder must be completed over alternate routes (final groups). Of these alternate routed calls, and those calls whose first choice route is over final groups, slightly more than three in 100 may be expected to encounter delays in obtaining trunks. Therefore, with a majority of the calls encountering no delays and only slightly more than three in 100 of the remainder encountering delays, the net result will be that, during the busy hour, throughout the network, less than three calls in 100 may be expected to be delayed because of all trunks being occupied.

IV. RANK AND FUNCTIONS OF SWITCHING CENTERS

The order of importance of a switching center tends to follow the rank of the unit or group with which it is associated. This is so, because the volume of traffic at the more important centers is roughly proportional in quantity and order of priority to the rank of the military unit with which the center is identified. The following paragraphs describe switching centers in descending order of importance.

4.1 *Zone Center*

A zone center is established in a military theater as soon as it becomes impractical to provide direct trunk groups between all long distance switching centers. Theater expansion may make it impractical to connect all long distance trunk switching centers to a single zone center. It is then necessary to establish forward and rear zone centers along the axis of communication. As the theater continues to grow the number of zone centers will increase but in any event each zone center in the theater must be connected by direct trunk groups with every other zone center if delays are to be minimized. While a zone center's primary function is to switch toll trunks, it may also take on some of the functions of a lower ranking center.

In Fig. 1(b), the zone centers correspond in importance and usage to the regional centers shown in Fig. 1(a).

4.2 *Primary Centers*

All local centers that are so situated strategically that they may be useful as through switching centers for other local centers are logical candidates for consideration as primary centers. To qualify they must either be fairly close to the zone center or have such a large volume of long-distance traffic to the zone center that a direct group of trunks can be justified. The function of a primary center is to serve as a concentration point for long-distance traffic of associated centers of lower rank.

As shown in Fig. 1, the primary center is the military equivalent of the Bell System sectional center.

4.3 *Secondary Center*

A secondary center functions to group a large volume of long distance traffic originating from many local centers geographically located around it. Such centers are established to economize on trunk plant which would be necessary between local centers and primary centers.

As shown in Fig. 1, the secondary center corresponds to what is known as a primary center in the Bell System plan.

4.4 *Local Centers*

Local centers serve as access points for calls between local networks and long-distance networks. Similar centers are known as toll centers in the Bell System toll switching plan. They are distinguished from other switching centers in the long-distance network in that they do not connect long-distance trunks together. A local center usually homes on a secondary center but in some instances, when strategically situated, it may home on a primary center or even a zone center.

Local centers are also known as end centers since they are located at the end of the toll axis of communication. As such they must be arranged to connect to a variety of lower echelon switchboards on a ringdown basis, the lower echelon switchboards usually being of the magneto type.

The plan, then, is arranged to provide an integrated long-distance switching network which allows for theater-wide toll switching operations with essentially no call delay. The layout of switching centers is so arranged that a minimum of toll links and toll switching points is used on most toll calls. This arrangement decreases the time necessary to set up a call and provides high grade transmission circuits.

Prior to the development of the plan herein described, most military toll traffic was engineered on a "ringdown" basis. Such a method of operation is time consuming in that on a multi-link connection each operator contacted must in turn ring forward to the next office in line. On disconnect the same procedure must be followed to release the multi-link connection. Also, any recall signals must be repeated by every intermediate operator in the connection.

The new plan speeds up the network operation by reducing the operator work time. The originating operator controls the setting up of a call until the called station is reached. An intermediate operator receives a verbal order from the originating operator, plugs into the desired trunk and has no further work to do on the call until a disconnect is received. Since automatic ringing is provided, the terminating operator also has no further work to do on the call until a disconnect is received.

Meanwhile, the originating operator has a positive indication that the called party has not answered since a "ringing" or "R" lamp is provided in the cord circuit which remains lit until the called party has answered. Since the originating operator will leave a call as soon as the terminating operator has plugged into the desired line, this "R" lamp will allow him to determine later whether the called party has answered. This avoids operator work time by eliminating the necessity for the originating operator to be associated with a connection or to monitor the connection at intervals to determine its status.

Furthermore, once a call has been established the originating operator receives switchhook supervision from both the calling and called party without any assistance from intermediate operators. If it becomes necessary, the originating operator may recall the terminating operator by actuating a ring-forward key. This recall does not involve any intermediate operators as it would in a "ringdown" plan. In fact the intermediate operators receive no indication that a recall has taken place.

When the calling and called parties both disconnect, the originating operator receives disconnect supervision. Pulling down both cords automatically sends disconnect supervisory signals to the next office in line until the terminating office is reached. Since the intermediate and terminating operators can pull down these connections without challenging on the connection and without ringing forward, the time required to take down a built-up connection is greatly reduced as compared to a "ringdown" system. Hence trunks can be engineered more tightly since the time to build up and release a connection has been reduced.

V. BLOCK DIAGRAM

Although many circuits were of necessity developed to realize the design requirements, only a few basic circuits are involved once an inter-office connection is established. These circuits are illustrated in block diagram form in Fig. 2 in single line notation.

Using Fig. 2 and starting in the upper left-hand corner a multi-link call can be traced through three toll switching offices equipped with switchboards. A common battery line is used at both the originating and terminating end of the call. The cord circuits provide interconnecting facilities at each of the switchboards with an operator telephone circuit bridged to each cord circuit. Interoffice channels are provided by the two-way straightforward trunks interconnected by carrier channels and associated signal converters. In Fig. 2, an alternate inter-office channel is shown using signal-extension circuits instead of a carrier channel.

It will be observed that the systems control board is shown between carrier facilities and the signal converters. This unit consists of a patching jack field and testing equipment. It provides access for testing and patching but is not actively involved in the connection.

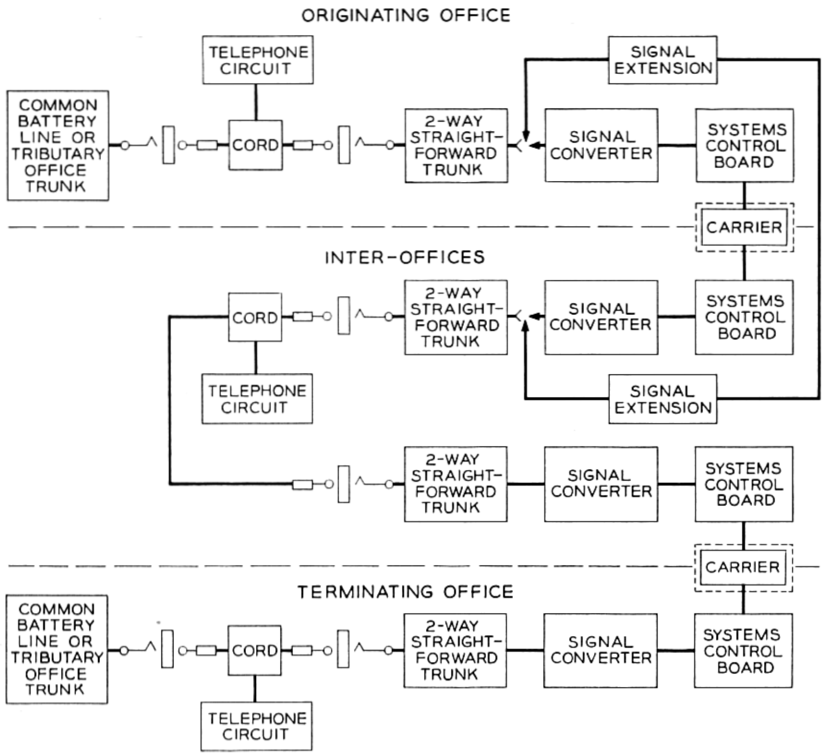

Fig. 2 — Block diagram showing inter-office connections.

VI. BASIC FEATURES OF THE CENTRAL OFFICE

The circuitry for the office may be divided into four general categories according to the functions performed. In the first category is the positional and face equipment which is used by the operator. This includes cord circuits, operator telephone circuits, holding and bridging circuits, local conference circuits, busy back circuits, and trunk and line jack appearances.

The trunk and line relay circuits comprise a second category. Although these circuits are associated electrically with the face equipment, the units themselves may be located as much as 25 feet away from the switchboard positions.

The power circuits include the 48-volt batteries, the battery charger and the power distribution circuits. This is the third category.

The fourth category covers the test and miscellaneous circuits. It includes the local test desk position, the systems control board used for toll test work, the portable relay test set, the trunk group register circuit, and the signal converters.

VII. POSITIONAL CIRCUITS

Each position consists of two half-position units mechanically and electrically tied together. A full position contains twenty cord circuits and two operator telephone circuits. Provision is made to split a full position so that two operators working side by side may handle heavy position traffic.

Each position is also arranged so that it may be used as a teletypewriter switching position when voice frequency teletype service is used. With this mode of operation the operator telephone circuit is replaced by a teletypewriter through appropriate switching and the regular straightforward trunks are used to transmit VF teletypewriter signals. When a trunk signal appears, the operator plugs a cord circuit into the associated trunk jack. The order is then typed on the position teletypewriter instead of being passed verbally. After reading the order, the position operator plugs into the desired trunk to complete the connection.

This type of operation was a design requirement for the over-all system. Therefore, the straightforward trunk and cord circuits were designed to limit distortion in the voice frequency band, so that VF teletypewriter and facsimile signals may be passed without undue distortion.

VIII. CORD CIRCUIT FEATURES

The universal-type cord circuit is a ten relay circuit arranged for automatic ringing, supervisory signals on both front and rear cords, visual indication that called station has answered, locked-in automatic flashing recall on rear cords and manual flashing recall on front cords, manual re-ring on called lines and trunks, and tripping of ringing during the silent interval after the called party has answered.

This cord circuit is used for station-to-station, station-to-trunk, trunk-to-trunk, and trunk-to-station calls. A low loss permalloy repeat coil is provided in the cord circuit. However, since the repeat coil must be bypassed on a trunk-to-trunk call to reduce transmission losses, means are provided to bypass automatically the repeat coil on this type of call.

The cord sleeve circuit consists of a marginal relay and a sensitive relay in series so that a low resistance trunk or station sleeve condition will operate both the marginal and sensitive relays whereas a high resistance sleeve condition is recognized by the operation of the cord sensitive relay only. In this switchboard all station and trunk sleeve conditions are low resistance with the exception of the straightforward trunk which has a high resistance sleeve condition. This circuitry, therefore, allows the cord repeat coil to be switched out on trunk-to-trunk connections involving straightforward operation. All other trunks are arranged to switch in the repeat coil since these other trunks are used to connect to tributary or terminating offices only.

IX. LINE AND TRUNK CIRCUIT FEATURES

The line circuit is a conventional common-battery, two-relay circuit.

The two-way straightforward trunk designed for this switchboard provides means for two-way service on a straightforward basis between switchboards. The circuitry is arranged to receive dc signals from the answer cord circuit over the "tip" lead and to transmit dc signals over the "ring" lead to the calling cord circuit.

On through connections when the repeat coil is switched out of the transmission path, a reversal is switched in between the "tip" and "ring" leads so that dc signals applied on the "ring" lead are transposed onto the "tip" lead at the opposite end of the cord.

Other features such as ac idle indicating lamps, locked-in disconnect, and capacitor-resistance terminations on the talking conductors in the idle or disconnect condition, are provided in the straightforward trunk design.

Trunk grouping is simplified by providing a grouping key with each trunk. A three-position toggle switch allows each trunk to be removed from a group of trunks, to be the first or intermediate trunk of a group, or the last trunk of a group. A "make busy" toggle switch is also associated with each trunk so that the switchboard appearance of a trunk may be made busy for maintenance purposes.

The straightforward trunk circuit has been designed as a two-wire trunk; that is, voice transmission in both directions takes place over the same pair of conductors. When used with carrier facilities which, for transmission reasons, are usually four-wire circuits, a signal converter is necessary to provide the hybrid coil used to derive a four-wire circuit from the two-wire trunk circuit. This mode of operation is more fully described in Section X.

As previously mentioned, it is possible to have two toll switching offices within a short geographic distance of each other. Provision of expensive carrier facilities between two such centers would not be economically sound in a civilian toll plant and would certainly be unsound for a military theater. Accordingly, a unit was designed which within certain limitations of distance would provide for the interconnection of straightforward trunks without using carrier facilities and associated signal converters. This unit is the signal-extension circuit.

The signal-extension circuit is the military equivalent of the Bell System signal lead extension circuit. Its use permits the interconnection of two toll offices on a loop or two-wire basis. The main component of the signal-extension circuit is a polar relay with four balanced windings. The windings of this relay are duplexed on the trunk conductor loop at each end in such a way that in the idle condition, battery and ground applied through the relay windings at each end does not allow the polar relays to operate at either end. When the trunk is seized at one end the battery and ground is reversed through the windings of the local polar relay. The local polar relay does not operate but at the distant end a similar polar relay does operate. This operation causes trunk seizure to take place. When the trunk signal at the distant end has been answered, the battery and ground through the distant polar relay windings is also reversed causing the local polar relay to operate as an off-hook indication. Since the polar relay windings are balanced, the tip and ring leads of the trunk loop remained balanced so that voice transmission over the trunk loop is not impaired by the imposition of the signaling voltages applied to the trunk loop through the polar relay windings. This particular type of signal-extension circuit is classified as a double-pole changer since the voltage applied to both tip and ring of the loop is changed to transmit signals over the loop.

Of course signal-extension circuits must be provided at both ends of the trunk loop with this arrangement. For short loops the saving in equipment over carrier-type operation is a very significant factor.

X. SIGNAL CONVERTER

When trunk loops between central-office installations exceed the design limits, loop signaling is no longer feasible using signal-extension circuits. Carrier facilities must be utilized for this long haul traffic. Since the carrier facilities in the military plan are four-wire facilities employing voice-frequency signaling and since the straightforward trunks are two-wire trunks employing dc signaling, it is necessary to provide a device which will make these two different types of facilities compatible on a system basis.

The signal converter was designed to perform this translation function. It is similar to the Bell System single-frequency signaling circuit and is an "in band" voice-frequency signaling device. On the four-wire side, signaling is accomplished by using two different frequencies, one for each direction. This is done to minimize the effect of signal echo currents. An "on-off" signaling arrangement is used, as in the Bell System counterpart, with the signaling tones "on" in both directions during the idle period and "off" on an established connection.

The converter includes a hybrid coil whereby the four-wire circuit for connection to carrier facilities is derived from the two-wire straightforward trunk appearance. Signaling tones are supplied by two vacuum tube oscillator circuits. The individual channel units, four per cabinet, are combination transmitter and receiver units in that the signal tone is applied to the transmitting side of the four-wire facility under control of the connected trunk circuit. Incoming signal tone or the absence of tone is recognized by the receiver side of the unit and is translated into dc supervisory signals to the connecting trunk. These units are not arranged to transmit dial pulses.

The circuit design of the converter is such that the nominal net trunk transmission loss between switchboards is limited to 3 db. This design permits the use of as many as seven links on a toll connection before the over-all transmission is impaired to the point where it is unacceptable to the military.

XI. TESTING AND MAINTENANCE FEATURES OF THE SWITCHBOARD

Basic design requirements for the switchboard and associated equipment stressed ease of maintenance. This requirement was met by utilizing an equipment design featuring readily removable units containing one or two circuits only. With this type of design, provision of replacement units makes it possible to relegate repair maintenance to a rear echelon maintenance depot. Such a maintenance plan can be successful however only if sufficient test features are provided at the central office to allow operating personnel to determine readily when an individual replaceable unit is defective.

Test and maintenance components provided are as follows:

1. A test desk position similar to an operator position, for making operational tests on lines, trunks and cord circuits.

2. A system control board for patching toll circuits (4-wire) and for making sectionalized tests and transmission measurements on toll facilities.

3. A portable relay test set for use in testing line and cord circuits in small offices where a test desk position is not justified.

4. A trunk group register unit which records trunk usage data for traffic study purposes.

In addition to the above mentioned test components, it is expected that standard test equipment now in general use will be available.

XII. POWER CONSIDERATIONS

Two main power sources are required to operate the central office:

1. A 115- or 230-volt ac source, and
2. A 48-volt dc battery source with the necessary ac rectifier to float the 48-volt dc battery supply.

The first power source may be derived from commercial power lines or from any one of the many available standard alternator sets.

The 48-volt dc power supply normally consists of four 12-volt storage batteries and a battery charger, or chargers, floated across the nominal 48-volt battery source.

Distribution of all the various power supplies to the relay units is accomplished through the equivalent of a power distribution board. This unit is known as the power supply control unit. In addition to providing the necessary outlets for distribution of ac and dc power, this unit contains a dc operated rotating ringing machine which provides ringing current and the ringing interruptions required.

XIII. BATTERY CHARGER

Three 10-ampere rectifier units are provided for each three switchboard positions and associated relay equipment.

The switchboard may include a maximum of 20 positions and provision is, therefore, made to multiple together both the 48-volt storage batteries and the battery chargers.

The battery chargers are so designed that one or more chargers may be used during light load periods to charge the spare set of storage batteries which will be provided.

Each battery charger provides a closely regulated dc supply for the floating battery at 48–52 volts dc or for battery charging at 57.5–62.5 volts dc. It operates on 115/230 volts ac, 50- or 60-cycle, single-phase power.

XIV. POWER SUPPLY CONTROL UNIT

One control unit per three positions is provided. This unit furnishes the necessary power connections for all types of power used in the central office. Facilities are included for multipling to similar power plants. It is at this point that the prime source, 115 or 230 volts ac, is connected for system wide distribution.

XV. SWITCHBOARD POSITIONAL EQUIPMENT

The basic switchboard position unit is packaged in a half-section sheet-metal container. Each container has rain proof, removable front and back covers. Half-section units are utilized to keep package weights below 250 pounds.

A full position comprises two identical half-section units mounted side by side and held together by the keyshelf extension, the multiple rack, and the position power adapter supply. The first line up of equipment shown in Fig. 3 shows how the positions are assembled. In this illustration the three positions to the left are operator positions while the extreme right hand position is a test desk position. Fig. 4 shows a rear view of the same equipment. Rear covers are removed on the right-hand position to show the manner in which cord packs are mounted in the half-section cases.

Each half-section case contains five cord packs or ten cord circuits. Shock-mounted plates, top and bottom, protect the relay equipment from shock and vibration in transit. An individual cord pack with the gasketed sheet-metal cover removed is illustrated in Fig. 5. Each vertical row of 10 relays is associated with one cord circuit. When the cover is in place it protects the relays from dust and mechanical damage.

The keyshelf extension shown in Fig. 3 provides a working surface for the operator and contains two operator telephone circuits. These units are of the plug-in type for ease of maintenance. The top of the keyshelf is 30 inches above the floor level thereby providing a comfortable desk height working level for the operator. Special operator's chairs are not necessary since any desk chair available will be satisfactory.

The position dial and dial cord unit is mounted in the middle of the keyshelf between the two half-section cases for use with civilian office dial trunks.

XVI. MULTIPLE RACKS

All line and trunk circuits must have lamp and jack appearances in the face of the switchboard to provide operator access. The lamps and jacks are packaged in groups of twenty appearances. Such units are known as line or trunk packs. Since each trunk pack appearance has an idle-indicating lamp as well as a trunk answer lamp, the over-all height of the trunk packs is greater than the line pack which provides only answer lamps. This difference in height necessitates two different multiple racks in which the line and trunk packs are mounted. In the illustration, the left position is equipped with only five line packs, and spacers fill up the five unused pack positions.

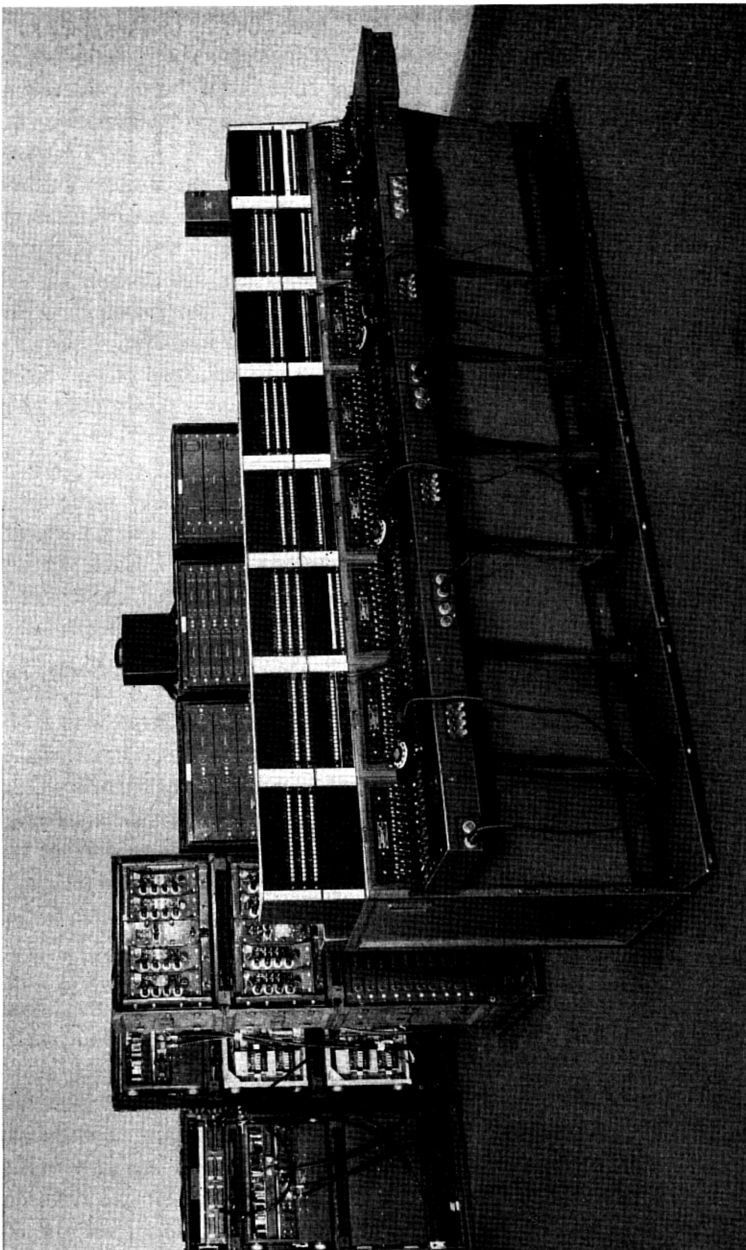

Fig. 3 — Typical three-position installation showing the preferred arrangement of switchboard and associated equipment.

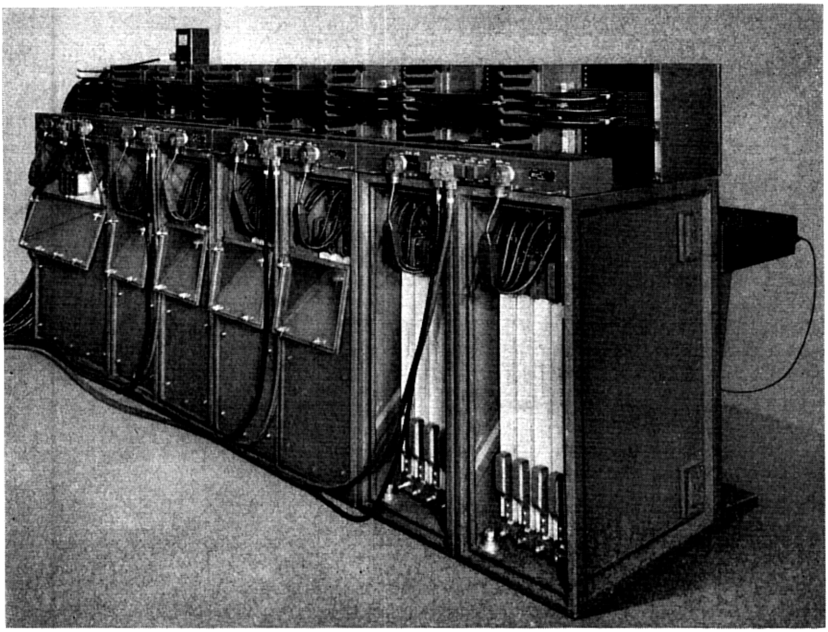

Fig. 4 — Rear view of switchboard position line-up. The right-hand position has both half-section rear covers removed to display the manner in which cord packs are mounted in position cases. The line and trunk multiple mounted on the top front of the position cases shows the orderly manner in which multiple cables are racked.

The rear of the multiple racks is equipped with removable cable racks which hold the multiple patch cables in an orderly fashion. Fig. 4 shows the rear of the position line up with the switchboard multiple on the top of the positions. In this instance a four-panel multiple was used. That is, a particular line or trunk appeared in every fourth panel, there being two panels in front of each full position. Multiple cables have been designed for a four panel multiple but if it is more desirable to confine all trunk and line appearances to one position, a two panel multiple may be installed. Such an arrangement would be suitable for a small office but a large office would undoubtedly require more lines and trunks and hence a four panel multiple.

XVII. GENERAL PURPOSE CASES

Portability and flexibility were the determining factors in the design of the carrying cases for the central office. To meet the desired objectives, five different size carrying cases are provided.

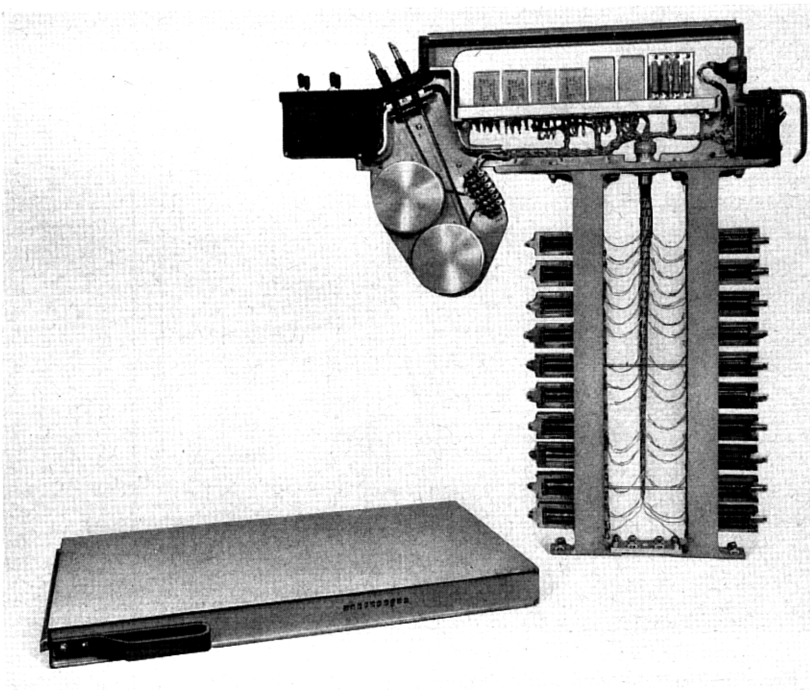

Fig. 5 — Switchboard cord pack containing two cord circuits with the dust cover removed.

Both multiple racks span a full switchboard position. Protruding "V" blocks on the base of each rack recess within indented slots in the position cases. Thumb screws provide means for fastening the multiple rack to the position. Successive multiple racks are fastened by similar means to the lower racks.

The trunk multiple rack is arranged to hold six trunk packs or 120 trunk appearances. The line multiple racks have a greater height and hold ten line packs or 200 line appearances.

The height to which the switchboard multiple may be raised is limited by the height at which an operator may readily see a lighted lamp. Because of this, the multiple is limited to 440 trunks and 960 lines. In an emergency, as many as 40 additional lines could be added with only a slight degradation in service.

Fig. 3 shows the trunk and line multiple fastened on the top of each position in the first line of equipment. In this illustration the multiple rack resting on the position cases is a trunk multiple rack in the position at the left but it contains only one trunk pack instead of the full complement of five. Spacers are provided to fill up the unused pack positions.

The top multiple rack is a line multiple rack.

Since the general-purpose cases used for mounting relay equipment were required to stack one upon another as shown in the rear lines of equipment of Fig. 3, it was necessary to make the base dimensions uniform and to vary the height to accommodate the varying amounts of equipment. Also to facilitate stacking, interlocking cleats or registering plates were riveted to both bottom and top surfaces of these general purpose cases to prevent slippage when stacked. Separate clamps were also designed which clip to the edges of adjacent cases when stacked to hold the stack in both a horizontal and a vertical direction.

Stiffening channels on the insides of the sheet-metal cases are provided. This is necessary to insure a rigid case, since it is necessary to remove both front and back covers before stacking. These channels also serve as points of attachment for shock mounts which hold all interior frameworks upon which relay equipment is mounted.

All cases feature an arrow-head type construction on all edges. These arrow heads absorb sharp blows on the case edges to prevent deformation of the case proper in transit. Four of the five types of cases are shown in Fig. 6 with both covers in place.

One of the five types of cases mentioned is provided to store the numerous quick-disconnect patching cables used throughout this system. These cases are equipped with means for holding down cables and components during shipment so that no damage occurs. These cases are also equipped with a special cover which when mounted flat provides a mounting base for the relay unit stacks. These bases may be observed in the two rear line ups of relay units shown in Fig. 3. Since these bases

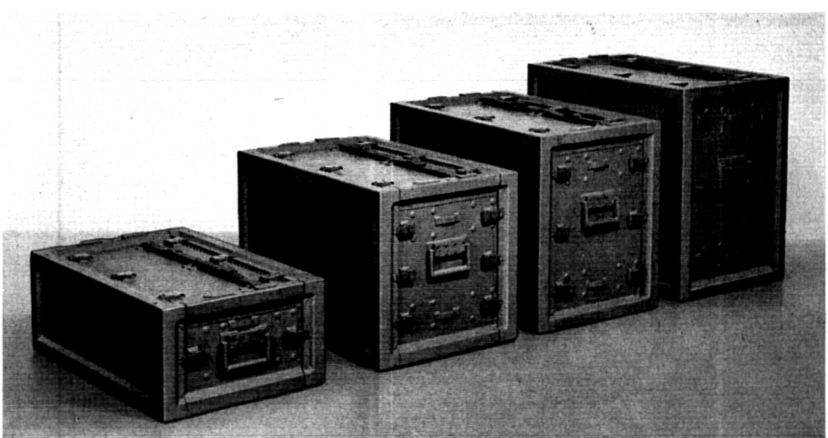

Fig. 6 — Typical general purpose cabinets. Front and rear covers are both removed when the office is installed.

provide about six inches of space under the first unit of a stack, spare cable may be dressed into them both for appearance and safety.

XVIII. UNITIZED RELAY MOUNTINGS

A unitized relay mounting is provided which permits rapid replacement of a defective unit without the necessity of unsoldering wired connections.

Three types of plug-in units were designed to package the eight different circuits. These units feature a multi-contact plug which mates with multicontact jacks mounted in a multi-unit framework. This multi-unit framework is shock mounted in the appropriate size of general purpose carrying case. Typical examples of these units are shown in Fig. 7.

Each plug-in unit is covered by a gasketed sheet-metal cover which protects the relays and other apparatus from moisture, dirt and dust. The plug-in units are mounted on stainless steel slides riveted to the framework and are held in place in the framework by means of quick-disconnect fasteners. Although three basic designs are used, the individual apparatus mounting plates may be drilled in a variety of ways to accommodate the various types of apparatus employed.

A typical trunk framework is shown in Fig. 8. This framework is shock mounted in a general purpose carrying case. Twenty trunk units

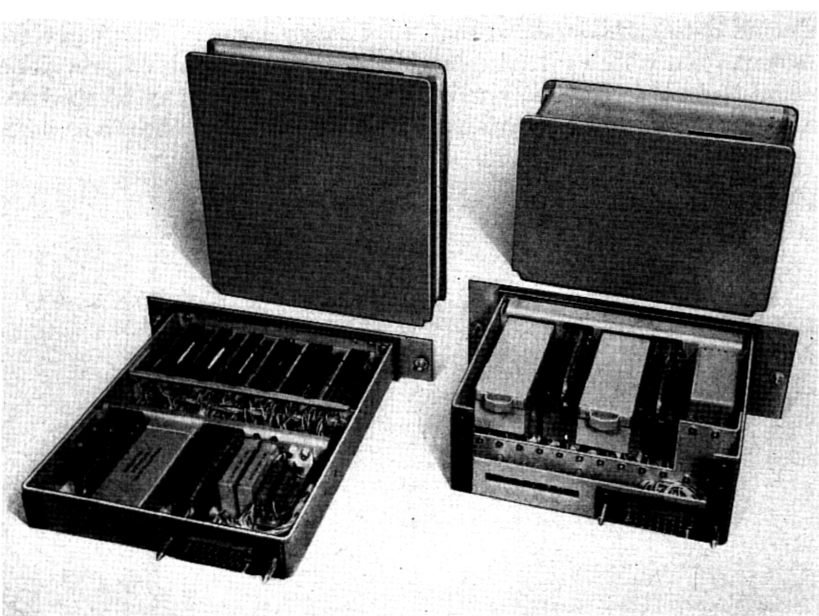

Fig. 7 — Typical plug-in type trunk units with dust covers removed showing in detail the manner in which apparatus is mounted.

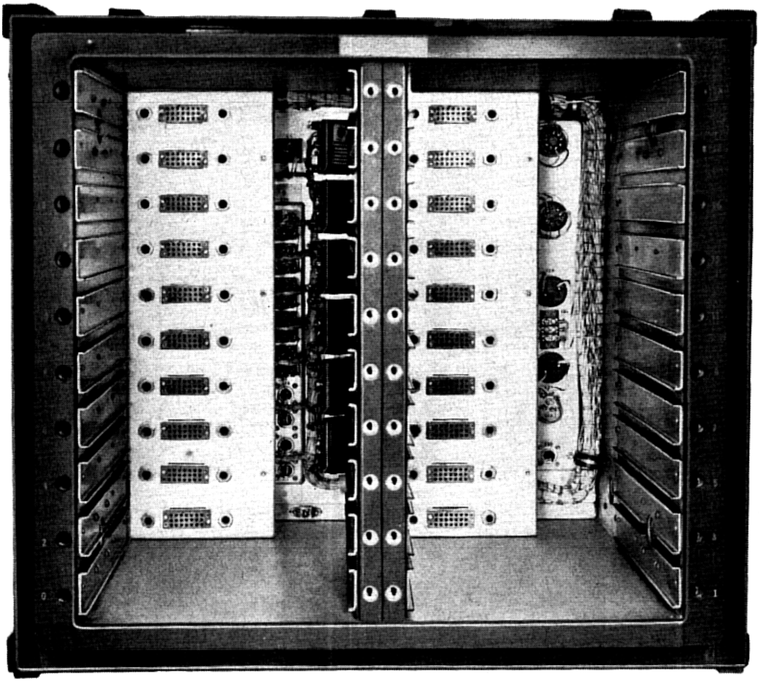

Fig. 8 — Trunk cabinet with the twenty plug-in trunk units removed to show interior construction of cabinet.

mount from the front of this cabinet as shown in Fig. 9. All power distribution and interconnecting leads are brought out on a hinged door on the rear of the unit. Therefore with this type of design, all cable connections are made at the rear of the cabinet but all plug-in units are removed from the front of the unit.

XIX. FIXED INSTALLATIONS

The central office meets military conditions where mobility and adaptability are prerequisite. Individual units are designed in such a manner that many physical arrangements are possible to meet the variety of conditions that may be encountered. In general, the tactical situation will be such that a permanent installation will be feasible. If such is the case, the floor plan arrangement shown in Fig. 3 is applicable. In this illustration a three position office together with the necessary power and relay equipment is located in an 18 by 21 ft. area. The typical layout is so arranged that all cable patching can be accomplished using a maximum cable length of 25 ft.

Previously, reference has been made to Fig. 3 to clarify the multiple-

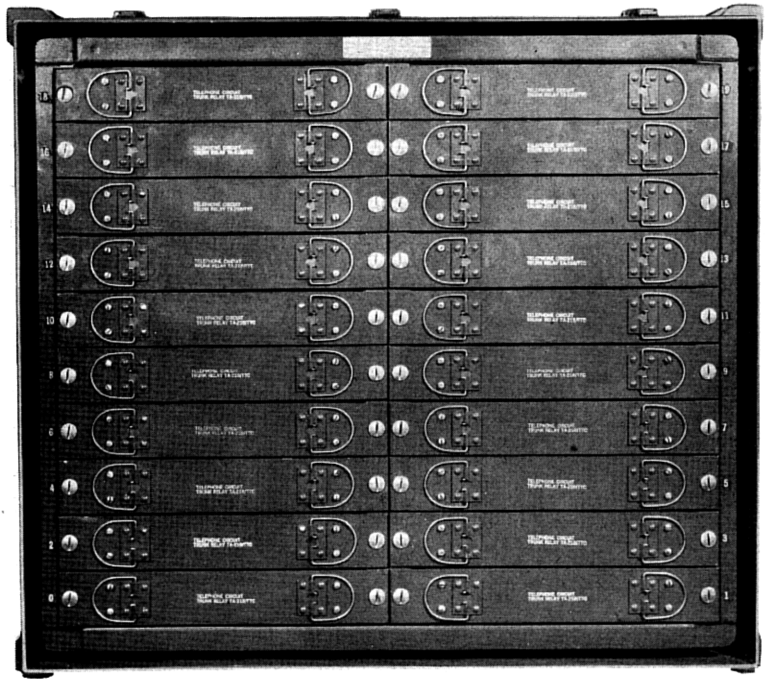

Fig. 9 — Two way straightforward trunk cabinet equipped with twenty trunk units. Individual trunk units may be removed from this side by releasing two fasteners.

rack arrangement. This figure also illustrates the manner in which a fixed installation may be set up. The first line of equipment from left to right shows three identical operator positions. The position at the extreme right is a test desk position used for maintenance purposes.

The second line of equipment in Fig. 3 on the extreme left shows partially two units of signal converters stacked upon a unit containing 20 trunk circuits. The remaining units in the second line-up partially display other trunk units and at the extreme right part of a unit containing 100 line circuits may be seen.

The third line of equipment does not show well except at the extreme left end. The first stack of units shows the cabling side of the systems control board used in making transmission measurements on toll facilities. Not visible in the third line-up are the main distributing frame and the various power units.

XX. MOBILE INSTALLATIONS

Details have been designed which would permit a complete central office to be mounted in a truck and a semi-trailer.

XXI. MAINTENANCE

Ultimately, all detailed maintenance on units of the central office will be handled at a repair depot except for some small maintenance jobs such as lamp or vacuum-tube replacement or the replacement of an equipment unit. To facilitate this type of maintenance all units are readily removable in groups of one or two circuits. The line unit is an exception in that the smallest plug-in assembly houses twenty circuits.

XXII. CORD REEL

Conventional switchboard designs in the Bell System employ 6-foot switchboard cords which hang down from the keyshelf in a cord pit. The cords are kept in position by the use of pulley weights on each cord. Such a design is not acceptable for military use because the space is not available for cord pits and frequent cord rebutting is not tolerable.

A new method of storing the switchboard cordage was developed as shown in Fig. 10.

The design of the cord pack on which this cord reel is used permits cord reels to be assembled on a mounting plate in groups of four, thereby providing the necessary switchboard cords for the two cord circuits housed in one cord pack. These assemblies include reels, cords, plugs, and connecting blocks which permit complete shop assembly and pre-tensioning of the reels prior to final assembly. Fig. 5 shows the manner in which cord-reel assemblies are fastened to cord packs. This method also permits rapid replacement of defective cord reel assemblies without removing the dust covers on the cord pack.

XXIII. 52-CONTACT CONNECTOR

A 52-conductor connector, shown in Fig. 11, is used to interconnect the various units. The receptacle, which mounts in the various units, has stationary contact pins. The cable connector, however, employs a spring-loaded solid pin to which the cable leads are connected. When the cable connector is tightened down on the receptacle, shown in the lower left-hand corner of Fig. 11, the spring-loaded terminals maintain adequate pressure at the point of contact. An additional feature is that a second connector may be attached to the first connector. Fig. 12 illustrates this connection as employed at the line and trunk multiple.

Fig. 10 — Cord reel assembly showing the switchboard cords in the retracted position. This assembly provides access to two cord circuits.

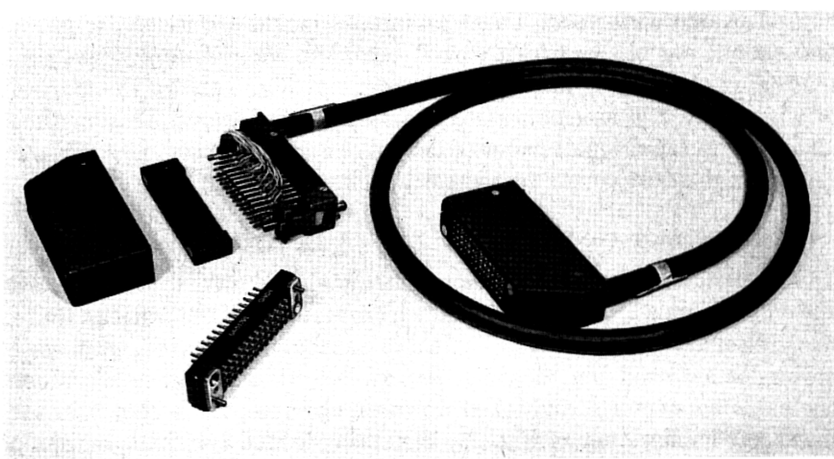

Fig. 11 — Patching cable assembly showing the method of terminating the cable on the 52-pin connectors. The connector in the lower left-hand corner is the mating connector which mounts in each unit and to which the patching cable connects.

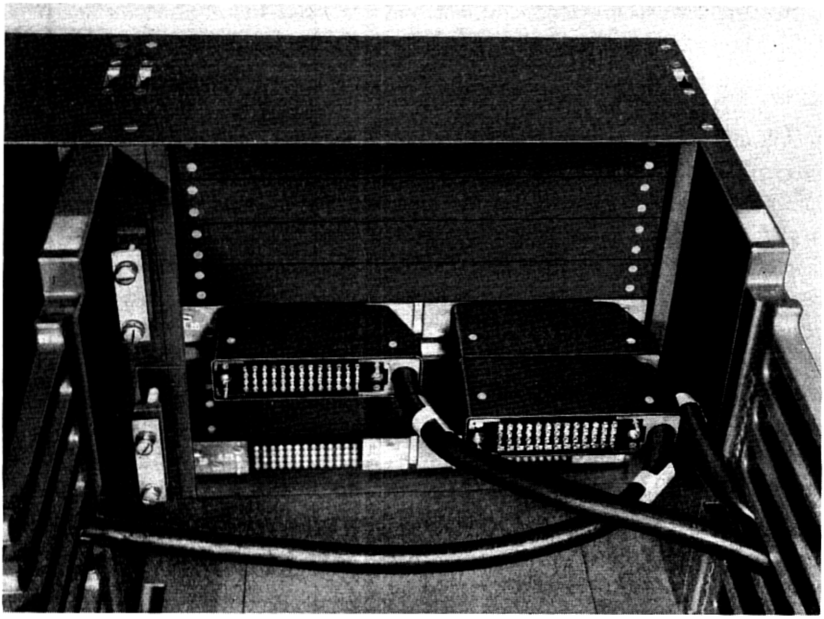

Fig. 12 — Rear view of a line and trunk multiple showing on the right-hand side the manner in which 52-contact connectors are used in establishing multiple trunk and line appearances in the switchboard.

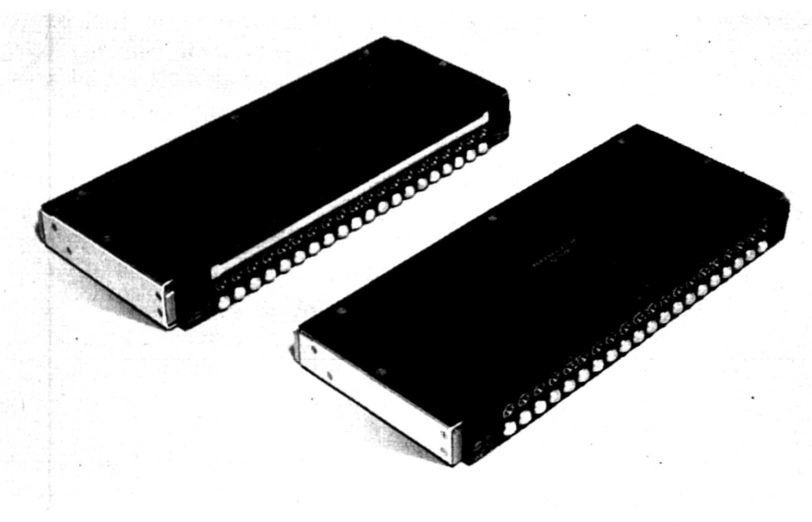

Fig. 13 — Trunk and line packs each containing twenty jack and lamp appearances. The pack on the left is a trunk pack, that on the right a line pack. Connection is made via two 52-pin connectors not shown here but mounted on the rear of each pack.

Soldered wire-wrapped connections are used for connecting wires to both the cable plug and the unit terminal receptacle.

XXIV. LINE AND TRUNK PACKS

Although the relay equipment for line and trunk circuits is located in carrying cases stacked near the switchboard line-up, provision must be made for the jack and lamp appearance of each line and trunk circuit in the switchboard multiple. The switchboard features self-contained line and trunk appearances in which each pack contains twenty line or trunk appearances. These packs are each equipped with two 52-contact connectors to provide for patching to the relay equipment and to the next multiple appearance. These packs are front mounted in multiple racks designed to accommodate them, and are held in place by removable number plates.

The answer lamps in each line or trunk pack are arranged to feed through a switch mounted in the face of each pack in groups of ten lamp appearances. This permits traffic-load control by providing a means of opening answer-lamp circuits in groups of ten lamps by operating a slotted switch from the face of the multiple. This switch may be operated either by means of a screw driver or a coin.

Fig. 13 shows the two types of pack provided. The pack at the left of the illustration is a trunk pack. The idle-indicating lamps are located under the top horizontal strip on the face of the pack. This strip is translucent allowing a lighted idle-indicating lamp to be seen by the operator. The second horizontal strip shows the 20 lamp caps for the 20 trunk answer lamps. In line with the lamp caps at each extreme end may be seen the slotted switch which actuates switch contacts to open up ten lamp circuits at a time for load control.

The pack shown at the right in Fig. 13 is a line pack. No idle-indicating lamps are provided, thereby reducing the thickness of the line pack over that of the trunk pack. The lamp switch arrangement, however, is the same as that used in the trunk pack.

The design of the line and trunk packs also provides ease of maintenance in that a defective pack may be removed from the front of the switchboard without disturbing adjacent line and trunk packs.

XXV. ACKNOWLEDGEMENT

The development of the switchboard and associated equipment involved numerous departments both at Bell Telephone Laboratories and at the Kearny works of the Western Electric Company. It was the teamwork, knowledge and ability of all which produced the final design.