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## *Remreed Switching Networks for No. 1 and No. 1A ESS:*

# Physical Design of Remreed Switching Networks

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*Five new switching frames have been designed for use in No. 1 and No. 1A* ESS *central offices. These new frames utilize the recently developed remreed sealed contact and are equipped with electronic network controllers. The new remreed switching frames occupy approximately one-quarter the floor space required for the ferreed switching frames that they replace. Other design features include improved maintainability, reduced installation interval, and reduced cost. This paper describes some of the more significant physical design features incorporated in these five new frame designs.*

## I. INTRODUCTION

Manufacture of the ferreed switching frames originally designed for use in No. 1 ESS central offices[1,2] is being phased out in favor of the new remreed switching frames. These five new codes of remreed frames are shown in Figs. 1 through 5 and provide the basic building blocks from which all line link and trunk link network configurations are constructed. These new frames make use of the recently developed remreed sealed contacts,[3] new all-electronic network controllers, and the new 1A technology packaging hardware.[4,5] Basic line link and trunk link network switching functions performed by the remreed frames were constrained[6] to be identical to those performed by the ferreed frames they replace.

Basic physical design concepts for the line link network configurations were developed at the same time the remreed trunk link network was being designed. This approach enabled us to take advantage of the commonality of apparatus and hardware piece-parts such as circuit packs, control units, mounting plates, grid-support hardware, wiring troughs, etc. The apparatus and piece-part commonality achieved be-

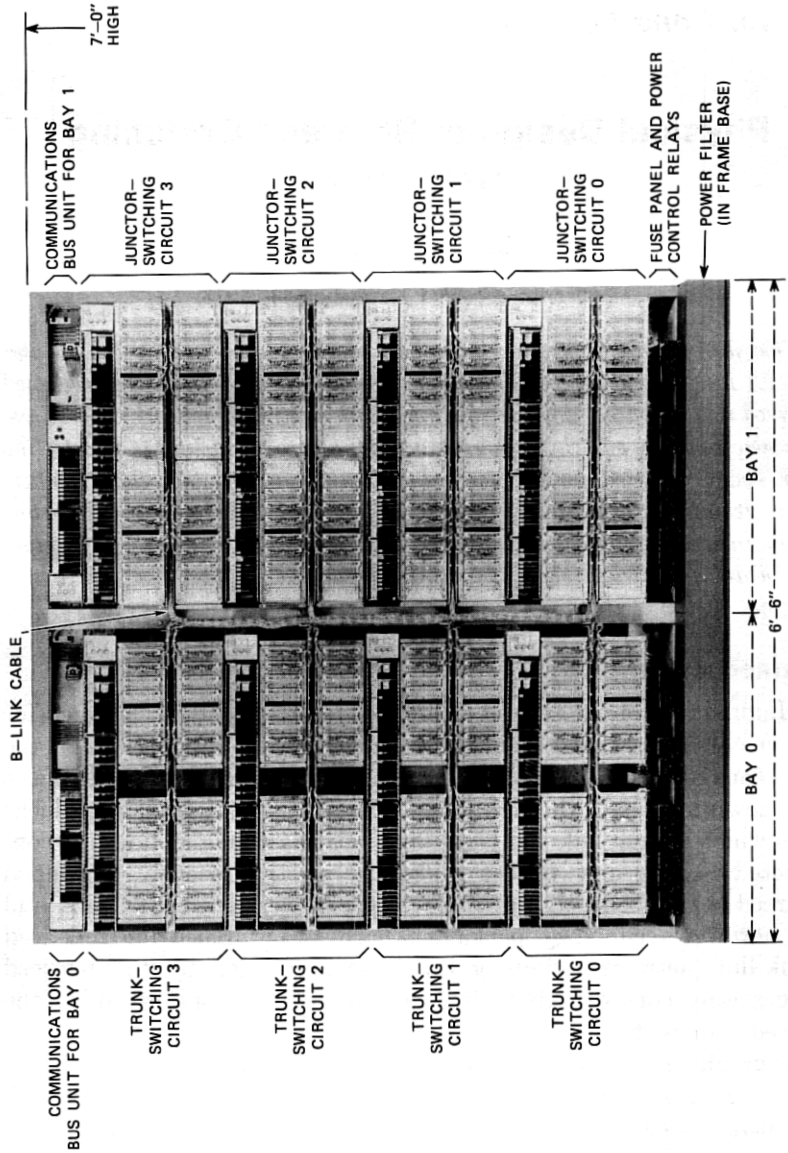



Fig. 1—Trunk link network frame (1024 trunks with 1:1 trunk-concentration ratio).

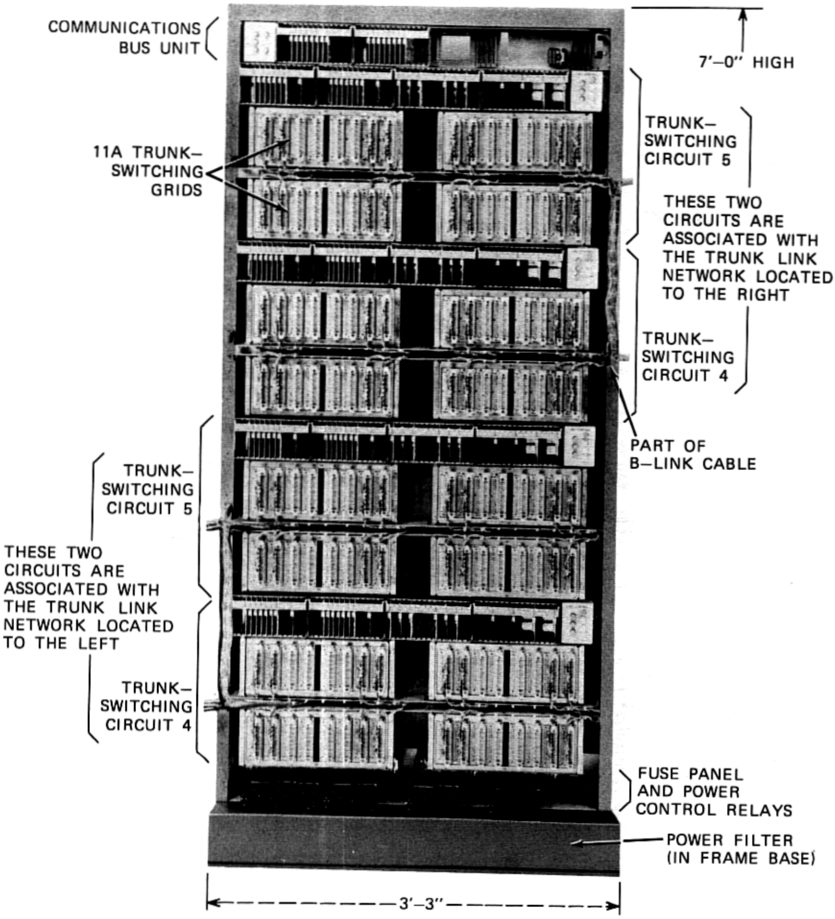



Fig. 2—Trunk-switching frame (shown fully equipped to provide additional trunk-switching circuits required for two different $1\frac{1}{2}:1$ trunk link networks).

tween the five remreed frame codes becomes quite obvious when Figs. 1 through 5 are compared.

## II. TRUNK LINK NETWORKS

### *2.1 Trunk link network frame*

Remreed trunk link networks are available in three basic configurations. These are the 1024 two-wire trunk link network with a 1:1 concentration ratio, the 1536 two-wire trunk link network with a $1\frac{1}{2}:1$ concentration ratio, and the 2048 two-wire trunk link network with a 1:1 concentration ratio.[1] The remreed trunk link networks represent a 4:1 space saving over the ferreed networks they replace. Other

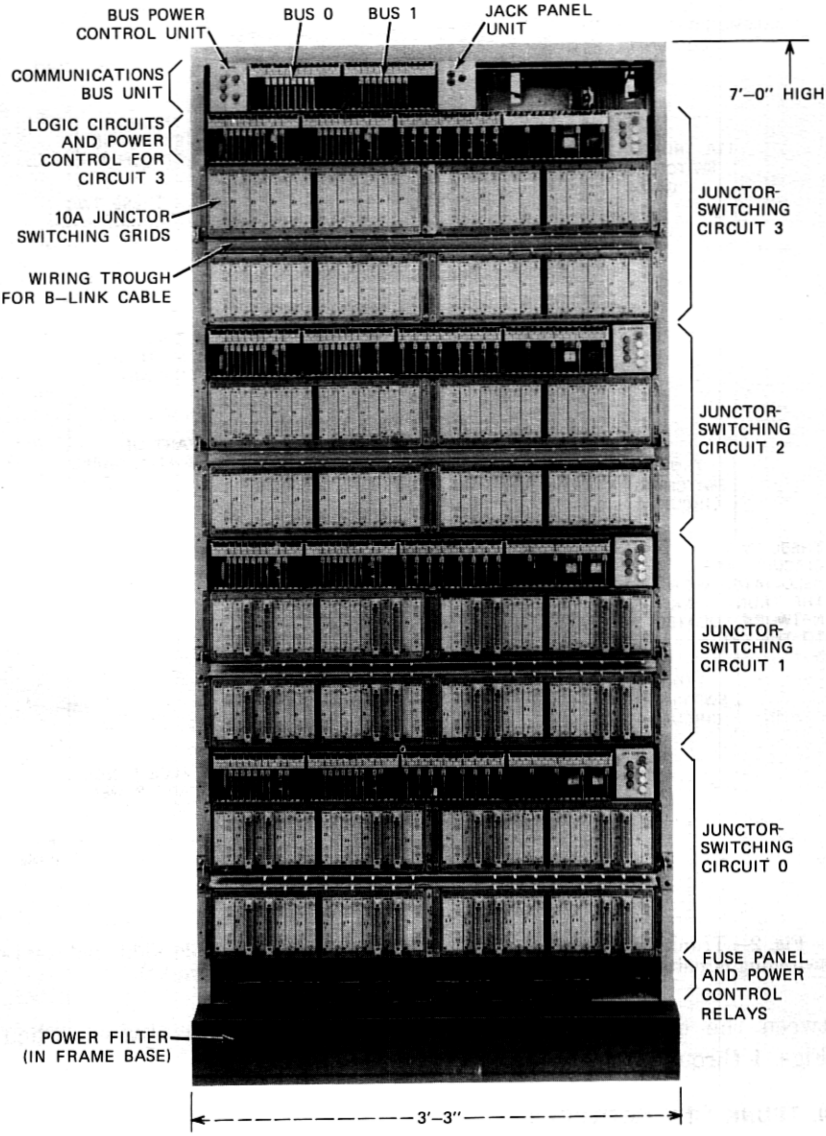



Fig. 3—Junctor-switching frame.

design features include improved maintainability, reduced installation interval, and reduced cost. The 6-ft, 6-in. TLN frame shown in Fig. 1 is the basic building block for the three trunk link network configurations. Some more significant physical design features incorporated in this equipment unit are as follows.

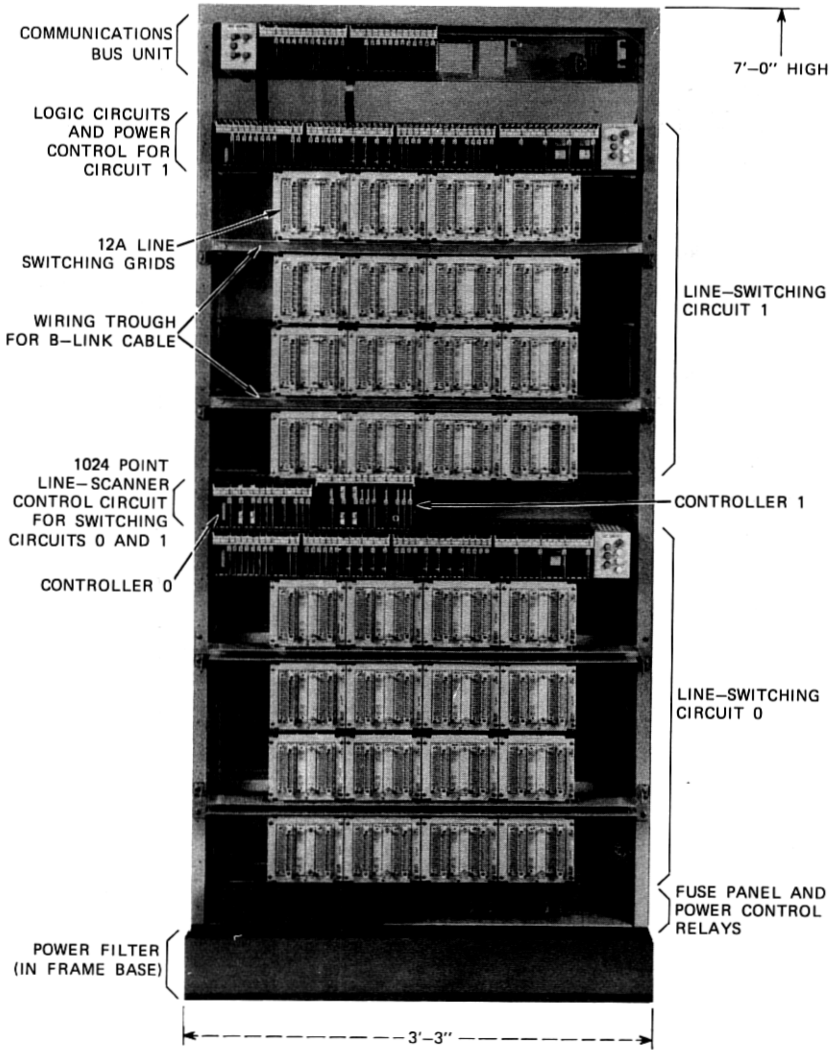



Fig. 4—Line-switching frame (for 2:1 line-concentration ratio).

### 2.2 Frame organization

A standard double-bay framework 7 ft high by 6 ft, 6 in. wide by 1 ft deep is used to provide the necessary frame-mounting space for the control, switching, power-filtering, fusing, alarm, and maintenance circuits. Equipment arrangement on the frame is, for the most part, in keeping with the standard pattern used on all No. 1 ESS frames. Communication bus circuitry, terminal strips, and power feeders are

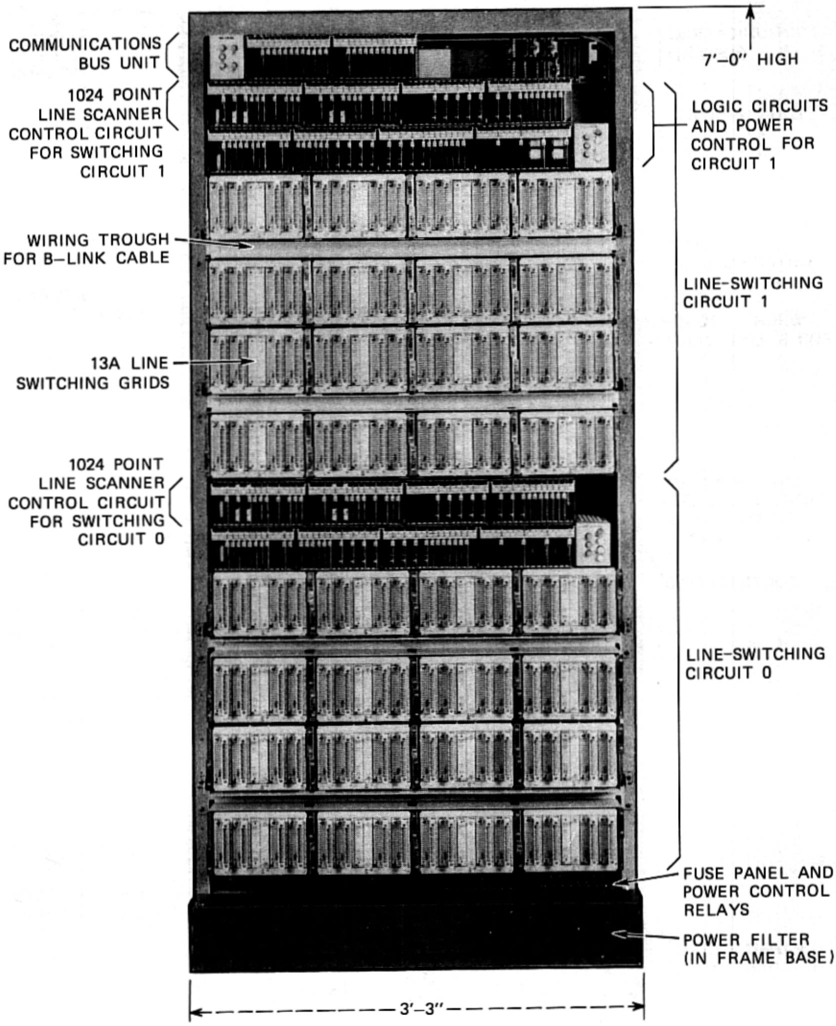



Fig. 5—Line-switching frame (for 4:1 line-concentration ratio).

located at the top of the frame and the power filters, fuses, and power-control relays are located at the bottom of the frame. The remaining frame space is utilized to support the switching and control circuits as outlined in Fig. 1.

Four identical trunk-switching circuits are provided in bay 0 and four identical junctor-switching circuits are provided in bay 1. Each switching circuit occupies 17 in. of frame-mounting space and consists of a 4-in. switching circuit control unit and a 13-in. mounting plate which supports the four switching grids associated with each control unit. Figure 15 provides a more detailed view of a junctor-switching circuit. Physical design aspects of the switching grids are described in Section IV.

A total of four stages of switching are provided by the trunk link network circuits, the first two stages by the trunk-switching circuits and the last two stages by the junctor-switching circuits. Each switching circuit accommodates 256 tip-and-ring pairs, or a total of 1024 pairs on a per-frame basis. The 1024 output pairs from the trunk-switching grids in bay 0 are wired to the 1024 input pairs of the junctor-switching grids in bay 1 via a 1024-pair connectorized cable. These wired links between the trunk and junctor circuits are referred to as the B links.[1] Advantages of the connectorized B-link cable used on all the remreed frames are reviewed in Section 5.1. One complete trunk link network frame provides any of its 1024 input pairs access to any of its 1024 output pairs.

### 2.3 Trunk-switching frame

Trunk link network configurations with a $1\frac{1}{2}$:1 concentration ratio and the 2048 network are made up of two frames as shown in Figs. 6 and 7, respectively. The 2048 network consists of two 1024 trunk link network frames which are interconnected by a 2048-pair B-link cable. No other hardware changes are required for the 2048 configuration.

The $1\frac{1}{2}$:1 trunk link network configuration is achieved by adding two additional trunk-switching circuits and multipling their outputs (B links) to the four junctor-switching circuits located in the trunk link network frame. These additional trunk-switching circuits are provided on the trunk-switching frame. This single-bay frame, 3 ft, 3 in. wide, contains the identical hardware arrangement as contained in bay 0 of the trunk link network frame. Each trunk-switching frame, as shown in Fig. 2, can be equipped with either two or four trunk-switching circuits. When the frame is equipped with four circuits, the bottom two are associated with the trunk link network frame on the left and the top two are associated with the trunk link network frame on the right (when viewed from the front). In offices that have an odd number of $1\frac{1}{2}$:1 trunk link networks, the trunk-switching frame would only be equipped with the bottom two circuits. In these cases, a 6 ft, 6 in. space is reserved to the right of the trunk-switching frame in the floor plan layout for the future addition of another trunk link network frame. The two associated trunk-switching circuits are easily added to the partially equipped trunk-switching frame during office growth.

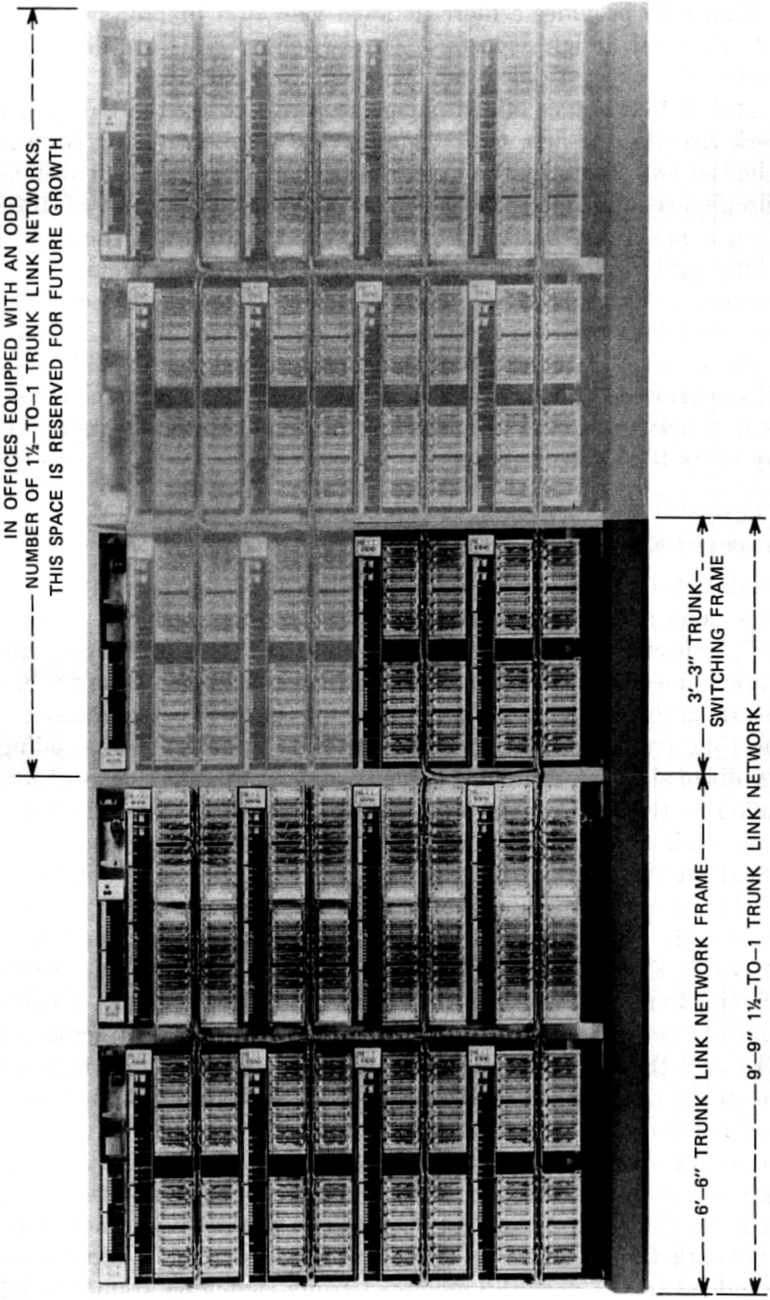



Fig. 6—Trunk link network frame combination for a $1\frac{1}{2}$:1 trunk-concentration ratio.

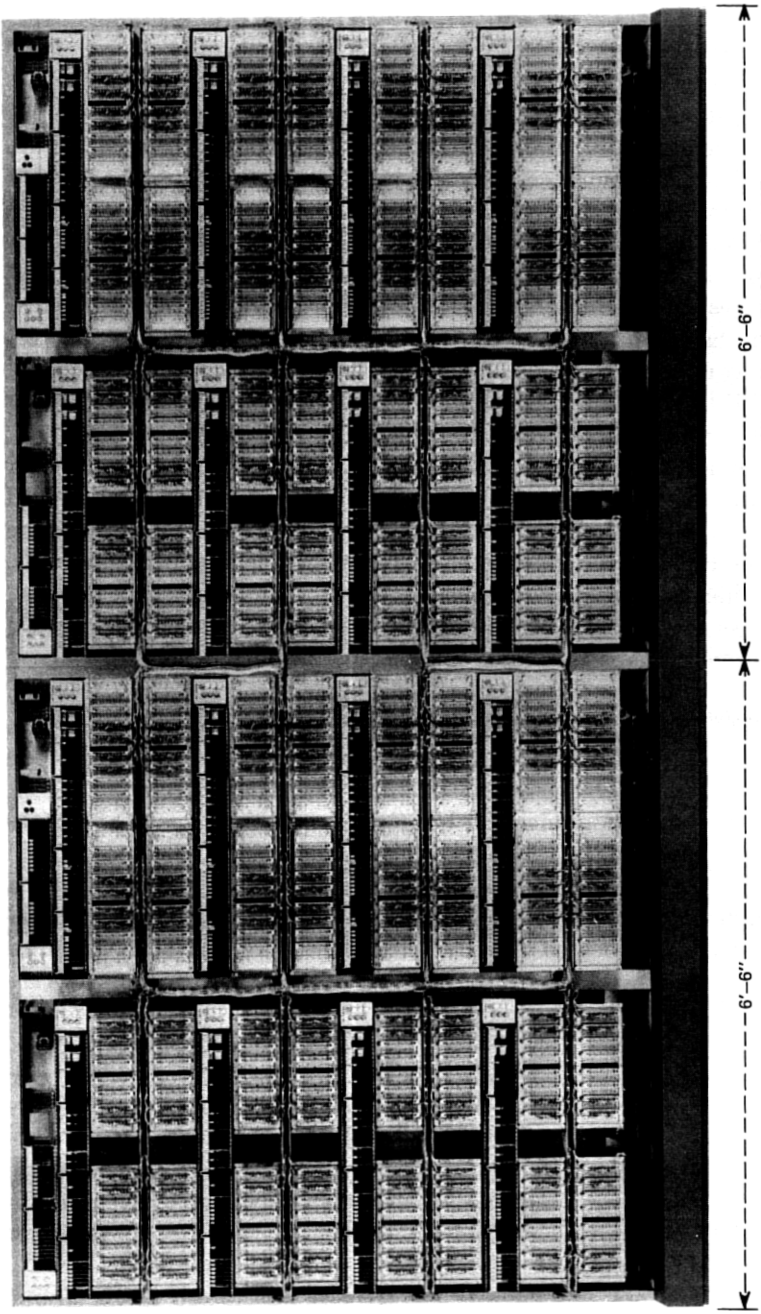



Fig. 7—Trunk link network frame combination (for a 2048 network with a 1:1 trunk-concentraion ratio).

## III. LINE LINK NETWORKS

### 3.1 Junctor-switching frame

Remreed line link networks are available which provide four basic concentration-ratio configurations. There are 2:1, 3:1, 4:1, and 6:1. Any of these four network configurations may be provided by the proper selection and interconnection of three basic remreed frames designed for this purpose, i.e., the junctor-switching frame, the 2:1 line-switching frame, and the 4:1 line-switching frame, as shown in Figs. 3, 4, and 5, respectively.

Each line link network provides four stages of switching. The first two stages of switching are performed by the line-switching circuits, and the last two stages of switching are performed by the junctor-switching circuits. As in the case of the trunk link networks, a connectorized B-link cable is used to link the outputs from the line-switching circuits to the inputs of the junctor-switching circuits.

The junctor-switching frame is common to all line link network configurations and contains 16 junctor-switching grids as described in Section 4.2. A standard single-bay framework 3 ft, 3 in. wide supports the associated junctor-switching frame equipment and is, in fact, identical to the equipment in bay 1 of the trunk link network frame. As in the trunk link network frame, the 16 junctor-switching grids provide access to a total of 1024 junctor-output pairs.

### 3.2 Line-switching frame (2:1 line-concentration ratio)

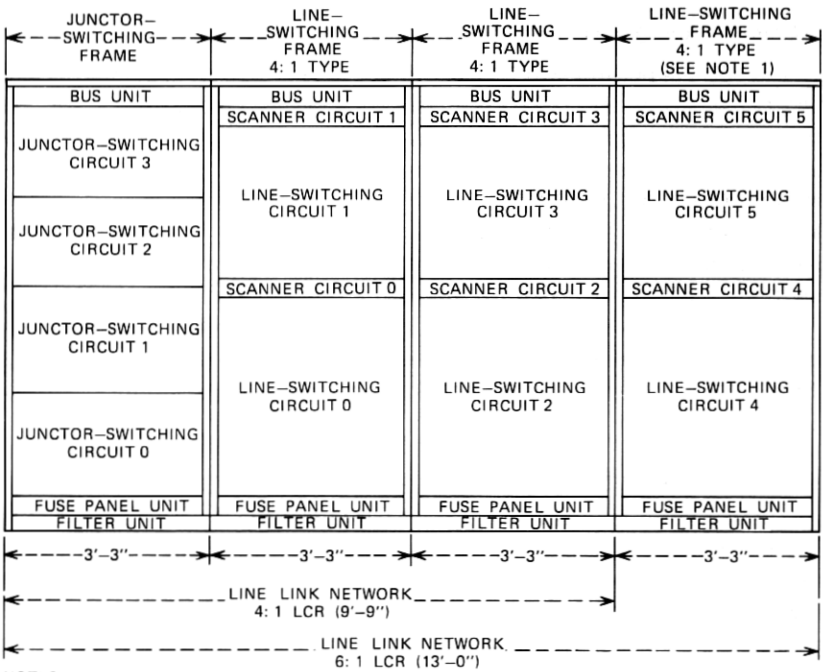
The 2:1-type line-switching frame shown in Fig. 4 contains two complete line-switching control circuits, one 1024-point scanner-control circuit, one communication bus circuit, and the associated switching grids, power filter, fusing, and alarm circuits. The 36 plug-in circuit packs required for one line-switching control circuit occupy a 4-in. high by 3-ft wide mounting plate. The 16 associated switching-grid packages are located directly below the control circuit. A standard single-bay framework 3 ft, 3 in. wide is equipped with two line-switching circuits and provides the first two stages of switching for 1024 incoming line pairs.

The 1024 line-scanner ferrods that monitor the state of each incoming line pair are provided as part of the remreed switch package. These line-scanner ferrods are controlled by the 20 circuit packs (10 for controller 0 and 10 for controller 1) located on a 4-in. mounting plate between the two switching circuits. Scanner-control circuitry[7] is duplicated, and both controller 0 and 1 have access to all 1024 line-scanner ferrods on the frame.

Communications bus circuits are located at the top of the frame and are described in Section 5.9. The power filters, fuse panel, and power-control relays are located at the bottom of the frame. Interconnections between the communication bus, line-switching circuits, and line-scanner controllers are accomplished using flat, flexible tape cables as described in Section 5.6.

### *3.3 Line link network (2:1 and 3:1 line-concentration ratios)*

A complete line link network with a 2:1 line-concentration ratio consists of two 2:1-type line-switching frames and one junctor-switching frame. These three frames are arranged as shown in Fig. 8. Frames are interconnected by a 1024-pair, connectorized, B-link cable which is shipped with the frames. This network configuration terminates a total of 2048 incoming line pairs and provides access to 1024 junctors. Half-equipped networks can be provided that will accommodate 1024 incoming line pairs. In this arrangement, the frame equipped with line-switching circuits 2 and 3 is omitted at initial installation, but space is provided in the floor plan layout for future growth to a full




NOTES:

1. THE ADDITION OF THIS FRAME CONVERTS THE 4: 1 LCR NETWORK TO A 6: 1 LCR NETWORK.

Fig. 8—Front view of line link network configurations with 2:1 and 3:1 line-concentration ratios (LCR).

network. Connectors on the B-link cable that terminate on line-switching circuits 2 and 3 are secured to a supporting structure provided for this purpose until such time as the complete network is required.

Line link networks with a 3:1 line-concentration ratio consist of one junctor-switching frame and three line-switching frames of the 2:1 type arranged as shown in Fig. 8. B-link interconnections for these frames are accomplished by the use of a 1536-pair, factory-formed, connectorized cable that is shipped to the field with the frames. In this arrangement, half the 1024 B links are multipled to the outputs of the 32 additional 12A grids provided on line-switching circuits 4 and 5. A wiring pattern for these multiple connections has been designed that minimizes traffic blocking on the multipled B links. A full line link network with 3:1 line-concentration ratio terminates 3072 incoming line pairs and provides access to 1024 junctors. Partial equipment arrangements that permit growth steps of 1024 and 2048 line pairs are permissible and are handled in the same manner as described above for the 2:1 line link networks.

### *3.4 Line-switching frame (4:1 line-concentration ratio)*

The 4:1-type line-switching frame is shown in Fig. 5. Sixteen switching grids and the associated control circuit provide for the interconnection and concentration of 1024 incoming line pairs to the 256 B-link output pairs and constitute a complete 4:1-type line-switching circuit. A 1024-point ferrod scanner-control circuit is provided for each 4:1-type line-switching circuit. A scanner ferrod associated with each incoming line pair is incorporated in the remreed switch packages on which the incoming line pairs are terminated.

A single-bay framework 3 ft, 3 in. wide supports two complete 4:1-type line-switching circuits and associated scanner-control circuits. Power filters, fuses, communication bus, and alarm circuits are also located on the frame.

### *3.5 Line link network (4:1 and 6:1 line-concentration ratios)*

A complete line link network with 4:1 concentration ratio is illustrated in Fig. 9. Connections between the 1024 output pairs on the two line-switching frames and the 1024 input pairs on the junctor-switching frame are made using a connectorized B-link cable which is plugged onto the frames during installation. This three-frame complex provides the means of connecting any one of the 4096 incoming line pairs to any one of the 1024 junctor output pairs through four stages of switching.

By adding one additional line-switching frame to the 4:1-type line link network and multipling its 512 output pairs to half of the 1024 B

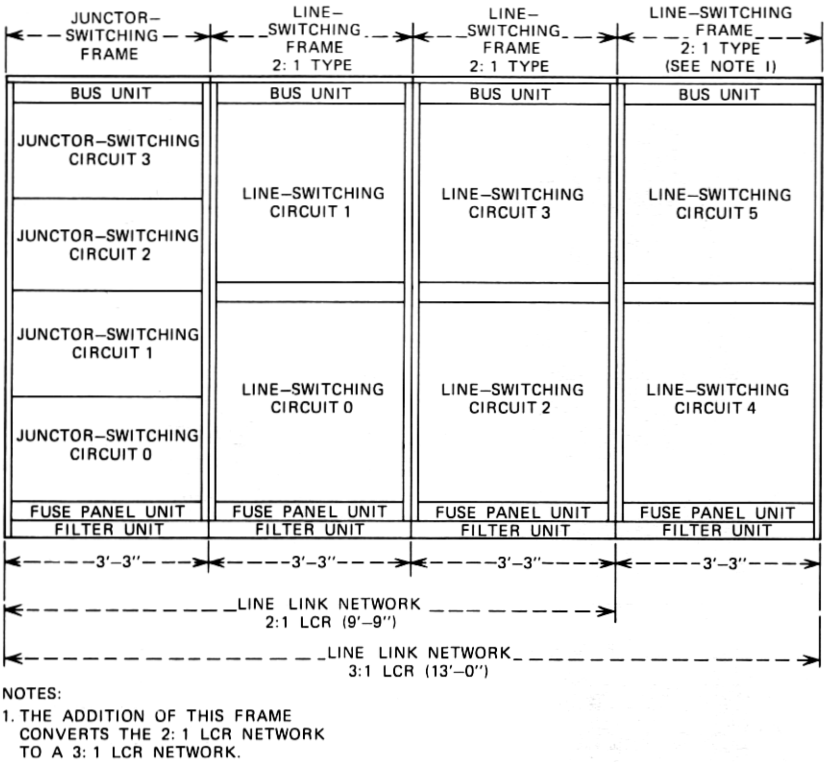



Fig. 9—Front view of line link network configurations with 4:1 and 6:1 line-concentration ratios (LCR).

links, a line link network with a 6:1 concentration ratio is obtained as shown in Fig. 9. The 6:1 line link network is capable of switching any one of its 6144 incoming line pairs to any one of its 1024 output junctor pairs.

## IV. SWITCHING GRIDS

Four different switching-grid units have been coded for the remreed switching application: the junctor-switching grid (10A grid), the trunk-switching grid (11A grid), the 2:1 line-switching grid (12A grid), and the 4:1 line-switching grid (13A grid). These grids are illustrated in Fig. 10.

Each of the four switching grids contains a prewired number of remreed switch packages[8] and a terminal field for access to the controlling circuit. The switch packages and terminal field are supported by two picture-frame-type mounting brackets tied together by two

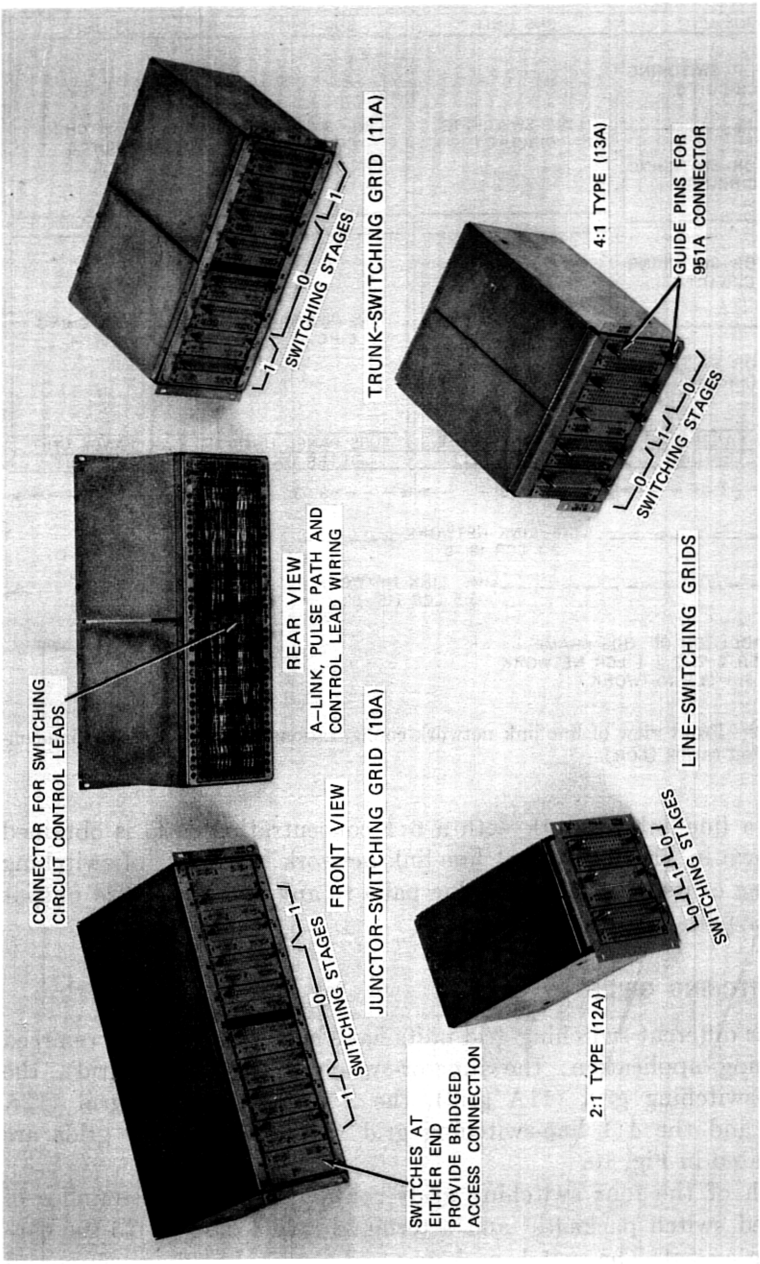



Fig. 10—Remreed switching grids.

cover details. These mounting brackets are designed to provide the necessary means to support the grids in the frame, to protect the switch packages from physical damage, and to allow switch-package alignment within the grid as required for automatic wire wrapping or flex circuit application.

The outputs from the switch packages in the first stage of switching are linked (wired) to the inputs of the second-stage switches. These links (A links) are wired on the rear of the grid in a specific pattern that permits each input terminal pair of the stage-0 switches to gain access to each output terminal pair of the stage-1 switches. One important design constraint of the switch packages and grid assembly was the optimization of the A-link, pulse-path, and control-lead wiring. Early in the design period, it was decided that the terminals for these leads should be arranged in a manner to facilitate their interconnection by means of either a double-sided flexible printed circuit or automatic wire-wrapping machinery. This decision, as well as the decision to provide a plug-in switching grid rather than a wired-in version similar to that used in the ferreed networks, dictated to a large extent the final design parameters.

Close cooperation between Bell Laboratories designers and Western Electric manufacturing and installation engineers resulted in the present design. For example, the output terminals of the stage-0 switches and the input terminals of the stage-1 switches were located at the rear of the switch packages. Pulse-path and control leads for both types of switches were also brought out on the rear terminals. Thus, all leads that control the switches or were required to interconnect the two stages of switching were constrained to terminate on terminals located at the rear of the switch packages. (See the rear view of the 10A grid in Fig. 10.)

### 4.1 Trunk-switching grid

The trunk-switching grid is a two-stage switching array that has 64 input pairs and 64 output pairs. Any input pair of this array may be connected to any output pair to provide a metallic two-wire path through the grid.

The trunk-switching grid shown in Fig. 10 contains eight remreed switching packages and associated mounting hardware. Four of these switch packages are used to provide the first stage of switching (stage 0) and four are used to provide the second stage of switching (stage 1).

Terminals on the front of the stage-0 switch packages are dedicated to the tip-and-ring inputs from the connecting trunk and service circuits. Front terminals of the stage-1 switch packages are reserved for the output tip-and-ring leads that are wired directly (via the B-link cable) to the input of the junctor-switching grids where the last two stages of switching are performed.

### 4.2 Junctor-switching grid

Junctor-switching grids are somewhat more complicated than the trunk-switching grids because of the two additional switch packages required for the bridged-access connection to the 64 switchable tip-and-ring pairs. These two-stage switching grids (Fig. 10) permit the interconnection of any one of 64 input pairs to any one of 64 output pairs. Four such grids are associated with each junctor-switching circuit. Each line or trunk link network is equipped with four junctor-switching circuits that provide a total of 1024 individual tip-and-ring terminal pairs, half of which may contain two connections.

The 1024 input pairs (or 1536 where multiple connections are provided) to the junctor-switching grids are connected to the outputs of either the 2:1 or 4:1 line-switching grids via a connectorized B-link cable as described in Section 5.1.

### 4.3 Line-switching grids, 2:1 type

Two basic types of line-switching grids have been coded for the line link networks. The 2:1 line-switching grid (12A grid) consists of three remreed switch packages and associated mounting hardware as shown in Fig. 10. Two switch packages are used to provide the first stage of switching and contain the line-scanner ferrods and cut-off contacts. The third switch package provides the second stage of switching.

In addition to providing two stages of switching, the 12A grid also provides a traffic-concentration function in the ratio of 2 to 1. Thus, the 32 incoming line pairs that terminate on a 12A grid have access to only 16 outgoing B-link pairs, which connect directly to the inputs of the junctor-switching grids. One complete line-switching control circuit[10] has the capability of controlling a total of 16 of the 12A grids that collectively provide 512 line pairs access to 256 B links.

### 4.4 Line-switching grids, 4:1 type

In most residential calling areas where a large number of low traffic lines are to be terminated, it is more economical to further concentrate the lines to ratios of 4:1 or 6:1. Line link networks with these higher concentration ratios are equipped with the 13A grids shown in Fig. 10. This grid code consists of five remreed switch packages and appropriate mounting hardware. Sixteen incoming line pairs are terminated to each of the four first-stage switches in the grid. The fifth switch package provides the second stage of switching as well as the traffic-concentration function. As in the case of the 12A grid, the line-scanner ferrods are incorporated in the stage-1 switch packages. Terminals on the front of the stage-0 switch packages are reserved for the incoming line pairs.

The 16 pairs of outputs from the grid appear on the front of the stage-1 switch package located in the center of the grid. As is the case with all the grid codes, terminations to the front of the grids are made on 951A-type connectors described in Section 5.2. Each 13A grid has the capability of connecting any one of its 64-input line pairs to any one of its 16-output B-link pairs. Each line-switching control circuit controls 16 grids that collectively provide 1024 line pairs access to 256 B links.

## V. APPARATUS AND EQUIPMENT

### *5.1 Connectorized B-link cable*

Outputs from the line- and trunk-switching grids are linked to the inputs of the junctor-switching grids via a connectorized B-link cable. Each line and trunk link network configuration has a unique B-link wiring pattern.[1] This wiring pattern provides a wired access between each of the line- or trunk-switching grids in the associated network and its corresponding 16 junctor-switching grids. The B-link cables plug directly to the front of the switching grids. Wiring troughs located between the grids provide a means of support for the B-link cable as well as allow grid removal without disturbing the B-link connections to other grids. This design scheme resulted in a standard cable configuration that could be fabricated, tested, and, in the case of the trunk link network frame, installed in the factory. For line and trunk link network configurations that are made up of two or more frames, it is more convenient to install the factory-formed-and-tested B-link cable after the individual frames are erected in place.

Another advantage of this approach is the elimination of the B-link cables from the overframe cable rack as required for the ferreed networks. For the 1:1 trunk link networks (both 1024 and 2048), this resulted in a 33-percent reduction in the number of leads required to be run in the cable rack and a 50-percent reduction in the number of wire-wrap connections that had to be made during field installation. Similar savings were realized for the line link networks and account for a significant portion of the reduced installation interval achieved by the introduction of the remreed networks.

### *5.2 B-link cable connector*

To implement the connectorized B-link cable design for the remreed frames and to achieve the plug-in grid design objectives, it was neces-

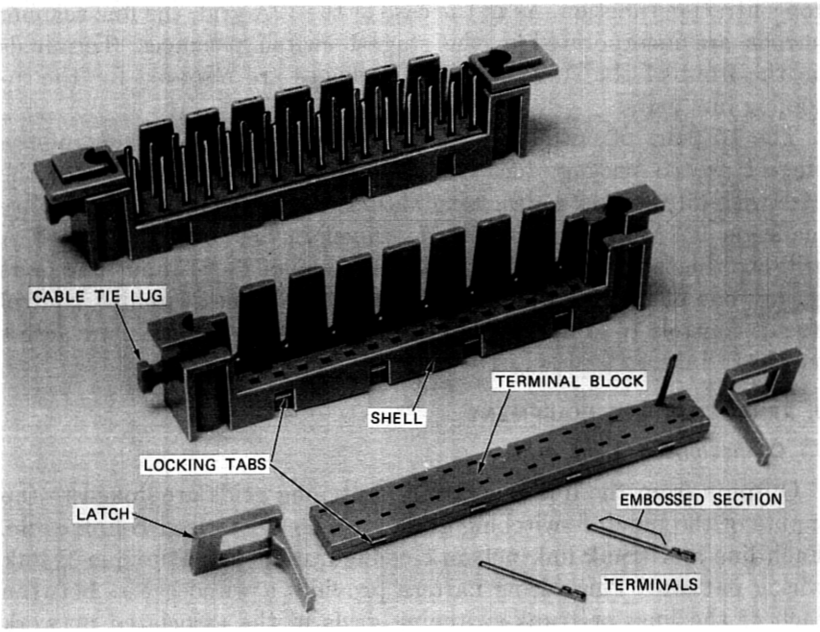



Fig. 11—B-link cable connector.

sary to develop an appropriate connector. The connector developed for this purpose is shown in Fig. 11. This connector provides the pluggable interface between the terminals on the front of the remreed switch packages and the switchboard and B-link cables. Although the B-link cables are factory-wired, the subscriber lines and trunk- and service-circuit leads (inputs to the line- and trunk-switching grids) and the junctor links (outputs from the junctor-switching grids) must be wired in during field installation.

The connectors on which these field-installed leads are terminated are shipped in place on the grids. During installation, the craftsperson forms, ties, and terminates the leads on these connectors. The wiring trough that supports the B-link cable is also used to support these field-installed cables. Tabs located on the wiring trough secure the cable as shown in Fig. 15 and are positioned to allow the cable to twist rather than bend when the connectors are disengaged for grid removal. This twisting motion permits the use of the solid wire required for wire wrap, while at the same time it provides the flexibility that is inherent in stranded wire.

Each connector provides 32 terminals designed to accept two 26-gauge wire-wrap connections. Terminals are assembled into the molded terminal block that is then locked securely into the molded shell by

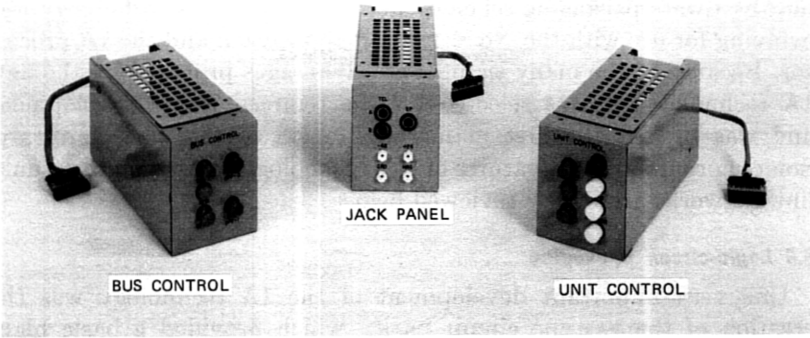



Fig. 12—Jack panel and manual power-control units.

the tabs provided for this purpose. The two latches are trapped in between the block and the shell during the connector assembly operation. Each switch package is equipped with two guide pins (shown in Fig. 10) which align the connector to the 32-terminal pin field during engagement. When the connector is properly seated, the two molded latches engage the groove on the guide pins and complete the locking feature.

### *5.3 Power-control panel unit*

Each communication bus and line-, trunk-, and junctor-switching circuit has its own individual power-control panel unit. These basic units (Fig. 12) are designed to share many of the same piece parts and differ only in their front panel assembly and associated umbilical cable wiring. The connectorized umbilical cable plugs directly into the frame circuit it controls.

These units permit the craftsperson to manually remove power from either duplicated controller during maintenance operations. A mechanical interlock arrangement provided on the pushbutton key assembly prevents simultaneous power removal from both controllers. A lamp array provided on the power-control unit indicates the operational status of the circuit it controls. A separate jack-panel unit provides telephone jacks and convenient access to the frame power supply via the test voltage supply jacks. Telephone jacks are multipled to all frames in the office and facilitate communication between craftspeople during maintenance and/or routine test operations.

### *5.4 Control-circuit hardware (1A technology)*

Implementation of the 4:1 space reduction for the remreed networks could not have been achieved as a result of the switch-package miniaturization alone. Independent of the remreed switch development, a new hardware-packaging scheme referred to as the 1A technology was evolving for use with the No. 4 ESS toll application and the 1A processor. Because of the many significant advantages provided by the new 1A technology, it was selected for the remreed frame development and was in fact the first major application of this new hardware. Some more important features of this technology as used on the trunk-link networks are briefly reviewed below.

### 5.5 Logic-circuit packaging

One very important development of the 1A technology was the creation of the FA-type circuit packs, which provided a basic high-density logic-circuit packaging method. FA-type circuit packs consist mainly of an aluminum heat sink, a ceramic circuit, and an 82-pin connector as shown in Fig. 13. The ceramic circuit provides bonding sites for up to 52 beam-leaded devices. The fixed geometrical location of these bonding sites as well as the standardization of the placement of power, ground, and crossover arrays makes it possible to generate the required interconnections between devices by computer programs. This computer-aided design philosophy has resulted in extremely fast turnaround time between design concept and artmaster generation.

Assembly of the ceramic to the aluminum heat sink is designed to provide intimate contact between the two. This large area of contact provides the necessary heat sinking required to fully utilize the 52 bonding sites when required. The aluminum heat sink is also used to support the 82-pin connector plug as well as guide the plug into its mating receptacle via the slots provided in the apparatus mounting.

Leads of the connector plug are thermocompression-bonded to the ceramic to establish electrical contact between the two. During the final stage of assembly, the beam-leaded devices that are bonded to the ceramic are encapsulated with an RTV compound, and a metal cover is provided to protect the ceramic assembly from physical damage during handling.

Two FA circuit-pack codes are used in the switching-control circuits[10] provided on all the remreed network frames. One pack contains the register and translator circuits which receive information from the communication buses. Each ceramic contains a total of 36 beam-leaded silicon-integrated-circuit devices that are required to implement this circuit function. The other circuit pack contains the controller-logic and group-check circuits. One such pack is provided in each of the two duplicated control circuits.

The packaging of discrete circuit components using the 1A technology has also resulted in tremendous improvements in circuit

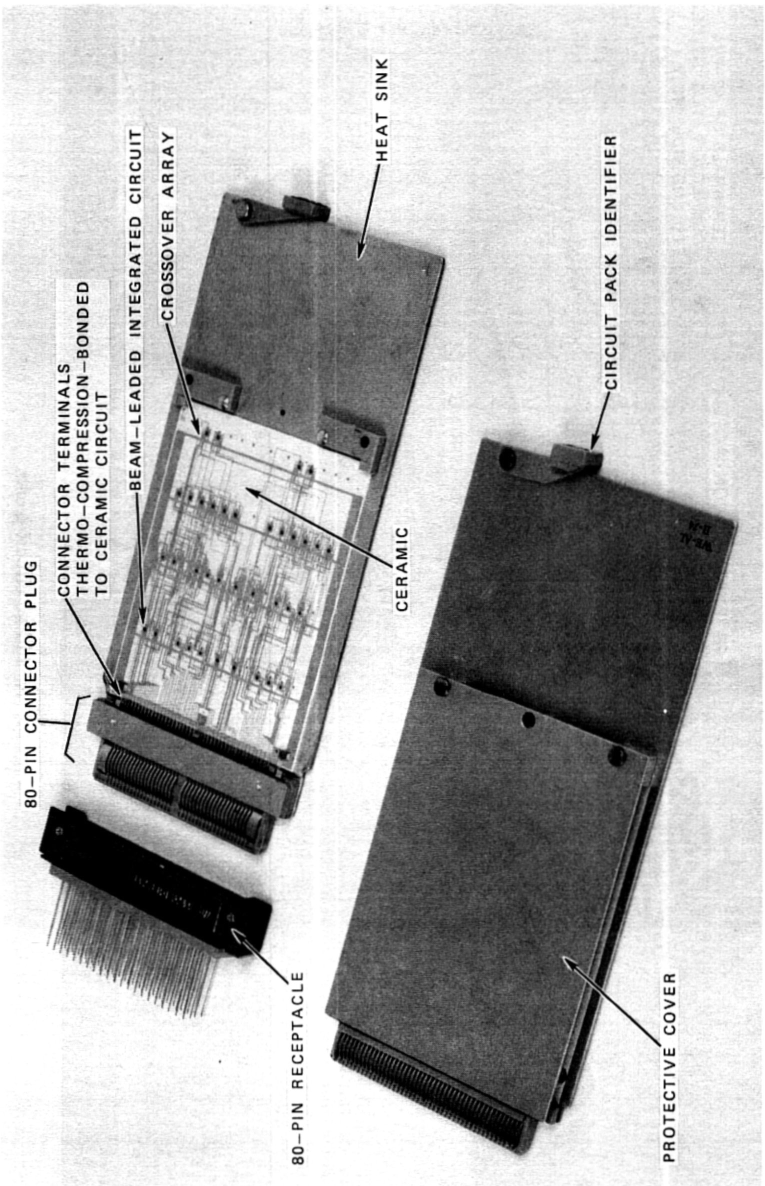



Fig. 13—FA circuit pack.

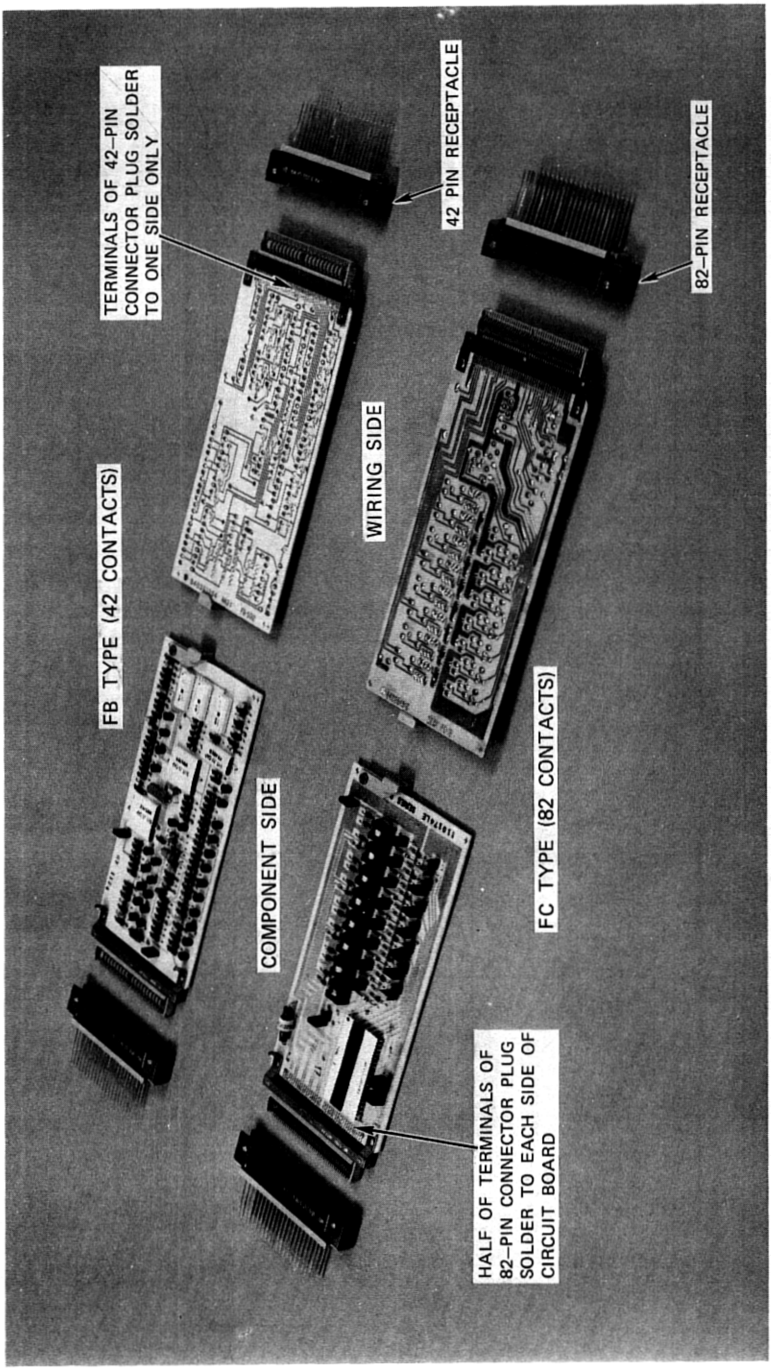



Fig. 14—FB and FC circuit packs.

density per pack and enables the designer to take full advantage of the board space provided. Two basic types of discrete-component circuit packs are available. These are coded as the FB and FC types, and provide either a 42-pin or 82-pin contact arrangement, respectively, as shown in Fig. 14.

Partitioning the circuits into discrete circuit packs was done in a manner to minimize the number of codes required and maximize the usage of the codes between the various line- and trunk-switching circuits. As a result, 26 of the 33 codes are used in more than one application.

### 5.6 Circuit-pack housing (apparatus mounting)

To accommodate the increased heat dissipation associated with this high-density packaging, a new apparatus mounting (Fig. 18) was developed. The open construction of this new mounting is designed to optimize the air flow around the circuit packs. Associated designation strips and circuit-pack identifiers are also designed to minimize the restriction of air flow and allow for sufficient circulation of natural convection currents to cool the packs even under extreme office conditions. The two apparatus mounting codes used in the remreed frames provide space for 14 or 16 circuit packs. These two codes permitted a frame-packaging scheme that utilized to full advantage the available frame space and also provided some physical grouping of the more important duplicated control functions shown in Fig. 15.

### 5.7 Flat, flexible tape cables

The communications bus circuit provides the interface between the central processor and the four switching circuits in the equipment bay. Information from the bus circuit is multipled to each circuit in the bay by means of flat, flexible tape cables, as shown in Fig. 16. The tape cables provide a controlled impedance and minimize crosstalk between adjacent signal leads. Each tape cable contains 8 signal leads and 16 ground leads. Each signal lead is located between two ground leads. Use of the backplane connectors described in Section 5.8 permits automatic mass termination of the 24 leads. Another design feature of the connector permits the termination of two cables to each connector to achieve the required multiple effect.

### 5.8 Backplane connectors

The connector used for the flat, flexible cable is just one of a family of connectors that were designed as part of the 1A technology hardware package. Each connector in this family utilizes the same 10-terminal

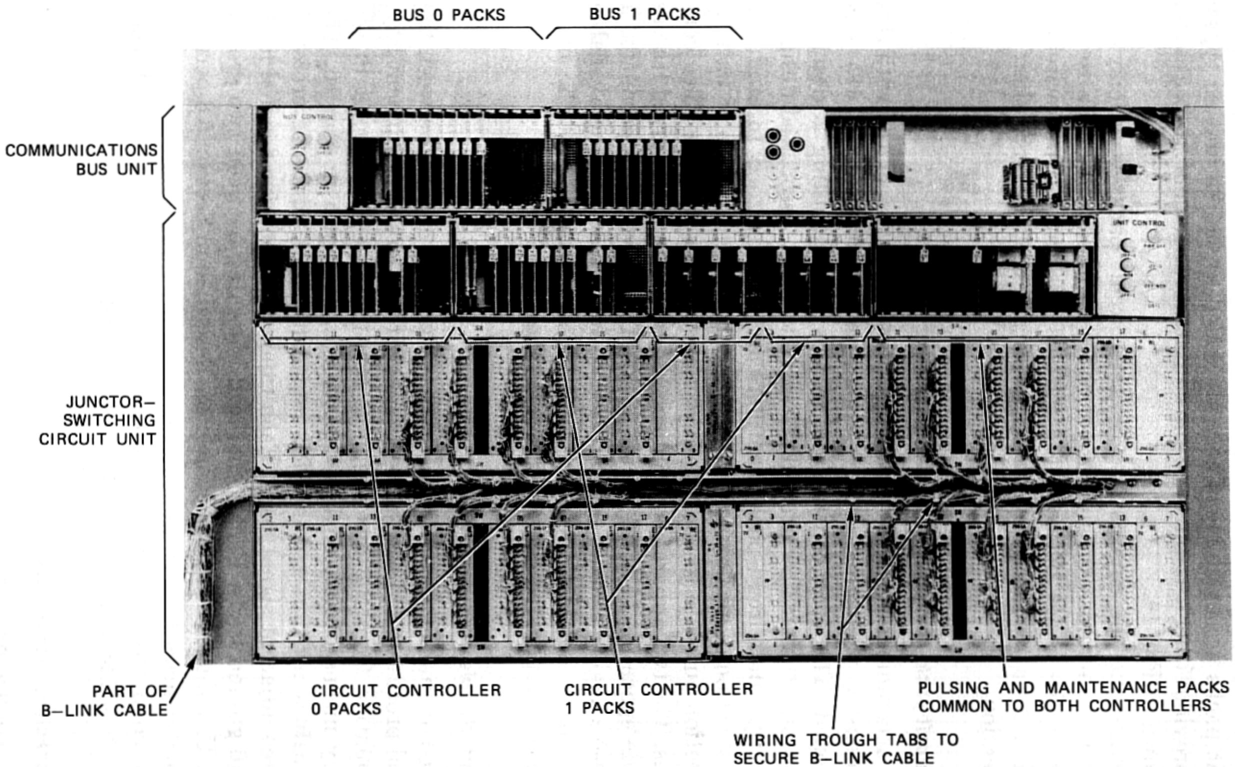



Fig. 15—Communications bus and junctor-switching circuit units.

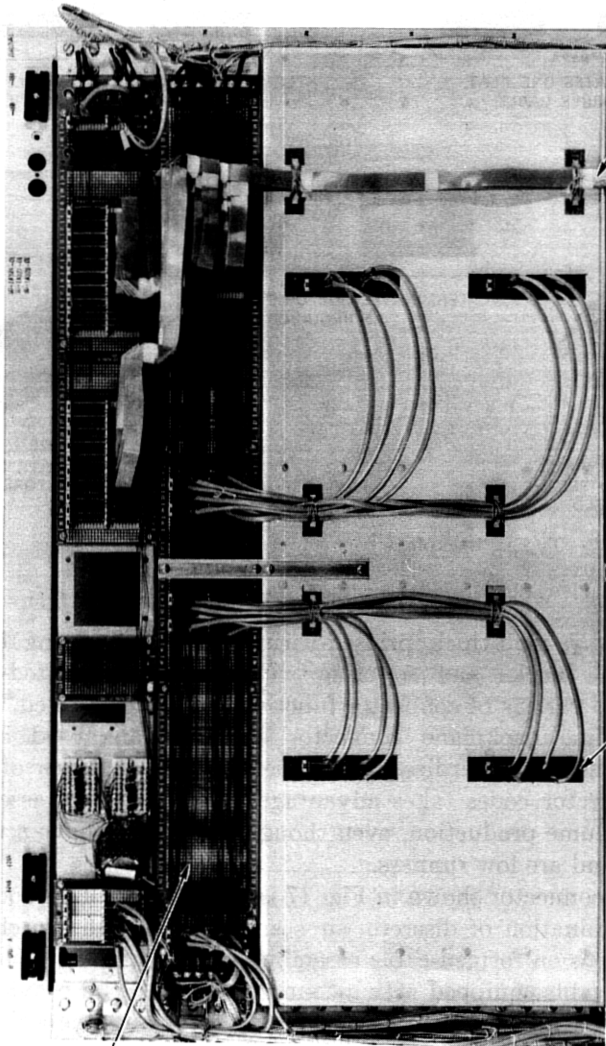



Fig. 16—Rear view of communications bus and junctor-switching circuit units.

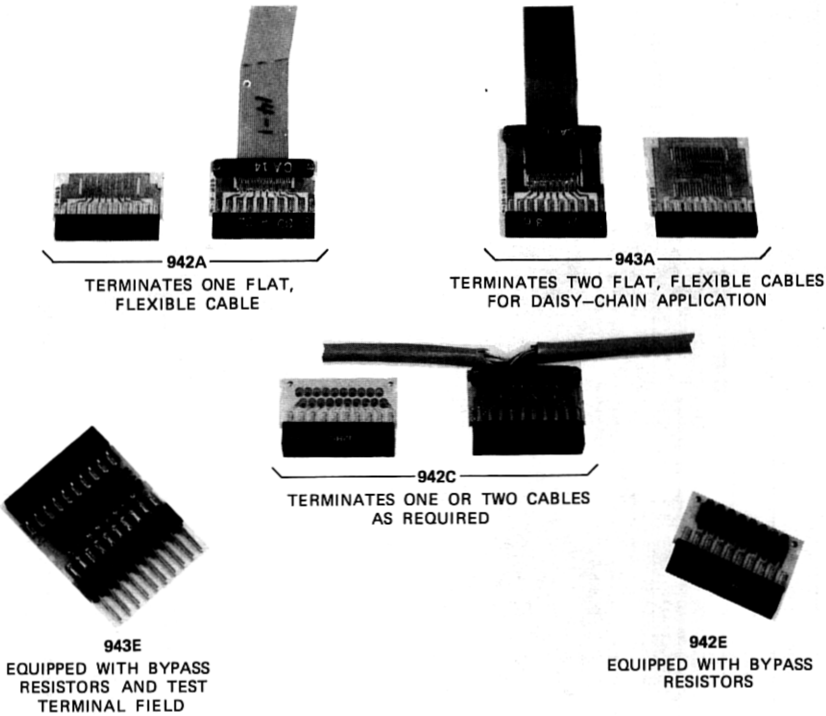



Fig. 17—Typical backplane connectors used on remreed frames.

block and a $\frac{1}{32}$-inch-thick printed-wiring board. By using one or two terminal blocks and selecting an appropriate printed-wiring board, a wide variety of connector functions can be generated. Figure 17 shows some backplane connector configurations used on the remreed frames. Standardization of the common features of these various connector codes takes advantage of the economy associated with high-volume production, even though some codes have a unique application and are low runners.

The 942C connector shown in Fig. 17 is widely used. This code permits the termination of discrete wires and is used with switchboard cable as well as on formed-cable assemblies. For example, a length of switchboard cable equipped with a connector at each end provides the interconnecting link between the switching grids and the switching-control circuitry on the trunk link network frame shown in Fig. 16. Four such cables are used for each grid to connect its 64 control leads. This technique greatly simplified the task of achieving the plug-in grid-design objectives.

### 5.9 Control-unit plug-in feature

The additional connectorization of the few maintenance and power leads that connect to the switching-circuit control units resulted in a completely connectorized control unit. This design feature permits the field craftsperson to completely remove and replace a control unit of any switching circuit without jeopardizing the operation of the other switching circuits in the frame. This feature was originally provided with the intent that, if any major redesign or rewiring of the control unit was required, it could be more economically done in the factory than in the field. In such a case, the field craftsperson would remove the unit, replace it with a new unit, and return the old unit to the factory for modification. A craftsperson can remove and replace a unit in approximately 1 hour. As a result of the comprehensive frame tests performed by the Western Electric Company prior to shipment to the field, this unit-replacement option has been infrequently used. This option has, however, proven its worth on units that were physically damaged in shipment and required extensive factory rework.

### 5.10 Plug-in frame concept

The duplicated communication buses (address and answer leads to the central processor) are multiplied from frame to frame. Information from the bus is picked off by a transformer located on the bus circuit packs. This new bus circuit pack was designed for use with the 1A processor and replaces the scheme formerly used in which the bus leads were hardwired to the transformers on each frame. This design permits the interconnection between frames to be achieved by means of a double-ended connectorized switchboard cable. Use of these bus packs on the remreed frames and the connection of the tip-and-ring leads to the 951A grid connectors resulted in an almost complete frame plug-in arrangement. Only the dc power feeders and ground return which serve the frame are hardwired during installation. This frame plug-in feature has been used to advantage on numerous occasions both in the field and in the test-and-evaluation laboratory. Less than 4 hours are required to completely remove and replace a remreed trunk link network frame.

### 5.11 Circuit-pack receptacle

A very important feature of the 1A technology is the design flexibility available through the use of the circuit-pack receptacle. These receptacles, as shown in Fig. 14, are available in two basic pin configurations (the 42-pin and the 82-pin) and are designed to mount directly to the frame mounting plates. Connectors are generally located on $\frac{1}{2}$-in. centers or multiples thereof on the mounting plate. The opening of the receptacle is designed to mate with the circuit pack plug. Overall connector dimensions are such that, when connectors are placed on $\frac{1}{2}$-in. centers on the mounting plate, the terminal field of adjacent connectors falls on a 0.125-in. by 0.125-in. grid which is acceptable for automatic wire wrapping. Terminals on the rear of the connectors are designed to provide a soldered connection to a multilevel printed-wiring board, two wire-wrap connections using 30-gauge wire, and an optional third wire wrap or the contact space for a backplane connector.

### 5.12 Machine-wrapped 30-gauge backplane connections

A terminal density of 64 terminals per square inch can be achieved by using the 1A hardware. This density precludes the use of hand-wiring techniques except for very limited repair work or minor wiring modifications. As a result, semiautomatic and/or fully automatic wire-wrapping equipment is used for the manufacture of the remreed units. Electrical characteristics of units wired by this equipment are uniform from unit to unit. Automatic wire-verification techniques check for missing or misplaced wires and provide a convenient method of monitoring the performance of the automatic wrapping machines. Machine wiring is fast, economical, and essentially error-free and permits the designer to control path routing as well as wire density in localized areas.

The ability to specify the path routing of machine-applied wires on the switching grids made it possible to meet the stringent crosstalk and transmission design requirements. In this case, the tip-and-ring leads of a pair were controlled to run in the same horizontal and/or vertical wiring channel, i.e., the space between adjacent rows of terminals. Electrically noisy leads such as the pulse leads were routed in selected wiring channels which were dedicated to such leads. Using this technique, a grid wiring pattern was developed that not only satisfied the transmission requirements but provided adequate margin.

### 5.13 Power and ground backplanes

A highly reliable low-impedance ground-return path is essential for proper circuit operation. The backplane technique developed for use on the remreed control units satisfies this grounding requirement and in addition provides a power-distribution point that permits power wiring to individual circuit packs to be applied by automatic machine techniques. A typical backplane board is shown in Fig. 18. The grounding scheme consists of an etched copper path around the perimeter of the rear of the backplane board to which pins pressed into the board

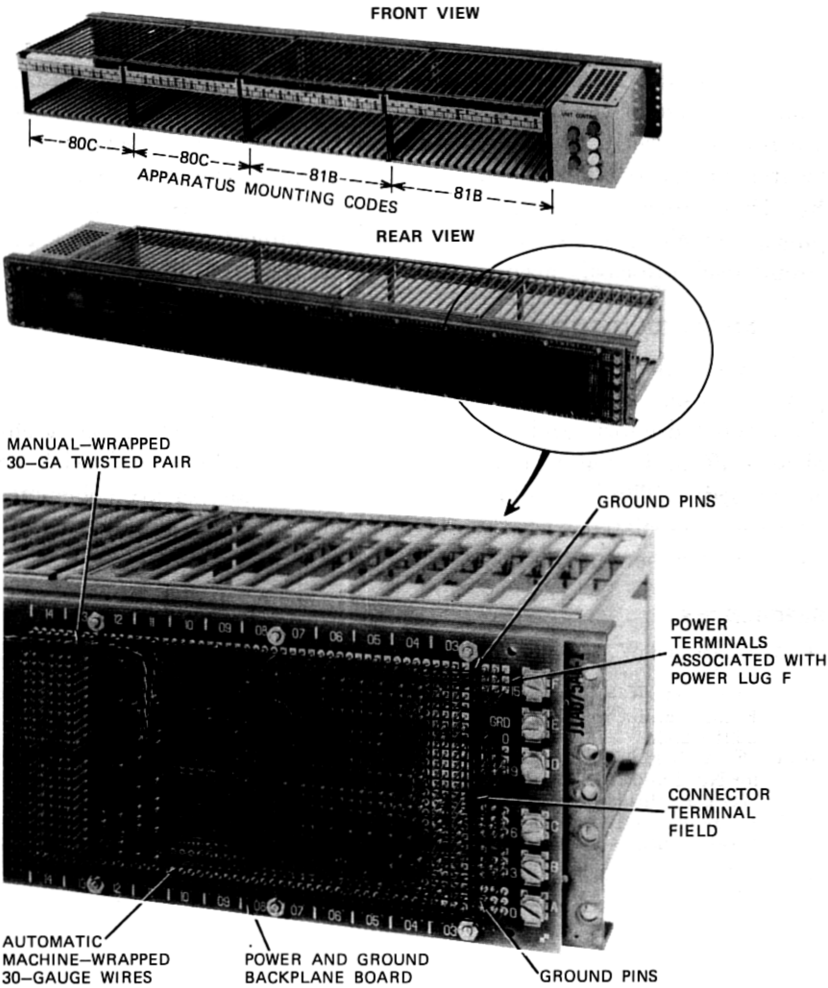



Fig. 18—Junctor-switching control unit (less circuit packs).

are soldered. Ground pins are located above and below all possible circuit-pack connector locations. Ground leads are machine-wrapped between these ground pins and the dedicated ground pins of the 947-type connectors as required.

Circuit packs which require multiple ground connections are also easily accommodated by this technique. A screw-type terminal lug is pressed into the board and soldered to the copper ground circuit along one edge of the backplane board. A ground wire connected to this terminal is routed to the ground side of the power filter located in the base of the frame to complete the ground-return path.

Power connections are handled in much the same manner. In this case, the screw-type terminal lug, the power portion of the printed circuit, and the 25-mil-square pins dedicated for power are localized along the edge of the board. Leads from the screw-type terminal lugs are routed directly to the controlling power relay or associated fuse located at the bottom of the frame. This technique is illustrated in Fig. 18. Connections between the circuit-pack terminals and the power pins are machine wrapped. Multiple power connections to a particular circuit pack are easily accommodated when required.

## VI. ACKNOWLEDGMENTS

Design of the 1A technology packaging hardware and the subsequent physical design of the remreed network frames are the direct result of the combined efforts and talents of many other members of the technical staff and technical assistants whose contributions I wish to acknowledge. The individual contributions of many of my colleagues who were associated with this development effort are detailed in the companion papers in this issue.

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