SWITCHING SYSTEMS MANAGEMENT
NO. 4A AND 4M CROSSBAR
SYSTEM DESCRIPTION
ELECTROMECHANICAL-CARD TRANSLATOR SYSTEM

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1. GENERAL

1.01 This section provides a description of the card translator (CT) system used in the 4A and 4M Toll Switching Systems. It covers the general method of operation when establishing a connection and a description of the equipment elements. Most of the equipment elements used in a CT office will be used in an electronic translator (ET) office with the exception of decoders and card translators. The equipment elements peculiar to an ET office and general information pertaining to the elements are covered separately in Dial Facilities Management Practices (DFMPs), Division H, Section 13c(2). Centralized automatic message accounting (CAMA) operation is discussed only where necessary for clarity.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 The title for each figure includes a number(s) in parentheses which identifies the paragraph(s) in which the figure is referenced.

1.04 The 4A/4M Toll Switching System is a part of the distance dialing network for customer and operator dialing of toll calls. The network provides for customer dialing of calls to points outside the local or extended service area by direct distance dialing (DDD) and for operator dialing of such calls by "Operator Distance Dialing". The 4A/4M switching equipment provides a means for automatically completing connections: (a) between various long-distance dial trunks (intertoll trunks), (b) between intertoll trunks and trunks which are used to either complete or originate calls in the toll center area (toll connecting trunks). The switching equipment is controlled by dial pulses (DP) or multifrequency pulses (MF) originated by customers or long-distance operators.

1.05 Calls arriving at the 4A/4M toll office may have been originated by an operator or customer. Operator and customer calls may be given different routing treatment during translation of the dialed digits by use of an incoming trunk class. In a CT office there are only two incoming trunk class indications available for this purpose. In an ET office it is possible to have up to 16 incoming trunk classes so that with the same dialed digits, several different routing choices would be available. Incoming calls are generally routed from the digital information alone.

1.06 After the dialed digits have been registered, the switching control equipment of the 4A or 4M system selects a route that can forward the call to the destination.

COMMON CONTROL

1.07 Common control is a term applied to certain equipment units in the office which are common to many of the switching frames which set up a talking connection. A common control system has the ability to store, alter, and reuse digits. Some of the common control circuits are: markers, senders and link controllers, as well as decoders and card translators in a CT office, or decoder channels, distributor registers, and the stored program control (SPC) in an ET office. Some common control circuits associated with the CAMA portion of the 4A/4M systems are: transverters, billing indexers, recorders, position link controllers, and master timers.

1.08 The common control equipment is used on each call only long enough to set up a talking connection, after which it releases and is ready to serve another call. In this manner a few units of complicated equipment are used for short periods of time to set up the switches for a proportionately large number of calls.

CONNECTORS

1.09 Connectors are used to connect various common control equipment to each other temporarily during the process of setting up a call. This is done by a group of multicontact relays in the connector which cut through a number of leads between circuits. Connectors are equipped with a chain (or preference) circuit which causes the connector to select equipment elements in a specific order of preference. For instance, a given marker connector will try to select a specific marker as its first choice. If the first choice marker is busy, the connector will attempt to select its second choice marker. This procedure will continue until an idle marker is selected.

1.10 The name of a particular connector is derived from the equipment that is being sought by the connector. For example, a marker seeking an outgoing frame does so through an outgoing frame connector. An incoming sender seeking a decoder does so through a decoder connector.

4-WIRE TALKING PATH

1.11 The 4A and 4M switching systems have 4-wire transmission systems. This means that two voice paths per trunk are provided through the switches, one for each direction of transmission.

1.12 The 4-wire transmission system eliminates a need to convert 2-wire trunks to 4-wire and back to 2-wire for voice repeaters and also eliminates the undesirable transmission effects caused by these conversions.

1.13 A conversion from a 4-wire facility to two wires is required, however, at the originating and terminating ends of the toll connection so that the call can be switched through local automatic switching equipment or a local switchboard. These are the only conversion points no matter how many intermediate switching offices and trunks are used in the toll connection.

ROUTE TRANSLATION

1.14 Route translation in a 4A or 4M office is accomplished in one of two ways; by a decoder-card translator complex or by an electronic translation system. In a CT office, information for routing calls is contained on metal cards which are stored in card translators. In an ET office, information for routing calls is stored in the memory store portion of a SPC complex.

CARD TRANSLATOR

1.15 The card translator is an electromechanical device which uses metal cards, electron tubes, phototransistors, and transistor amplifiers to perform its functions. Every 4A or 4M CT office has three or more card translators.

STORED PROGRAM CONTROL STORE

1.16 In an ET office the store utilizes a piggyback twistor (PBT) memory device for storage of all route translation information. The PBT provides nondestructive readout, and it can be altered electrically for temporary storage of information or for changes in routing information. Store frames are always provided in pairs, the total number varying with the size of the office and the services provided and a minimum of five pairs of store frames required.

2. SWITCHING PRINCIPLES

2.01 The 4A or 4M system is a crossbar system, and therefore its basic switching element is the crossbar switch. A description of the switch is given in this part since an understanding of its operation is essential to an understanding of the system as a whole.

CROSSBAR SWITCH

2.02 The crossbar switch is an electrically operated relay mechanism consisting of 10 horizontal paths and either 10 or 20 vertical paths. Any horizontal path can be connected to any vertical path by the operation of select and hold magnets. The points of connection are known as crosspoints. The switch with 10 vertical paths has 100 crosspoints and is called a 100-point switch. The one with 20 vertical paths has 200 crosspoints and is called a 200-point switch. A partial perspective view of a 200-point crossbar switch is shown in Fig. 1. The 4A and 4M offices use 5-wire crossbar switches which means that each crosspoint makes 5 separate connections.

2.03 A crossbar switch usually has each horizontal path strapped on the wiring side, thus making ten horizontal paths, as shown in Fig. 2.

2.04 In a split switch this horizontal strapping is cut in order to provide more than ten horozontal paths. For example, a switch can be split between the tenth and eleventh verticals, providing the total of 20 horizontal paths on the switch. (See Fig. 3.)

2.05 A photograph of the apparatus sides of a 100-point and a 200-point switch is shown in Fig. 4.

SWITCHING FRAMES

2.06 The function of a 4A or 4M office is to switch toll calls coming into the office on incoming trunks to outgoing trunks to other offices. The connections in the talking paths of these calls are established through crossbar switches located on two kinds of switching frames, incoming frames and outgoing frames. As the names indicate, the incoming trunks are connected to crossbar switches on incoming frames and the outgoing trunks to crossbar switches on outgoing frames. Most offices have an equal number of incoming and outgoing frames, but in some offices certain conditions may require the provision of an unequal number.

2.07 A simple diagram of the talking path or channel between an incoming trunk and an outgoing trunk is shown in Fig. 5. It is observed that the incoming trunks are terminated on the horizontals of the incoming frames primary switches. The calls are extended from here to the incoming secondary switch horizontals over incoming links ("A" links), and from these to the outgoing frames primary switch verticals over junctors ("B" links). The outgoing links ("C" links) then extend the calls to the outgoing secondary switch verticals. The outgoing trunks are terminated on the horizontals of the outgoing link secondary switches. The fan-out pattern of these links, or channels, provides multipath access from every incoming trunk to every outgoing trunk in the office. (See Fig. 6.)

A. Incoming Frames

2.08 Each incoming frame is made up of primary and secondary switches. The basic incoming frame provides for the termination of 200 incoming trunks (100 on the primary bay and 100 on the first primary extension bay). Additional trunk terminations are obtained by adding primary extension bays (up to the third primary extension bay), each providing 100 terminations. The number of terminations for incoming trunks is usually increased to 400 in a 2-train office and may be increased to 300 in a single-train office. Up to 40 incoming frames may be provided in a single-train office with a maximum termination capacity of 300 incoming trunks per frame. Generally this termination capacity cannot be utilized in a full size single-train office and the practical capacity is usually 8,000 incoming trunks and 8,000 outgoing trunks. A 2-train office can have up to 40 incoming frames per train with a maximum of 400 incoming trunks per frame with the trunks multipled to both trains. The overall trunk capacity for a maximum size 2-train office is 16,000 incoming trunks and 24,000 outgoing trunks; however, this outgoing trunk capacity is not feasible.

2.09 Each primary bay, or primary extension bay has ten 200-point, 5-wire, nonsplit, crossbar switches. Each switch has 10 horizontals and 20 verticals. The incoming trunks are terminated on the horizontals of the switches (100 per bay). A group of incoming trunks from a given office is spread over as many incoming frames as feasible to provide satisfactory loading on the frames. The incoming trunks on each incoming frame will consist of trunks from several different offices.

2.10 The verticals of each primary switch are multipled to the correspondingly numbered verticals of each like-numbered switch on each primary bay on the same frame. The 200 multipled verticals of the primary switches are connected to the horizontals of the secondary switches by means of 200 incoming links (or "A" links). A typical frame layout is shown in Fig. 7.

2.11 A secondary bay and a secondary extension bay are always provided. Each of these secondary switch bays is equipped with ten 200-point, 5-wire, crossbar switches. The switches are split in the standard arrangement. The left horizontals and right horizontals of the split switches on the secondary bay are multipled to the corresponding left and right horizontals of the secondary extension bay. The 200 incoming links (or "A" links) from the verticals of the primary switches are distributed in a fixed pattern over the horizontals of the 20 secondary switches.

2.12 The verticals on the primary switches are designated left and right (0L to 9L and 0R to 9R). The left half of the split switches on the secondary bay and secondary extension bay are all designated as left (0L to 9L) while the right half of the split switches on the secondary bay and secondary extension bay are designated as right (0R to 9R). The left verticals of the primary switches terminate on the horizontals of the correspondingly designated left secondary switches; similarly, the right verticals of the primary switches terminate on the horizontals of the correspondingly designated right secondary switches. The secondary switch horizontal corresponds to the primary switch number. In offices using junctor grouping frames, the secondary and secondary extension bays may be equipped with nonsplit switches. In this arrangement, the secondary bay switches are full left switches with vertical numbering of 0L to 19L. The secondary extension bay switches are full right switches with vertical numbering of 0R to 19R. Some existing offices may be equipped with junctor plans not requiring secondary extension bays but this arrangement is no longer available.

2.13 The incoming ends of 400 junctors are connected to the 400 verticals of the incoming secondary switches (the outgoing ends connect to primary switches on outgoing frames as will be described shortly). The vertical-to-horizontal spread of the "A" links on the incoming frame makes every one of these 400 junctors (or "B" links) available to each incoming trunk terminating on the frame. The 400 junctors are divided into 20 groups of 20 junctors each. Each junctor group consists of one vertical frame each of the 10 left and 10 right secondary switches. To reduce the number of junctor vertical terminations on the outgoing frames, each junctor group is shared by a pair of incoming frames.

2.14 Each even-numbered and next higher odd-numbered frame is paired (as will be described later) and share the use of their 400 junctors. The verticals of the left secondary switches of the even-numbered incoming frame are multipled to the correspondingly numbered verticals of the left secondary switches of the odd frame. Similarly, the verticals of the right secondary switches of the even-numbered incoming frame are multipled to correspondingly numbered verticals of the right secondary switches of the odd frame. This provides each trunk terminated on the primary switches access to 400 junctors.

2.15 The outgoing frame, like the incoming frame, is made up of primary and secondary switches (Fig. 8). Connections from the incoming frames to the outgoing frames are made over junctors which interconnect the incoming frame secondary switch verticals and the outgoing frame primary switch verticals. On the outgoing frame these connections are extended from the horizontals of the primary to the verticals of the secondary switches by means of "C" links. Outgoing trunks are terminated on the horizontals of the secondary switches. Outgoing links are similar to the incoming links and they give each trunk access to every junctor on the frame.

B. Outgoing Frames

2.16 There are two arrangements of primary switches used dependent upon the junctor plan employed. One arrangement provides for one primary bay consisting of ten 200-point, 5-wire split crossbar switches. The horizontal wiring of these switches is split in half, thus providing 20 horizontals on each switch. The 200 outgoing links (or "C" links) originate on the horizontals of the primary switches, and terminate in a fixed pattern on the verticals of the secondary switches. The 200 junctors (or "B" links) from the incoming frames terminate on the primary switch verticals. With this arrangement, the junctors are provided on a group to frame basis. That is, each pair of incoming frames has junctors to each individual outgoing frame.

2.17 Another arrangement of primary switches provides for the addition of another bay of switches (primary extension bay). The primary bays and primary extension bays are equipped with ten 200-point, 5-wire, split, crossbar switches. The arrangement of junctors, outgoing links, and multipling between frames is identical to the arrangement described for incoming frame secondary switches. In this case, the junctors are provided on a group basis, with each pair of incoming frames having junctors to each pair of outgoing frames.

2.18 Each outgoing secondary bay or secondary extension bay has ten 200-point, 5-wire, nonsplit, crossbar switches. The outgoing trunks are terminated on the horizontals of the switches (100 per bay). A group of outgoing trunks to a given office is spread over as many outgoing frames as feasible. Therefore, the outgoing trunks on each outgoing frame will consist of trunks to several different offices. Each outgoing frame can accommodate up to 300 outgoing trunks.

2.19 The verticals of each secondary switch are multipled to the correspondingly numbered verticals of each like numbered switch on each secondary switch on the same frame.

JUNCTORS

2.20 "A" and "C" links provide the connection between the primary and secondary switches of individual incoming and outgoing frames. Junctors, on the other hand, provide the connection from the secondary switches of each incoming frame to the primary switches of each outgoing frame in an office.

2.21 "A" and "C" links are permanently connected in a fixed pattern which is the same for all incoming or outgoing frames, regardless of the size of an office. In contrast to this, there are different junctor patterns for different sizes of offices. Pattern means the junctor distribution plan. That is, the incoming and outgoing frame terminations of each junctor, without regard to whether the junctor is run directly or through a distributing frame.

2.22 Incoming trunks are assigned to the incoming frames in such a manner that each frame handles about the same amount of traffic. This traffic (from each frame) spreads about equally over all the outgoing frames. Therefore, the junctors from each incoming frame are divided into as many groups as there are outgoing frame groups. Each of these groups has the same number of junctors. (There are a few minor exceptions in which some groups may have more junctors than others.)

2.23 A junctor joins a vertical of an incoming frame secondary switch to a vertical of an outgoing frame primary switch. There are 20 verticals on each of the ten incoming frame secondary switches and a like number on the ten outgoing frame primary switches. Therefore, there is space for connecting a maximum of 200 junctors on each of these frames, assuming that incoming frame secondary extension bays are not furnished.

2.24 For example in 2.23, each incoming frame has room for not more than 200 junctors and there is a group of junctors to each outgoing frame, it follows that the more outgoing frames there are the smaller each group will be. However, there is a minimum number that can be provided in a group in order that the group does not become so small as to be inefficient.

2.25 When an office grows, junctors have to be provided from each incoming frame to all of the new outgoing frames and vice versa. In order to make room for the added trunks and still preserve the arrangement whereby the incoming trunks from each office are spread over several incoming frames, and the outgoing trunks to each office are spread over several outgoing frames, some of the existing trunks have to be reassigned. The result is that each incoming frame ends up with about the same number of trunks, the same total number of junctors, and about the same amount of traffic. However, the traffic from any one incoming frame is now spread over more outgoing frames, and the number of junctors to each outgoing frame can be reduced without impairing service.

2.26 Because the number of junctor groups from each incoming frame or pair of incoming frames is always equal to the number of outgoing frames, there will be different junctor patterns for different sizes of offices. If an office did not grow, then junctors could all be cabled directly and would be fixed (for each size office). However, offices do grow and therefore, provisions must be made for changing the number of junctor groups which also changes the sizes of the groups.

2.27 Certain junctors are not affected by the growth of an office, and these can be permanently connected from the incoming frames to the outgoing frames. The number that can be connected in this manner depends on the number of frames provided in an office. The larger the installation, the greater the number of junctors that can be connected directly. The remaining incoming and outgoing frame verticals are used to provide the additional number of junctors required for the particular size of office involved. These additional junctors are either cabled directly between frames or cross-connected at junctor grouping frames.

A. Frame Grouping

2.28 With the basic equipment arrangement, each incoming frame has access to 200 junctors (or "B" links) which are terminated on the verticals

(200) of the secondary switches. Similarly, each outgoing frame has 200 junctors (or "B" links) terminated on the verticals (200) of the primary switches. In order to provide more efficient trunking between incoming and outgoing frames, the standard junctor plans provide an arrangement where the junctors from an even-numbered frame and the next higher odd-numbered frame are combined. Each of the frames has access to the junctors of both frames. The two standard junctor plans provide for interconnecting 10 incoming groups to 20 outgoing frames, or 20 incoming groups to 20 outgoing groups (Fig. 9).

2.29 Grouping of incoming frames is accomplished by adding an extension bay of secondary switches to the incoming frames. The verticals of the switches of the secondary bays and secondary extension bays of a frame are multipled to like-numbered verticals on the other frame of the group. Grouping of outgoing frames is accomplished by adding a primary extension bay, and multiplying the verticals in the same manner as described for incoming frames.

2.30 Usually a second switching train is required in an office when the number of incoming trunks exceeds 8000. A switching train is a group of incoming and outgoing switching frames interconnected by junctors and sharing certain common control units. Where two trains are provided, all incoming trunks terminate on both trains to permit connection to any outgoing trunk, since an outgoing trunk has only one train appearance. There are two types of traffic handled in a 4A or 4M office, intertoll and toll completing. Intertoll traffic is traffic from one toll office to another toll office, and toll completing traffic is traffic from a toll office to a local office. At one time, each switching train was dedicated to one type of traffic so the trains were designated intertoll or toll completing corresponding to the traffic being handled. However, the toll completing train was generally underloaded, so intertoll and toll completing traffic is now shared between both trains to provide train traffic balance.

B. Switching Trains

2.31 An office which has only one switching train is termed a combined train office because one train is handling both intertoll and toll completing traffic. (See Fig. 10.)

2.32 An office which has two switching trains is termed a separate train — combined operation office. In this case, two complete switching trains are provided and are designated as the intertoll train and the toll completing train. With this arrangement, both trains handle a mixture of intertoll and toll completing traffic. The train designation serves to identify equipment rather than traffic handled. (See Fig. 11.)

C. Office Size

2.33 The size of an office is expressed in terms of the number of incoming and outgoing switching frames provided in each train. An office equipped with 12 incoming frames and 14 outgoing frames in each train is called a 12-by-14 office. In the case of a separate train office, this would indicate 12 incoming frames for the intertoll train and 12 incoming frames for the toll completing train. Similarly, there would be 14 outgoing frames in each of the trains.

2.34 Standard cabling arrangements permit orderly growth from a minimum of 3 incoming groups (6 frames) and 6 outgoing frames to a maximum of 20 incoming and outgoing groups (40 frames) per train.

CONTROL OF SWITCHING OPERATIONS

2.35 There are a number of possible connections between each incoming and every outgoing trunk in an office. These are called channels. A channel is a combination of an incoming link, a junctor, and an outgoing link. These three can be formed (by crosspoint closures) into a chain that interconnects an incoming trunk and an outgoing trunk.

2.36 On each call, the marker determines the location of the incoming trunk. At the same time it also selects an idle outgoing trunk to the called office, identifies the location of the outgoing trunk, and proceeds to set up a channel between the incoming and outgoing frames. This channel and the relationship between the common control equipment and the switching frames are shown in Fig. 12.

2.37 The location of the incoming trunk in terms of the incoming frame number is passed to the marker. The frame number is identified by a multifrequency signal obtained from the winding of the primary select magnet associated with the incoming trunk. It is passed to the marker via the incoming trunk, sender link frame, decoder connector, and marker connector. The marker, knowing the incoming frame number, connects to that frame via a frame connector. It then operates the trunks select magnet, and the 20 "A" links available to the incoming trunk are extended to the marker for selection.

2.38 Having previously selected an outgoing trunk to the called office, the marker receives the outgoing frame number on which the trunk is terminated, in a manner similar to that of the incoming frame. That is, a multifrequency signal is obtained from the winding of the secondary select magnet associated with the outgoing trunk, and is passed to the marker from the outgoing frame to the trunk block connector. The marker, knowing the outgoing frame number, connects to that frame via a frame connector. The marker then operates the outgoing secondary select magnet, and the 20 "C" links of the switch on which the outgoing trunk is terminated are extended to the marker for selection. The marker also gains access to test the junctors ("B" links) through the outgoing frame connector.

2.39 While each incoming trunk and each outgoing trunk has 20 links which it can use, the total number of junctors which can interconnect these links to form channels varies from a minimum of 20 for the ultimate size office to 60 for the smallest office.

2.40 The marker selects an idle channel between the incoming trunk handling the call and an outgoing trunk to the desired office. Between 20 and 40 incoming trunks on an incoming primary switch share the associated 20 incoming "A" links. Similarly, between 20 and 30 outgoing trunks on an outgoing secondary switch share the associated 20 outgoing "C" links. The group of junctors ("B" links) which interconnect the particular incoming secondary and outgoing primary switches are either dedicated to these switches or multipled to the corresponding switches on ***paired*** frames (Fig. 9). Each incoming secondary switch has one or more junctors to each outgoing primary switch.

2.41 Because of this sharing of links and junctors the marker has to select or match an idle incoming link, junctor, and outgoing link to form a transmission channel between the incoming trunk and the selected outgoing trunk.

2.42 The marker tests 20 channels at a time. Where there are more than 20 junctors in a group, the marker can make several tests, using a different subgroup of junctors each time. However, the same 20 incoming and 20 outgoing links are used on each test because there are only 20 available to each incoming and outgoing trunk.

2.43 For safety and traffic reasons, the outgoing trunks to a given office are spread over as many outgoing frames as feasible. If an idle channel to the first idle outgoing trunk seized by the common control equipment cannot be found, this trunk is released and the marker makes another attempt to find a different trunk in the same group. The marker tests in such a manner that the second outgoing trunk chosen is generally on a different outgoing frame. If a second idle trunk can be found, a new group of junctors and outgoing links will be used. The incoming links are the same since the same incoming trunk still has the call. The marker can now test all the new junctors in the same way until an idle channel is found. If these tests fail, an attempt to set this call up to a reorder announcement trunk is made. Should this also fail, the common control equipment is released and the incoming call is left high and dry (not connected).

3. FUNCTIONS OF PRINCIPAL EQUIPMENT ELEMENTS

3.01 The basic circuit functions of the principal equipment elements (common control and switching equipment) are described here. In order to understand the functions of these individual equipment elements, it will help to see how they work together. For this reason, an overall picture is presented first by describing how a call is processed through an office. This illustrates the part each equipment element plays in switching the call. The function of each element is briefly discussed, but the primary purpose is to name the elements and point out the relationship between them.

3.02 Two typical calls are discussed. One through a combined train, combined operation CT offices and one through a separate train, combined operation CT office. It is assumed in this discussion that these calls do not encounter any irregularities or competition from other calls.

A. Call Through a Combined Train—CT Office

3.03 A combined train—combined operation office uses one switching train to handle both intertoll and toll completing traffic.

3.04 The transmission path and the elements used in setting up the path for a call through a combined train office are shown in Fig. 13. In this example, it is assumed that the call requires 3-digit translation and is switched to a system which receives multifrequency pulsing.

3.05 This call arrives at the 4A or 4M office over an incoming trunk and leaves over an outgoing trunk.

3.06 Each incoming trunk in a single train office has two major appearances. One on the incoming frame (used for the talking connection), and one on the sender link frame (used for passing information to the common control equipment).

3.07 Incoming dial pulse CAMA trunks (also incoming dial pulse non-CAMA trunks in offices not equipped with DP senders) have an appearance on an incoming register link frame, as well as the previous appearances.

3.08 The sender link frame is the first used and consists of two sets of crossbar switches. The incoming trunks appear on one set of crossbar switches, and the incoming senders appear on another.

3.09 As soon as the incoming trunk is seized, it signals a sender link frame to connect an incoming sender. Then the sender link connector signals a controller connector to seize an idle link controller. The link controller then tests for, and seizes an idle incoming sender, and closes the crosspoints between this sender and the incoming trunk at the sender link frame. This completes the function of the link controller and controller connector so they can release from the connection and serve other calls.

3.10 As soon as the incoming sender is attached, it signals either the outward operator, the incoming register (in the case of a dial pulse CAMA call), or the sender in the calling office, that it is now ready to receive pulses. When the required number of digits has been registered (three to eight), the sender signals the decoder connector to seize an idle decoder. This decoder immediately activates its home translator which contains all 3-digit code cards. Now the 3-digit code in the sender is transmitted through the decoder to the home translator. Here a card which is coded to correspond to these digits, drops. This card contains information for switching the call through the use of a 3-digit translation.

3.11 The decoder reads the card, and if so directed will check the group busy chain relay circuit to determine whether an idle trunk appears in the first subgroup or some other subgroup of the selected trunk group. When an idle subgroup is indicated, the card corresponding to that subgroup is read and the decoder then signals a marker connector to seize an idle marker. When a marker is seized, the marker connector signals the decoder connector to connect the incoming sender to this marker. This connection is necessary because the marker has to give certain information to the sender, after the decoder has been released.

3.12 The marker obtains the trunk block connector location of the outgoing trunks for this call from the decoder and the dropped card. Guided by this information, the marker selects an outgoing trunk through a trunk block connector.

3.13 While the marker is selecting the outgoing trunk, it is also identifying the frame on which the incoming trunk is located. Having selected the outgoing trunk, the marker then identifies the outgoing frame on which the selected outgoing trunk is located.

3.14 The decoder, using information obtained from the card translator, also tells the marker how the incoming sender should outpulse for this call, and whether it should outpulse the digits as received, skip 3- or 6-digits, or convert certain digits. When the marker has received all this information, it signals the decoder to release.

3.15 Now the marker proceeds to set up the talking path from the incoming trunk to the selected outgoing trunk. Through the outgoing frame connector, the marker gains access to the outgoing links and to the junctors. After the outgoing frame has been seized, the marker gains access to the incoming links through the incoming frame connector. (The incoming frame appearance of the incoming trunk has already been identified by the marker via the sender link.) The marker then tests the incoming and outgoing links and the junctors to find an idle channel between the incoming and the outgoing trunks. It then closes the crosspoints to establish this channel.

3.16 Now the marker passes the outpulsing information to the sender and releases from the connection. The sender outpulses the digits through the sender link over the transmission path to the outgoing trunk and through to the called office; then the incoming sender and sender link release.

3.17 Generally the connections in the transmission path are held by the incoming trunk until the calling end disconnects; then all the connections are released. Where timed disconnect applies (on CAMA trunks) or where intercontinental traffic is involved, release of the connection does not depend entirely on calling party disconnect.

B. Call Through a Separate Train—CT Office

3.18 A separate train—combined operation office has two complete switching trains. Each train handles both intertoll and toll completing traffic. Each train has a separate set of incoming and outgoing frames, markers, and trunk block connectors. Both trains share the same incoming senders (and outgoing senders, where required), sender links, link controllers, decoders, and card translators.

3.19 An incoming trunk in this office has three major appearances. Two on the incoming frames (one for each train), and one on the sender link frame. Dial pulse CAMA trunks (and dial pulse non-CAMA trunks in offices not equipped with DP senders) have an additional major appearance on the incoming register link frame.

3.20 In the example in Fig. 14, a call comes in on an intertoll trunk. It is assumed that this call is to be switched through the intertoll train to another toll office that receives MF pulsing. This call is also completed using a 3-digit translation. It proceeds in the same manner as the call just described in a combined train—combined operation office, up to the point where the decoder selects a marker.

3.21 The decoder reads the card which was dropped on this call and is directed to an outgoing intertoll trunk on the intertoll train. Therefore, the decoder signals its marker connector to seize an idle intertoll marker. When a marker is seized, the marker connector signals the decoder connector to connect the incoming sender to this marker.

3.22 The marker obtains the locations of the outgoing trunks for this call from the decoder and the translator card. Guided by this information, the marker selects an outgoing intertoll trunk through an intertoll trunk block connector. The marker then identifies the outgoing frame appearance of the selected trunk.

3.23 The decoder and the translator card also tell the marker how the incoming sender should outpulse, and whether it should outpulse the digits as received, skip 3- or 6-digits, or convert certain digits. When the marker has received all this information, it signals the decoder to release. From this point on, the call proceeds as previously described.

3.24 If the trunks to the called office terminated on the outgoing frames of the toll completing train, then the toll completing train appearance of the incoming trunk would be used. This call would proceed, in the same manner, up to the selection of a marker. Then a toll completing marker would be used and the call would be completed on the toll completing train. If an all-trunks-busy condition is found by a marker and the first alternate route is in a different train, that marker is released and the decoder selects a marker associated with the different train.

C. Calls Requiring Outgoing Senders

3.25 Outgoing senders are necessary for calls which are switched through a 4A office to offices which receive revertive pulsing (RP) or panel call indicator (PCI) pulsing. This is because 4A incoming senders can outpulse only MF and DP to distant offices.

3.26 Outgoing senders are necessary for calls which are switched through a 4M office to offices which receive dial pulses, revertive, or call indicator pulses. This is because 4M incoming senders can outpulse MF only to a distant office.

3.27 The outgoing trunks that connect to such offices have an appearance on outgoing sender link frames. These frames are similar to incoming sender link frames.

3.28 A call through a 4A or 4M office requiring PCI or revertive outpulsing, uses two senders. An incoming sender to register the called number from the incoming trunk, and an outgoing sender to outpulse the called number.

3.29 When an outgoing trunk to an office requiring revertive or PCI pulsing is seized at a 4A or 4M office, or an outgoing trunk to an office requiring dial outpulsing is seized at a 4M office, the trunk signals the outgoing sender link that an outgoing sender is needed. The sender link seizes a link controller through a controller connector. The link controller tests for an idle sender and attaches it to the outgoing trunk. The link controller and connector then release and are free to serve other calls.

3.30 As soon as the outgoing sender is attached, a signal is sent to the incoming sender, telling it to pulse the called digits into the outgoing sender. Incoming senders pulse direct current key pulsing (DCKP) signals into outgoing senders. DCKP is an intraoffice pulsing procedure. These digits are pulsed from the incoming sender through the incoming and outgoing frames, the outgoing trunk, the outgoing sender link, and into the outgoing sender. The incoming sender and sender link then release from the connection. Now the connection consists of the transmission channel, the outgoing trunk, the outgoing sender link frame, and the outgoing sender. The outgoing sender then outpulses the called digits over the outgoing trunk and releases from the connection. (See Fig. 14.)

4. EQUIPMENT ELEMENTS

4.01 Most of the equipment elements are common to CT and ET type offices with minor modification necessary on some circuits for ET application. Some of the elements are different, so the discussion of equipment elements is covered in two parts: common equipment and equipment peculiar to CT offices. Equipment peculiar to ET offices is discussed in DFMP, Division H, Section 13b(2).

ELEMENTS COMMON TO CT AND ET OFFICES

A. Marker

4.02 The marker is one of the major equipment elements in a 4A or 4M Toll Switching System. It locates an idle outgoing trunk and the incoming trunk handling a call. It then marks an idle path between the two trunks, and establishes the transmission path. This path or channel between the incoming and the outgoing trunks consists of an incoming link ("A" link), a junctor ("B" link), and an outgoing link ("C" link).

4.03 The marker in a CT office uses directive information supplied by the card translator and the decoder to establish the transmission path of a call through the office. In an ET office the directive information to the marker is supplied by the stored program control (SPC) and the decoder channel. (See Fig. 15.) Some of this information is used by the marker to seize a suitable outgoing trunk. The marker stores other directive information and later transmits it to the sender. This information instructs the sender how to outpulse the registered digits.

Seizing an Outgoing Trunk

4.04 All of the outgoing trunks (a trunk group) to a certain distant office are spread over as many outgoing frames in one train as is practical. In order for the marker to select one of these trunks without having to go to each frame, the test leads for a trunk group are gathered at the trunk block connector. This arrangement enables the marker to go to just one place to test for an idle trunk to a certain office.

4.05 Information from the card translator and decoder or from the SPC and decoder channel directs the marker to the trunk block connector containing the leads of the desired group of trunks (Fig. 16). The marker tests these leads for an idle trunk and seizes the first one available. The trunk selected may be a guarded or an unguarded trunk.

4.06 A guarded trunk, upon releasing from an established connection, causes itself to look busy to the marker for a predetermined time interval, ensuring the complete release of the trunk equipment in the distant office. As soon as a guarded trunk is seized by the marker, a signal is sent to the distant office, telling it to expect a call on this trunk. An example of a guarded trunk is a 2-way intertoll trunk.

4.07 An unguarded trunk does not have the built-in busy timing arrangement, and can be selected by the marker as an idle trunk immediately upon release from a previous call, and before trunk equipment has entirely returned to normal; however, a timing interval provided by the sender causes the seizure signal to the distant office to be delayed for a predetermined period of time. An example of an unguarded trunk is a toll connecting trunk to a step-by-step office.

Identifying the Incoming Frame

4.08 The marker also has to know the incoming frame number in order to establish the transmission path; therefore, the incoming frame sends its distinctive MF signal (three of eight frequencies) identifying this number to the marker over the select magnet lead associated with the incoming trunk. This lead is extended to the marker through the sender link, and the decoder connector (Fig. 17). This identifying signal is called the frame identification frequency (FIF) signal.

Identifying the Outgoing Frame

4.09 At this stage the marker knows it has an idle outgoing trunk but it does not know the number of the outgoing frame on which this trunk appears. It must know this in order to establish the transmission path. The outgoing frame number is supplied to the marker by sending the distinctive MF signal (three of eight frequencies) assigned to this frame over the select magnet lead associated with the selected outgoing trunk. This signal is extended to the marker through the trunk block connector. (See Fig. 17.)

Testing Incoming and Outgoing Links

4.10 When the incoming and outgoing frames have been identified, the marker reaches out to these incoming and outgoing frames by seizing their associated connectors. An incoming connector for the incoming frame and an outgoing connector for the outgoing frame. Through these connector circuits, the marker gains access to the incoming links, outgoing links, and junctors.

4.11 The marker operates the primary select magnet associated with the incoming trunk being served. This operation signals, to the incoming connector, the number of the primary switch on which the incoming trunk appears. The connector then presents to the marker the test leads of the 20 incoming links which are between this primary switch and the 10 secondary switches on the incoming frame.

4.12 Similarly, the marker operates the secondary select magnet associated with the seized outgoing trunk and the secondary switch number is signaled to the outgoing connector. The connector then presents to the marker the test leads of the 20 outgoing links between the secondary switch and the 10 primary switches.

Access to Junctor Group

4.13 Before the marker can select the particular links to be used in the channel, it must gain access to the junctors. Since the marker knows which incoming and outgoing frames are being used on this call, it also knows which junctor group is between these frames. The outgoing frame connector extends to the marker the test leads for 20 junctors in this group.

Seizing an Idle Channel

4.14 The marker now has access to the test leads for the 20 incoming links, 20 junctors, and 20 outgoing links that can be used to switch this call.

4.15 The marker tests these links and junctors simultaneously and seizes the first channel that matches. Matching means that, starting with the primary switch which has the incoming trunk handling the call, the marker must seize:

(a) An idle incoming link going to an incoming secondary switch having access to:

(b) An idle junctor to an outgoing primary switch which in turn has access to:

(c) An idle outgoing link to the outgoing secondary switch with the seized outgoing trunk.

4.16 When the marker has selected an idle channel, the incoming secondary and outgoing primary select magnets and all of the hold magnets associated with this channel are operated. It will be remembered that the incoming primary and outgoing secondary select magnets were previously operated by the marker. This establishes the transmission path between the incoming trunk and the outgoing trunk.

Junctor Subgroups

4.17 The marker is arranged to test the minimum size junctor group at one time, (20 junctors). When the junctor group has more than the minimum number of junctors, the group is divided into subgroups.

4.18 For example, a train with 4 incoming groups (8 incoming frames and 8 outgoing frames) has 40 junctors in each junctor group. Therefore, each group is divided into 2 subgroups of 20. When the marker is establishing the channel, it first tests one subgroup for an idle junctor that matches the incoming and outgoing links and, if none is found, the marker walks to the other subgroup and repeats the test. Another example of subgrouping is in an office where there are 7 incoming groups and 14 outgoing frames. In this case, 25 junctors are available in each group. These are divided into 2 subgroups: one subgroup with 20 junctors, the other subgroup with 5 junctors. The marker first tests the subgroup of 20 junctors and if an idle junctor which matches the incoming and outgoing links cannot be found, it tests the second subgroup of 5.

Information to the Incoming Sender

4.19 When the marker receives directive information from the decoder and card translator or from the decoder channel and SPC, it uses some of this information immediately and some of it is stored for later use. The stored information is sent to the incoming sender at the proper time.

4.20 The stored information directs the incoming sender to outpulse the digits in such a way that the needs of the next office are met. For example, if the call is switched to a step-by-step office, the sender spills forward dial pulses to direct the step-by-step switches toward completion of the call. In another case, such as to a 4A toll office, the sender is directed to spill forward multifrequency pulses. If the call is switched to a manual office, the sender is told not to spill forward any digits.

4.21 Other directives include the number of code digits to be outpulsed. For example, the next office may not require the area code. Therefore, the incoming sender is instructed to skip these code digits when spilling forward. In other cases, the incoming sender is instructed to convert the code digits to fit the needs of the next office. For example, code conversion is frequently required to switch calls through step-by-step intertoll systems which use arbitrary route codes.

Second Trial Feature

4.22 The marker has a second trial feature for making a second attempt to complete a call. Second trial is made under various conditions:

(a) ***Trouble Conditions:*** Second trials due to trouble conditions are performed in two slightly different ways, depending on the phase of marker operation in which the trouble occurred. If trouble is encountered while the decoder or decoder channel is still connected to the marker, the trouble recorder frame is requested to make a trouble record by the decoder or decoder channel. The decoder or decoder channel also signals the decoder connector that a second trial is to be made. This action results in the release of the decoder channel, the marker connector, and the marker from the connection. The call cycle now starts again. The decoder connector selects a decoder or decoder channel, which in turn selects a marker. This marker is given a second trial indication, which causes it to change the direction of its trunk hunting and channel testing. In this way, if the trouble encountered on first trial were associated with the selection of a trunk or channel, testing the second time in a different direction might avoid the trouble. If the second marker also encounters trouble in completing the call, it requests a third trial in order to route the call to reorder announcement. If the marker encounters trouble after the decoder or decoder channel has been released in the normal course of its functions, the marker causes a trouble record to be made. The marker then sends a second trial indication to the decoder connector and releases itself. The call now proceeds in the same manner as described above. A decoder or decoder channel and marker are again selected, and another attempt is made to complete the call.

(b) ***Failure to Match:*** Second trial is made when the marker has seized an outgoing trunk but cannot establish a channel between the outgoing and incoming trunks. The condition is called failure to match and is usually caused by not finding junctors that match with the available links. The procedure for second trial in this case is exactly the same as the procedures discussed above, except that no trouble record is made.

(c) ***Routing Instructions:*** If a trunk group has been selected by means of information obtained from the group busy chain relay circuit, the marker is given a follow with second trial routing instruction. This is done because the selected trunk group may become busy in the short interval before the marker can select a trunk, even through the decoder was assured that at least one trunk was idle. The marker uses this instruction if it finds all the desired outgoing trunks busy on first trial. The second trial is made the same way as described before, except that no trouble record is made.

(d) ***Cancel Follow With Second Trial:*** As part of dynamic overload control, the marker is arranged to cancel second trial whenever the decoders or decoder channels are overloaded due to heavy traffic. The traffic control circuit signals the marker to route follow with second trial-all trunks busy (FST-ATB) attempts to the final reorder announcement (FRA) trunk group instead of requesting a second trial, thereby eliminating unproductive second trial decoder or decoder channel and marker usage.

4.23 The marker frame is shown in Fig. 18.

B. Switching Frames and Their Connectors

Incoming and Outgoing Frames

4.24 The incoming trunks used in the talking connection are on the incoming frames. Similarly, the outgoing trunks used in the talking connections appear on the outgoing frames. Two-way trunks appear on both frames.

4.25 The marker gains access to the incoming links for test purposes through an incoming connector mounted on the incoming frame. It gains access to the outgoing links and the junctors through an outgoing connector mounted on the outgoing frame. (See Fig. 17.)

Home and Mate Operation of Frames

4.26 The marker has dual access to each incoming and outgoing frame for the purpose of testing links and junctors. For this purpose the incoming, and also the outgoing, frames are paired into home and mate frames. This pairing is as follows: 0 and 1, 2 and 3, etc.

4.27 Dual access is provided by enabling the connectors on home and mate frames to reach both frames of the pair. Therefore, the marker has two ways to reach each frame. Fig. 19 shows how this home and mate arrangement works.

4.28 The marker is instructed to use either the connector on the even numbered frame of a pair or the odd numbered frame of the pair. This instruction is part of the routing information furnished the marker by the card translator or the electronic translator. Each frame has a connector which internally is made up of a set of marker connector relays and a duplicate set of frame connector relays. One set of the frame connector relays is designated as the home connector and the other set as the mate connector. The incoming trunk may or may not be located on the frame which the marker has been instructed to use. When the marker is directed to an even or odd numbered frame and the desired trunk is located on that frame, the home connector is used. If the desired trunk is located on the other frame of the pair, the mate connector is used. On a second attempt to set up a connection, the even or odd preference instruction to the marker is reversed to permit the use of a different connector on the second attempt. The solid lines of Fig. 19 show home operation and the dashed lines show mate operation.

C. Incoming Sender

4.29 The major functions of the incoming sender are: to signal the office originating the call to start outpulsing, to register the incoming digits and to outpulse them (according to directions from the marker) toward a connecting office, an outgoing sender, or toward overseas destinations.

4.30 There are four types of incoming senders in use in 4A and 4M toll offices: the multifrequency toll sender, the dial pulse toll sender, the CAMA sender with an associated incoming dial pulse register, and the overseas sender. In newer office installations, a multifrequency toll sender with an associated incoming dial pulse register is sometimes used, which eliminates the need for the dial pulse toll senders in those offices. Each type of sender is designed for a specific purpose. (See Fig. 20 and 21.)

4.31 The multifrequency incoming toll sender is designed to receive only multifrequency pulses (two out of six frequencies). There are two types of MF senders; a flat-spring type and a wire-spring type. Both types are designed to receive MF pulses from switchboards equipped with MF keysets or from senders in other offices which transmit MF pulses. The wire-spring type MF sender is also designed to receive MF pulses from an incoming dial pulse register in the same office. The MF incoming sender is arranged to register up to 11 digits and to outpulse up to 14 digits MF, DP, or DCKP in 4A offices, or MF and DCKP in a 4M office.

4.32 The dial pulse incoming toll sender is designed to receive only dial pulses from switchboards equipped with dials, from step-by-step offices, or from senders which transmit dial pulses. It is arranged to register up to 11 digits and to outpulse up to 14 digits MF, DP, or DCKP in a 4A office, or MF and DCKP in a 4M office. In offices using the wire-spring multifrequency incoming sender and equipped with incoming registers, the dial pulse incoming sender is generally not required, although it is sometimes used for economic reasons due to the volume of DP traffic.

4.33 The CAMA incoming sender is designed to receive only multifrequency pulses (two out of six frequencies), from a local office or from the CAMA dial pulse register. The DP CAMA trunk terminates on both the register link and sender link. On a dial pulse call, the trunk seizes a CAMA DP register which registers the dialed digits. The register then seizes an idle CAMA sender through its appearance on the sender link frame and outpulses the registered digits to the CAMA sender. MF pulsing between the register and sender follows the transmission path from the register link, incoming trunk, and sender link to the sender. This sender is also arranged to operate in conjunction with special CAMA equipment. It is arranged to register up to ten digits of the called number and seven digits of the calling number. It can outpulse MF, DP, and DCKP in a 4A office, and MF and DCKP in a 4M office.

4.34 The overseas sender is designed to receive only multifrequency pulses (two out of six frequencies) from the gateway switchboard, from an overseas connecting office via the overseas facilities with or without time assignment speech interpolation (TASI) equipment, and eventually from the DDD network. It is arranged to register up to 14 digits and can outpulse MF pulses toward properly equipped overseas facilities at ten pulses per second or toward the DDD network at seven pulses per second. The overseas sender can also outpulse DP or DCKP in a 4A office, or DCKP in a 4M office toward the DDD network.

4.35 All types of incoming senders are arranged to outpulse DCKP pulses when serving calls that require outgoing senders. Outgoing senders are used when the 4A or 4M Toll Systems switch calls directly to panel offices or to No. 1 Crossbar Systems which require revertive pulsing, or to manual offices equipped with call indicator positions which require PCI pulsing. In a 4M toll office, all calls using dial outpulsing require the use of an outgoing sender. In such cases, the incoming sender spills forward DCKP pulses to the outgoing sender. Then the outgoing sender converts these DCKP pulses to revertive, panel call indicator (PCI), or dial (4M offices only) pulses and spills them forward to the next office over the outgoing trunk.

4.36 Unless otherwise stated, the following description will cover the MF and DP incoming toll sender only.

Seizure of the Incoming Sender

4.37 Upon receiving a seizure signal, the incoming trunk signals the sender link frame to connect an incoming sender. In an ET office, the sender is not connected to the trunk until the SPC has acknowledged the receipt of incoming trunk and sender identity and has sent a check signal to the link controller. An incoming trunk has access to only the type of sender with which it is compatible (incoming MF pulsing trunks have access to MF senders, incoming DP pulsing trunks have access to DP senders, incoming CAMA trunks have access to CAMA senders, and overseas trunks have access to overseas senders). (See Fig. 20 and 21.)

4.38 When the incoming sender is attached to the incoming trunk and is ready to receive pulses, it signals the operator or sender in the distant office to begin pulsing.

Registering the Pulses

4.39 The KP pulse which precedes the MFKP digit sequence is a distinctive combination of frequencies which prepares the MF receiver associated with the incoming MF sender to receive and register the code digit numericals and the start (ST) pulse which follow.

4.40 The ST pulse indicates to the sender that all the digits have been sent.

Outpulsing Instructions

4.41 After the code digit and numericals are registered, the incoming sender must receive instructions on how to outpulse this called number.

4.42 After a predetermined number of digits are registered (3 through 8), the incoming sender seizes a decoder or decoder channel which in turn seizes a marker. After route translation is performed, the marker instructs the sender how to outpulse the called number. The outpulsing instructions are as follows:

(a) The kind of pulses to be spilled forward (MF, DP, or DCKP).

(b) How many of the registered code digits are to be spilled forward.

(c) Whether any of the code digits should be converted before spilling forward.

(d) Whether any code digits should be prefixed before spilling forward.

(e) Not to outpulse anything (for example, on a call to an operator or test line).

Outpulsing the Digits

4.43 The incoming sender prepares to outpulse the registered digits in accordance with these instructions. In the meantime, the marker has established a channel between the incoming trunk and the outgoing trunk. The incoming sender waits for a signal from the distant office, or from an outgoing sender in the same office, that it is ready to receive pulses. Upon receipt of this signal, the incoming sender spills forward the digits, as instructed, via the sender link, incoming trunk circuit, incoming frame, outgoing frame, and outgoing trunk circuit to the distant office or outgoing sender.

4.44 At the end of outpulsing, the incoming sender and sender link release, leaving the transmission path through the incoming and outgoing frames.

4.45 Where no outpulsing is required, the sender simply checks that an outgoing trunk is attached, and then releases. The incoming sender frame is shown in Fig. 22, 23, 24, and 25.

4.46 The incoming senders do not require specific modification for ET application. However, pretranslation features must be removed from senders used in ET offices.

D. Sender Link Frame

4.47 At the sender link frame, incoming senders are attached to incoming trunks. Each sender link frame is arranged to handle a certain type of incoming trunk and sender (MF trunks with MF senders, DP trunks with DP senders, CAMA trunks with CAMA senders, and overseas trunks with overseas senders). One frame has appearances for 100 trunks and 40 senders. The links for MF and DP senders are 12-wire links. The links for CAMA and overseas senders are 18-wire links. A sender link frame contains sixteen 6-wire, 100-point crossbar switches. Eight of these are primary switches and eight are secondary switches. Incoming trunks appear on the horizontals of the primary switches and incoming senders appear on the horizontals of the secondary switches. The primary and secondary switches are connected by links which are spread in a vertical to vertical pattern. This arrangement permits any incoming trunk to reach any available sender on the same sender link frame.

Trunk Appearances on Primary Switches

4.48 The eight primary switches are divided into two groups, four "A" switches and four "B" switches (Fig. 26). The same trunks (a maximum of 100) appear on both the "A" and the "B" switches in order to give each trunk access to all the senders. These trunks are connected to like numbered horizontals.

4.49 Each sender link trunk group has four links to the sender switches. The "A" switches provide two of these links, for example, links 0 and 1 for trunk group 0. The two additional links are provided by the "B" switches.

Sender Appearances on Secondary Switches

4.50 A maximum of 40 incoming senders have appearances on the horizontals of the secondary switches. These senders are arranged in four groups of ten or fewer senders. Two of these groups appear on the "A" switches and two on the "B" switches. Each group of 10 senders is terminated on 2 switches (20 horizontals) as shown in Fig. 26. Two horizontals (one on each of the 2 switches) are required for each sender because the 12 leads (18 for CAMA and overseas senders) from each trunk must be carried all the way from the trunk to the sender.

Attaching the Sender

4.51 When an incoming trunk signals for an incoming sender, the sender link connector signals a controller connector to seize an idle link controller. The link controller closes the crosspoints between the incoming trunk on a primary switch and the incoming sender on a secondary switch.

4.52 When the connection is established between the incoming trunk and the incoming sender, the sender link connector releases and is ready to serve other calls on its sender link frame.

4.53 MF incoming senders and trunks appear on MF sender link frames, and DP incoming senders and trunks appear on DP sender link frames, as shown in Fig. 20. MF and DP senders and trunks do not appear on the same frames. The sender link frame is shown in Fig. 27.

E. Link Controller and Connector

4.54 The link controller operates like a marker. It closes the crosspoints between an incoming trunk and an idle incoming sender on a sender link frame. (See Fig. 28.)

4.55 Each sender link connector has access to two controller connectors. (See A and B in Fig. 29.) When an incoming trunk signals for an incoming sender, the sender link connector signals one of the controller connectors (depending on which is available or, if both are available, the one that is preferred at that time) to connect to a link controller.

4.56 Test leads associated with the incoming trunks, the links, and the incoming senders are closed through the sender link and controller connector to the link controller. The link controller then tests for and selects an idle sender and sender link and connects the incoming trunk to the sender. The controller then releases from the connection and is ready to serve other calls.

4.57 The link controller and connector frame has space for two link controllers and two controller connectors (Fig. 29). Link controllers and controller connectors are generally furnished in groups of four although some offices are arranged for six. Each group of 4 controllers and connectors serves approximately 16 sender link frames. The number of sender link frames served by one group of controllers is not fixed, because traffic requirements vary in different offices. When the capacity of the controllers is reached, another group of controllers and connectors is provided.

4.58 The sender link access to controller connectors and link controllers for a four controller group is shown in Fig. 30.

4.59 There are minor modifications to the link controllers and connectors in an ET office. The link controller is modified to provide service bid indications and incoming trunk and sender identification to the SPC. Changes are also made to enable the link controller to receive check signals from the SPC before closing crosspoints between trunk and sender. Several connecting leads are added to the controller connector to connect the sender link frame to the peripheral scanner. The purpose of the leads is to provide the SPC with identification of a sender link frame within a link controller group.

F. Trunk Block Connector

4.60 An outgoing trunk group is spread over at least two outgoing frames. In order to facilitate the checking of these trunks, leads from each of the outgoing trunks are brought to trunk block connectors and grouped according to destination. In this way, a marker goes to only one place to test trunks that may be spread over many outgoing frames. A marker seizes the proper trunk block connector in accordance with the location information obtained from a decoder and card translator in a CT office or from a decoder channel and SPC in an ET office. At the trunk block connector the marker tests for and seizes an idle outgoing trunk.

4.61 A trunk block connector contains the appearances of up to 400 outgoing trunks. These trunks are arranged in groups of 40, which is the maximum number a marker can test at one time.

4.62 The trunk block connector is made up of multicontact relays and is mounted on a 2-bay frame called a block relay frame (Fig. 31). It is divided into two parts which are referred to as the even half-connector (in the left bay) and the odd half-connector (in the right bay). These two half-connectors are exactly alike. The 400 trunks which are terminated on the even half-connector are multipled to corresponding contacts in the odd half-connector. This is done in order to provide duplicate access for the markers to these trunks.

4.63 The trunks appearing on each half trunk block connector are divided into two groups (0 and 1) of 200 trunks each. When a marker seizes group 0 in the even half-connector, all other markers are locked out of this connector and out of group 0 on the odd half-connector (since these are the same trunks). But another marker can seize group 1 in the odd half-connector.

4.64 The preference for a particular trunk block connector depends on the number of the sender used in the call. A marker connected to an even-numbered sender prefers an even half-connector, while a marker connected to an odd-numbered sender prefers an odd half-connector. However, if one of the connectors is busy, a marker will use the other one, regardless of preference.

4.65 When a marker has selected an outgoing trunk, it removes the 200-trunk lockout in the trunk block connector. However, the connector remains attached to the marker until the marker is released. This is necessary since the select magnet for the outgoing trunk is operated through the connector.

4.66 The older block relay frame mounts two trunk block connectors, while the newer block relay frame mounts three trunk block connectors. The marker cut-in relays are also mounted on this frame (Fig. 31). In two train offices, each train has its own block relay frames. One such frame can serve ten markers.

G. Decoder Connector

4.67 This connector is used to connect an incoming sender to a decoder or decoder channel, and later in the call when a marker is seized, to connect the incoming sender directly to that marker.

4.68 In a CT office, the standard decoder connector frame accommodates four connectors (Fig. 32 and 33), each of which can serve seven incoming senders. The senders have access to a maximum of 12 decoders. When more than 12 decoders are required, the decoders split into 2 groups (A and B) with up to 12 decoders per group. Each sender has access to the decoders in one group only. Where decoder grouping is added, the office can be provided with up to 24 decoders.

4.69 In most existing offices, a decoder connector frame has been furnished which accommodates three connectors with each connector having access to 18 decoders (nongrouped) and serving 5 senders. Both 3- and 4-connector frames may be used in a decoder group provided the group size does not exceed 12 decoders and the 3 connector frames and decoders are arranged for increased capacity. Each decoder connector (3- or 4-connector frame) can reach all the markers in the office.

4.70 In an ET office, a decoder connector can serve seven to nine (offices arranged for full increased capacity) incoming senders. Each sender has access to a maximum of ten decoder channels in an office. Each decoder connector can reach all the markers in the office. Both 3- and 4-connector frames may be used in ET offices with the qualification that the 3-connector frames must be provided with increased capacity features (Fig. 32 and 33).

4.71 On an incoming call, the incoming sender seizes a decoder connector in bidding for a decoder or decoder channel. A chain circuit in the seized connector will select an idle decoder or decoder channel and cut through the necessary leads by operating its multicontact relays. After route translation by the card translator or electronic translator, this decoder or decoder channel seizes a marker connector which in turn selects an idle marker as directed by the decoder or decoder channel. The marker connector then signals the decoder connector to operate its multicontact relay associated with the preferred marker. This connects the incoming sender to the marker being used on this call. After the decoder or decoder channel has released, the incoming sender remains connected to the marker until the marker completes its functions. Then the marker and decoder connector are released.

H. Marker Connector

4.72 This connector cuts through a large number of leads between a decoder or decoder channel and a marker. In addition, the marker connector signals the decoder connector to cut through certain leads between the incoming sender used on the call and the selected marker.

4.73 Marker connectors used in a single train office can serve a maximum of ten markers. When a decoder or decoder channel signals a marker connector to seize an idle marker, the chain (or preference) circuit selects any idle marker, since they are all combined markers.

4.74 Marker connectors used in a 2-train office can serve a maximum of 20 markers, 10 intertoll and 10 toll completing markers. In order to select the proper kind of marker (intertoll or toll completing), this connector is equipped with two chain circuits; one chain for the intertoll markers, and one chain for the toll completing markers. When a decoder or decoder channel signals the marker connector to seize a marker, it tells the connector which kind of marker is required. The connector then uses the proper preference chain to select the right kind of marker.

4.75 The marker connector releases when the decoder or decoder channel is released from a call. A marker connector for a single-train or a 2-train office is shown in Fig. 34. The marker connector frame accommodates three connectors with the number of connectors in the office being equal to the number of decoders or decoder channels.

I. Outgoing Senders

4.76 Outgoing senders are required in 4A offices when either revertive or PCI (panel call indicator) pulses are to be outpulsed. In 4M offices, the outgoing sender is required when revertive, PCI, or dial pulse outpulsing is to be used (Fig. 35).

4.77 Outgoing trunks that require revertive or PCI pulses in 4A or 4M offices or dial pulses in 4M offices are connected to outgoing senders by an outgoing sender link and connector, controller connector, and link controller. These connect the outgoing sender in exactly the same way as an incoming sender link and connector, controller connector, and link controller connect an incoming trunk to an incoming sender.

J. Multifrequency Pulsing Receiving Frame

4.78 Each MF incoming sender has an MF receiver associated with it. The function of the MF receiver is to receive and amplify MF pulsing signals and to convert these signals into DC pulses to operate various code combinations of relays in the associated sender. Each MF pulsing signal consists of a combination of two frequencies out of six different frequencies. Fifteen combinations are available; 10 for digits and 5 for special signals.

4.79 The multifrequency pulsing receiving frame is used where the MF senders are equipped with flat spring relays. The frame mounts 12 receiving units, with one receiving frame required for each 12 MF incoming senders (4 frames).

4.80 CAMA and overseas senders and MF senders equipped with wire-spring relays have the multifrequency pulsing receiving unit mounted with the sender on the sender frame.

K. Multifrequency Current Supply Frame

4.81 This frame (Fig. 36) mounts the 6-frequency oscillator unit which generates multifrequency current for outpulsing by the incoming senders and the switchboard operators. A minimum of two supply frames are furnished per office and the sender frame load is divided as equally as possible between them. Transfer arrangements are provided to permit one oscillator unit to carry the entire signaling load in the event either of the two units has trouble (signal output drops below a predetermined level).

L. Frame Identification Frequency Supply Frame

4.82 This frame (Fig. 37) mounts the oscillators, amplifiers, and mixing resistors which generate the frame identification frequencies used by the marker in identifying incoming and outgoing link frames. Two frequency supplies, a regular and an alternate, are furnished. Control equipment causes a periodic transfer from one supply to the other to distribute the use and to insure that both supplies are operating satisfactorily.

M. Traffic Overload Reroute Control (Manual)

4.83 Manual traffic overload reroute control (TORC) is a special circuit developed for regional center use (Fig. 38). It is used to enable manual rerouting of regional center to regional center traffic during periods of traffic congestion.

4.84 The manual transfer of traffic is accomplished by the operation of control keys on the regional center traffic control circuit for CT offices or network control for ET offices. The key arrangement is designed to permit the transfer of all or a portion of the traffic load. Transfer in a CT office is accomplished by altering the number of decoders used while in an ET office, the transfer is accomplished on a percentage of traffic basis.

4.85 All regional centers have direct trunks to all other regional centers. For this reason, any regional center can be the alternate or via office for all other regional centers. In CT offices, the choice of via routes for a particular regional center is limited to four. In an ET office, any regional center route may be chosen as the via office for any other regional center. While manual TORC is in operation, the traffic eligible for TORC treatment and overflowing the RC-RC route will automatically be offered to an alternate route through a via office.

N. Traffic Control Console

4.86 The traffic control console houses the controls (keys, switches, and lamps) for operating and monitoring circuits on the traffic control frame (Fig. 38) which can manually or automatically activate certain traffic control features.

4.87 This circuit is used in No. 4 offices to cancel the follow with second trial, all trunks busy (FST-ATB) feature of the marker and to cancel short sender timing. A decoder queue indicator circuit (CT office) or a decoder channel queue indicator (ET office) senses when all the office decoders are busy and causes cancellation of FST-ATB and short sender timing. A sender queue indicator circuit monitors the ST relays on the sender link frames. The sender queue is designed to give a low level output and a high level output, each output dependent on a predetermined number of ST relays operated. A low level output causes cancellation of FST-ATB.

4.88 In regional centers, a sender queue low level output may also cause cancellation of alternate route traffic being routed through the regional center by subtending offices. When the predetermined low level is reached, signals are sent to the subtending offices to cancel alternate routing through this office. The subtending offices in turn send this office an acknowledgement signal showing they have received the cancellation signal. Manual cancellation of alternate routing can be made at any time without operation of the sender queue low. It is also possible to manually cancel an individual route or routes, or to manually exclude individual routes from cancellation. A sender queue high level output may be used to cause cancellation of direct route traffic into the regional center. When the predetermined high level is reached, signals are automatically sent to the subtending offices to cancel direct routes to this office. Provisions for manual cancellation of direct routes are similar to those described for alternate routes.

O. Circuit Busy Announcement Trunks

4.89 These trunks are concerned with the overflow traffic in the office. Overflow trunks (or circuit busy announcement (CBA) trunks) are associated with a particular trunk group, for example, an outgoing intertoll trunk group. These trunks are used when the routing instruction from the card translator or the SPC indicates follow with overflow (FOF). The marker, having found all the trunks in the regular trunk group busy, would be directed to test for an idle CBA trunk assigned to the particular trunk group. When the CBA trunk has been selected and a connection established with the incoming trunk, either a 120-IPM tone or, if an announcement has been patched to the trunk, a no circuit announcement will be returned to the originating operator or customer.

P. Group Busy Chain Relays

4.90 The group busy chain relays are located on the circuits busy announcement trunk frame and are used to indicate the busy/idle status of the subgroups in a trunk group. There is one relay associated with each subgroup of 40 or fewer trunks, with up to 4 subgroups comprising a trunk group. The relay is held operated as long as there is an idle trunk in the subgroup, and it releases when all the trunks become busy.

4.91 In a CT office, chain leads from the group busy relays are used by decoders to check the availability of trunks during relay-to-relay or card-to-relay operation. In an ET office, leads from the group busy relays are terminated at ferrods on the peripheral scanner. By scanning these ferrods, the SPC can determine the availability of trunks during translation. The group-busy relays provide the busy or idle status of trunk groups at switchboards and at the traffic supervisory rack by lamp indications.

Q. Trunks and Trunk Relay Equipment

4.92 Two general types of trunks, intertoll trunks and toll connecting trunks, carry traffic to and from a No. 4A or 4M Toll Switching System.

4.93 There are several categories of intertoll and toll connecting trunks. These categories are discussed here, together with the functions of trunk relay equipment.

4.94 Intertoll trunks are trunks which connect two toll offices. These trunks may be one-way or 2-way trunks and they are classified according to the direction of traffic flow. An intertoll trunk that carries traffic in only one direction is called a one-way trunk. For example, a trunk that carries outgoing traffic from office A to office B is called a one-way outgoing trunk at office A and a one-way incoming trunk at office B. Two-way intertoll trunks carry traffic in both directions.

4.95 Trunks which connect a toll office with local offices and with switchboards are called toll connecting trunks.

4.96 Toll tandem trunks provide toll operators with access to the 4A or 4M Toll Switching System. These trunks are one-way trunks which transmit MF or DP pulses.

4.97 Incoming DDD access trunks are used to switch calls from local offices equipped with automatic message accounting (AMA) facilities to a 4A or 4M office. These are one-way incoming trunks which appear on the incoming frames of an office.

4.98 Incoming CAMA trunks are used to switch calls from local offices not equipped with AMA facilities to a 4A or 4M office. These are one-way incoming trunks which appear on the incoming frames of an office.

4.99 Outgoing toll completing trunks are used to carry calls switched from 4A or 4M offices to local and community dial offices. They are usually connected to incoming intertoll trunks. These trunks are one-way outgoing and appear on the outgoing frames in an office. Toll completing trunks are arranged for dial pulsing to step-by-step offices, multifrequency pulsing to crossbar offices, revertive pulsing to panel dial offices, and panel call indicator to manual offices.

4.100 Miscellaneous trunks have appearances on the outgoing frames only.

4.101 Leave-Word (TX) trunks carry delayed call traffic between the 4A or 4M toll office and the TX (delayed outward) operators. The term TX has been replaced with LW (leave word), WH (we have party ready), or CB (call back) in traffic documents. Some of the trunks available are:

11XX—Regular TX

1150—Universal TX

1151—Conference Operator

1152—Mobile Service and Marine Operator

1153—Charge Operator

1154—Toll Terminal Operator

4.102 Service Trunks: Carry traffic between the 4A or 4M toll office and various assistance type operators. The trunks may also be referred to as operator trunks. Some of these trunks are as follows:

Code 121 — Inward operator

Code 131 — Toll information operator

Code 141 — Rate and route operator

Code 161 — Trunk trouble reporting

Code 181 — Toll station operator

Code 191 — Transfer to CLR operator

4.103 Announcement connecting trunks are used to connect to an announcement or to return 120 IPM interrupted tone to the originating operator or customer when difficulty is encountered in completing a call. The delay may be due to busy trunks, insufficient equipment, or lack of information. Some of these trunks are as follows:

CBA — Circuit busy announcement

FRA — Final reorder announcement

MCA — Misrouted CAMA announcement

NCA — No-circuit announcement

ROA — Reorder announcement

SOA — Sender overload announcement

UCA — Unauthorized code announcement

VCA — Vacant code announcement

4.104 Plant trunks are used by the plant personnel for maintenance and testing purposes, and are accessed by the following codes:

Code 100—Balance test line for balance tests and noise measurements

Code 101—Communication and test with 17C and 17D (overseas) testboards

Code 102—Milliwatt supply

Code 103—Supervisory and signaling test

Code 104—Manual and automatic 2-way transmission test

Code 105—ATMS responder test line

Code 107—One-way manual PAR measurements

Code 108—2-way manual echo suppressor test

4.105 The following trunks have appearances on both the incoming and the outgoing frames.

4.106 Junctor converter trunks are used in certain 4A or 4M offices for interconnecting 3- and 4-row teletypewriter stations. Each circuit has two appearances on the outgoing frames of the same train. One appearance is used when the calling station is 3-row, and the other when the calling station is 4-row. Both of these appearances loop back to a common incoming appearance. This common appearance is multipled to both trains in a separate train office.

4.107 Digit-absorbing trunks are primarily used to complete incomimg calls that arrive at the 4A or 4M office with the home toll center code preceding a 4- or 5-digit TX code. The completion of the call is accomplished by routing the call over a digit-absorbing trunk with instructions to delete the first three digits to eliminate the unwanted toll center code. The call is then presented to the 4A or 4M machine for the second time using the remaining digits for translation. In effect, this allows the 4A or 4M machine to perform a 9-digit translation.

Trunk Groups and Subgroups

4.108 A trunk group is made up of trunks which connect two switching offices together. For example, the trunks between two No. 4 toll offices, such as White Plains and Boston, would comprise a trunk group. Each trunk group may be composed of incoming, outgoing, and 2-way trunks and contain a maximum of 160 outgoing and 2-way trunks from a given office. In ET offices, this trunk group maximum size is increased to 320 trunks. Large trunk groups are divided into subgroups of up to 40 trunks by the marker design, since it can only test a maximum of 40 trunks at a time.

4.109 On a particular call, the decoder in a CT office, or the SPC in an ET office, will preselect a subgroup of 40 or less trunks during route translation. A group-busy chain relay circuit monitors the busy/idle status of each trunk in the trunk group and indicates the lowest subgroup containing at least one idle trunk. This subgroup is then presented to a marker for test. In offices not equipped with group-busy chain relay circuits, the decoder or SPC cannot determine the busy/idle status of trunk groups and must present each subgroup sequentially to the marker until an idle trunk is found. This operation is known as HOLD routing. Because of the time consumed in this method, most offices use group-busy chain relay circuits.

4.110 With respect to traffic engineering, trunk groups may be classed in three categories: high-usage trunk groups, individual final trunk groups, and common final trunk groups. These terms relate to the usage and availability of alternate routes.

4.111 A high-usage trunk group is a group of trunks for which an engineered alternate route is provided and for which a certain amount of traffic is engineered to overflow to an alternate route. The number of trunks is determined on the basis of relative trunk efficiencies and the economic consideration of routing via the direct or via the alternate route.

4.112 An individual final trunk group is a group of trunks for which no engineered alternate route is provided. The individual final group is restricted to direct routed traffic to insure that alternate routed traffic into the trunk group will not block direct routed calls. These trunks may overflow into a common final trunk group terminating in the same office. The trunks in this group are usually to the same or a higher class office, and the number of trunks provided are engineered to result in a low probability of calls encountering an all-trunks-busy condition.

4.113 A common final trunk group is a group of trunks for which no engineered alternate route is provided, and is to or from the same or a higher class of office. The number of trunks provided is engineered to result in a low probability of calls encountering an all-trunks-busy condition. High-usage and individual final trunk groups overflow to these common final trunk groups.

Pads

4.114 In order to understand pads which are used to introduce a transmission loss on certain trunks, it is necessary to understand some of the fundamental requirements of a good transmission system.

4.115 If all the intertoll trunks in a connection had no transmission loss, the received volume on all connections (assuming the same subscriber and neglecting the effect of the toll connecting trunks for the moment) would be the same, regardless of the type or length of the connection. The reduction of transmission loss to zero is not practicable for several reasons, one of which is that, if gains were set high enough to do this, undesirable echo or, in the worst case, singing would occur.

4.116 The transmission loss of every intertoll trunk is reduced to a very low value through gain provided by the carrier system or the use of repeaters for voice frequency circuits. Thus the overall loss, for all practical purposes, does not vary significantly whether there is one or several intertoll trunks in the connection.

4.117 The different trunks making up an intertoll group may use different transmission facilities. For example, some trunks may use carrier facilities of various types, while others may use voice-frequency facilites. Also the local looping used to get to the transmission terminals may be varied. Most long-haul connections use a mixture of microwave and coaxial cable. All of these factors affect the transmission loss of an intertoll trunk.

4.118 Regardless of the makeup of a trunk, gains are set to levels high enough to give adequate transmission on all intertoll trunks even with a high-loss toll connecting trunk in the connection. The spare gain is used to compensate for loss of toll connecting trunks.

4.119 It is not practical to adjust gain for each individual trunk. Also, it is not desirable to have appearances of trunks with various transmission levels at the toll testboard and the circuit patching bay.

4.120 A uniformity of transmission levels is obtained by the use of adjustable nonswitching pads, called "P" pads (pads are artificial conductor losses). These pads are used in both the transmitting and receiving branches of every trunk. They are inserted between the line side of the trunk and the transmission facility. For each trunk, these pads are adjusted to a loss which, when added to the loss caused by echo suppressors, signaling units, office cable, etc, brings the transmission level of the particular trunk into uniformity with the others which appear at the testboard and circuit patching bay. Thus, the loss introduced by the "P" pads varies from trunk to trunk, depending upon the makeup of the trunks. For each trunk, the loss in the "P" pads remains fixed unless a change is made in the office layout of such a nature as to change the trunk loss (for example, removing an echo suppressor).

4.121 Toll connecting trunks may be low- or high-loss trunks and thus have considerable effect on the transmission level when they are used in a connection between offices. Low-loss trunks are not a problem, but to compensate for the loss in high-loss toll connecting trunks, intertoll trunks are provided with spare gain. Since an intertoll trunk may or may not be connected to a toll connecting trunk to complete a connection, some way of controlling the spare gain in the intertoll trunk is needed. This control is accomplished by switchable "A" pads in the transmitting and receiving branches of intertoll trunks. If an intertoll trunk is connected to another intertoll trunk, the spare gain is not needed and the "A" pad remains in the circuit. The loss introduced by the pad offsets the spare gain provided by the repeaters. If an intertoll trunk is connected to a high loss toll connecting trunk, the spare gain is needed and the "A" pad is automatically switched out.

Trunk Circuits

4.122 Trunk circuits are associated with the incoming and outgoing ends of every trunk. These circuits perform both signaling and transmission functions. The signaling functions consist of receiving and forwarding supervisory signals exchanged by a calling office and a called or intermediate office. The transmission functions include continuation of trunk conductors, providing 2- to 4-wire conversion where necessary, and passing information to the common control equipment.

Signaling Functions

4.123 Incoming trunk circuits receive supervisory signals (for example, rering or disconnect). They pass these signals to outgoing trunk circuits, which in turn pass them on to the next office. The outgoing trunk circuits also receive signals (such as start dialing and off-hook), which they pass back to the incoming trunk circuits. These circuits then pass the signals back to the sender, the originating switchboard or to the preceding toll system, as appropriate.

Transmission Functions

4.124 Trunk circuits provide a transmission path for the trunks which are connected to the switches. Four-wire trunks can be brought directly through the switches without conversion; however, 2-wire trunks require hybrid coil arrangements in the trunk circuit to accommodate the necessary 2-wire to 4-wire conversion.

4.125 Toll connecting trunks are trunks to or from local switching offices (usually 2-wire). A 2-wire trunk of this type is connected from 2-wire to 4-wire by a repeat coil hybrid in the trunk relay circuit. This circuit also contains the balancing networks needed to balance a particular trunk. Balancing networks are adjustable to match the 2-wire line impedance as closely as practical to obtain proper operation of the hybrid coil.

Passing Information to Common Control Equipment

4.126 When a call arrives at a 4A or 4M office, the trunk circuit sends a start signal to a sender link frame which informs the controller that a trunk has a call and wants an incoming sender. The controller will attach the proper type of incoming sender (MF, DP, CAMA, or overseas) to the trunk through the sender link frame. The trunk circuit then passes class information to the sender. Some of this class information conditions the sender for proper operation. If dial pulse inpulsing is being used, the trunk also informs the sender (in this case, a DP incoming sender) whether loop or CX pulsing is being employed. If the trunk is of the loop dialing type, pulses are received via the "T" and "R" leads on a loop basis. If the trunk is of the CX type, pulses are received via the "R" lead while the "T" lead is used for supervisory signaling between the trunk and sender. Other trunk class information is used for translation screening and for traffic register operation. Incoming trunk class information in ET offices is determined by the SPC by matching the incoming trunk against data in permanent memory for that particular trunk.

ELEMENTS PECULIAR TO CT OFFICES

A. Decoders and Card Translators

4.127 The decoder, together with the card translator, decodes the code digits registered in the incoming sender into information for switching the call. This information is obtained from a card which the decoder causes to be dropped in the card translator. The decoder, like the marker, has second trial features. Because these are often associated with a card failing to drop, they are discussed later in connection with the card translator. (See Fig. 39.)

4.128 A sender seizes decoder through a decoder connector. The point at which a decoder is seized differs with the type of sender and the number of digits registered in the sender. Non-CAMA flat spring senders equipped with the interchangeable area and office code feature seize a decoder when eight digits or a start signal has been registered, whichever comes first. Non-CAMA flat spring senders without the interchangeable area and office code feature seize a decoder when six digits or a start signal has been registered. Where a sender is arranged for pretranslation, the sender will seize a decoder after registering three digits. Overseas and non-CAMA wire-spring MF senders seize a decoder when the start signal has been registered, regardless of the number of digits registered. CAMA senders seize the decoder when the start signal has been received, and the first digit of the calling customer identifying number has been registered in the sender by the CAMA operator or through automatic number identification (ANI).

4.129 When a decoder is seized by an incoming sender, it uses the first three digits registered in that sender to make a 3-digit translation in its home translator. A card drops in the translator corresponding to these three digits. There may be two cards in the translator for the 3-digit code, if incoming trunk screening is required and the VO (via only) or NVO (non via only) incoming trunk class may be used to select either one of the two 3-digit cards. This procedure can be considered a starting point for obtaining a translation on every call. Any further action that the decoder takes is determined by the information contained on this first dropped card as follows.

4.130 If the first card indicates that it has enough information to switch the call, then the decoder signals a marker connector to seize an idle marker. The decoder then passes the information it obtains from the card to the marker. The call is then completed. This operation is called a 3-digit translation.

4.131 When more than three digits are required to obtain a translation, the first card dropped indicates specifically how many digits are required. For example, one card indicates that four digits are necessary for a certain call; another card indicates that five digits are required for a call; another card indicates that six digits are required for a particular call. In all these cases, the decoder action is the same. The decoder restores the card, completes the translation if the required number of digits are registered in the sender, and if not, routes the call to reorder. For senders equipped with the pretranslation feature (manufacture discontinued) the decoder signals that more digits are required, releases from the sender, and is available for serving other calls. The action of the decoder being released due to insufficient digits being registered in the sender is called a pretranslation.

4.132 The decoder having dropped the 3-digit card for the first time on a call and receiving a signal from the incoming sender that it has sufficient digits registered (four, five, or six) restores the 3-digit card. A card corresponding to the registered code is then dropped or the decoder connects to a foreign area translator and causes a card to drop in this translator corresponding to the registered code.

4.133 One important item of information that the decoder gets from the card and passes to the marker is the location of the outgoing trunks that can be used for a particular routing. The locations of a maximum of 40 trunks can be obtained from one card, if there are more than 40 trunks for a particular routing, two or more cards are necessary. (One card is limited to 40 trunks because the marker can test a maximum of 40 trunks at one time.)

4.134 When there are two or more cards available, a decoder can operate in one of three different ways: card-to-card, relay-to-relay, or card-to-relay operation. In card-to-card operation, the decoder presents the information from a series of cards to a marker and leaves it up to the marker to test for an idle trunk. In relay-to-relay operation, the decoder first checks for idle trunks and then presents the information from the card corresponding to the subgroup containing one or more idle trunks to the marker. Card-to-relay operation contains certain features of both card-to-card and relay-to-relay operation.

Card-to-Card Operation

4.135 In this type of operation, the decoder advances from one subgroup of 40 trunks to another subgroup of trunks by presenting a series of cards (maximum four) to a marker which then tests for idle trunks in these subgroups.

4.136 From a routing instruction on the 3D card (or 6D card) that it drops, the decoder learns that this is card-to-card operation. It passes this information on to the marker by sending a hold signal (meaning more cards available) along with the location of the 40 trunks on the first card.

4.137 If the marker finds an idle trunk from the information on this 3D (or 6D) card, it signals the decoder to release and proceeds with the call. If the marker finds the first 40 trunks busy, it signals this to the decoder. Then the decoder restores the 3D (or 6D) card and, from information supplied by this card, advances to another card, the route advance 1 (RA1) card, which represents additional trunks. In this way, a maximum of four cards — a 3D (or 6D) card and three route advance cards (RA1, RA2 and RA3) representing 160 trunks — can be presented to the marker.

4.138 In order to dispose of the call if there are no idle trunks available, the last card carries a routing instruction which directs the marker to connect the call to a reorder or overflow trunk.

Relay-to-Relay Operation

4.139 In relay-to-relay operation, the decoder first checks for the availability of trunks in both direct and alternate route trunk groups before it offers information from a card to the marker. However, the decoder does not actually drop each card but it learns from the 3D or the 6D card which trunks to check. It checks these trunks by means of a group of route relays known as an alternate route tree. Each route relay represents a group of (maximum) 160 trunks. These relays are interconnected to provide a definite order of progression (a direct route progressing to successive alternate routes) according to the basic switching plan.

4.140 Each route relay is associated with a maximum of four group busy chain lead circuits, one chain lead circuit for each subgroup of 40 trunks. The operation of a route relay permits the decoder to check the group busy chain leads and to determine whether there are idle trunks in any of the subgroups. If there are no idle trunks, the decoder operates the next route relay, etc.

4.141 When all trunks in all subgroups are busy, the decoder can be arranged to react in either of two ways. The last subgroup of trunks can be made to appear to the decoder as having an idle trunk. The decoder causes the card representing the last subgroup of trunks to be dropped in the translator, decodes the information read from the card, and seizes a marker. The information pertaining to the last subgroup is presented to the marker, but the marker finds all trunks busy. The marker then uses routing information obtained from the translator card, to complete the call to a circuit-busy announcement (CBA) or a no-circuit announcement (NCA) trunk.

4.142 The preferred decoder arrangement has circuit-busy announcement (CBA) trunks assigned to the last subgroup. The group busy leads associated with the CBA trunks are tested at the same time as the regular trunk group busy leads are tested. If the regular trunks are all busy but a CBA trunk is idle, the decoder will cause the card representing the last subgroup to be dropped, will decode the information read on the card, and will seize a marker. The marker will test the subgroup for an idle trunk, which in this case, is a CBA trunk. If when the decoder tests the group busy leads, all the regular and CBA trunks are busy, the decoder does not drop a card but seizes a marker, the decoder directs the marker to test for an idle trunk in a no-circuit announcement (NCA) or reorder announcement (ROA) trunk group.

4.143 At a primary center, the theoretical maximum number of trunks that could be checked by the decoder in relay-to-relay operation is 960 trunks. These 960 trunks are represented by 24 cards called alternate route (AR) cards. The decoder can drop any one of these cards to gain access to an idle trunk.

Card-to-Relay Operation

4.144 This is a combination of the above two types of operation. The first part of this operation is like card-to-card operation. The decoder presents up to a maximum of four cards to the marker. The second part is like relay-to-relay operation. The decoder goes to the relay tree and checks the alternate route trunks that can be used to switch the call.

4.145 During the card-to-card part of this operation, the decoder presents to the marker a 3D (or 6D) card and, if necessary, a series of route advance (RA) cards. If the marker finds an idle trunk among the trunks presented by one of these cards, it uses this trunk to complete the call; however, if it is necessary to advance as far as the last RA card, the decoder starts the relay-to-relay part of card-to-relay operation. This last RA card carries the card-to-relay routing instruction which tells the decoder to go to the relay tree.

4.146 A maximum of 1120 trunks (160 in the card-to-card part and 960 in the relay-to-relay part) can be tested in this way.

4.147 One of these three methods of operation is used by the decoder on every call for which there are more than 40 trunks available. The decoder is told which method to use on a particular call by the routing instructions on the first 3D or 6D card dropped. The decoder frame is shown in Fig. 40.

B. Card Translator

4.148 The card translator translates the code digits registered in the incoming sender into information which is used by the common control equipment to switch a call. The card translator gets its name from the fact that metal cards are used in the translation process. This type of translator is unique to the 4A and 4M systems, and is quite different from the conventional relay-type translators used in other systems. (See Fig. 41.)

4.149 Each card translator contains metal cards which provide the routing information used for switching a specific call from a 4A or 4M system to another toll switching center or to a local office where it terminates. The translator stores the metal cards in 12 storage bins, each bin containing a maximum of 100 or minimum of 60 cards, of which all but two are coded. An uncoded card is placed at each end of the deck to minimize the effect of card bounce. Therefore, the capacity of a translator equipped with card (0.007-inch thickness) is 1176 coded cards and 24 blank cards. The capacity with the newer cards (0.006-inch thickness) is a maximum of 1476 cards. For planning purposes, however, 1308 cards should be considered as the capacity. Translator cards are not in any particular order and any card may be placed in any bin.

4.150 Each card is mechanically coded to correspond to an authorized code, typically an area code, an office code, or an area code plus an office code. This coding is done by using different combinations of small metal tabs on the bottom of the metal cards. These tabs are used to select or drop the proper card into the position where its routing information can be read. Each uncoded card has 40 tabs. (See Fig. 42.) The mechanical coding is done by removing some of the tabs so that those tabs remaining form a definite pattern or code.

4.151 Each card has 118 holes (Fig. 42). The holes in the card are coded to correspond to the routing information for a particular called code. The routing information for switching a specific call is incorporated on a given card by enlarging certain of the holes in a definite pattern.

4.152 When the translator cards are in the rack awaiting a call, the 118 holes are all lined up to form tunnels through the cards (Fig. 43). There is one phototransistor for each hole in the card and each phototransistor has an amplifier and detector circuit associated with it. A light source on one side of the stack of cards shines through the tunnels, activating the phototransistors lined up in front of the tunnels on the other side. The principle of the card translator is based on the activating of these light-sensitive phototransistors by beams of light. The phototransistors respond to these light beams by passing a signal to the amplifier and detector circuits. If the card translator is unoperated, the light has no effect on the amplifier and detector circuits. When a call comes in, the proper card is made to drop about 3/16 of an inch. This closes all the light tunnels except the ones corresponding to the enlarged holes in the dropped card. At the same time, the transistor amplifiers are activated and those opposite the open light tunnels are energized. The resulting amplified signals operate relays which transmit information to the decoder required to switch the call.

4.153 Changes in routing information are made by simply replacing cards. New routings are added by inserting new cards. Since the 4A and 4M systems are located all over the nation, the information on changed or added codes will not reach all control switching points (CSPs) at once. Therefore, a CSP in one area may have a call to an office in another area (6-digit translation) which is recognized as a vacant code because that office code was recently activated and this information was not yet recorded.

4.154 In order to route such calls, principal city routing (PCR) is employed. A CSP in each area is designated as a principal city CSP. Code changes or additions that affect offices in any given area are recorded immediately in the principal city CSP for that area. Calls requiring 6-digit translation, which appear as vacant codes to card translators outside the NPA, are routed to the principal city CSP. This includes calls to actual vacant codes (unassigned) as well as those that just look like vacant codes. The principal city CSP completes the call or connects it to a vacant code announcement (VCA) trunk.

4.155 There are three types of translators:

(1) Home translators

(2) Foreign area translators

(3) Emergency translator.

These translators are basically the same, both from physical and electrical characteristics. They differ only in the cards they contain and in their use.

Home Translator

4.156 There is a home translator for each decoder in the office. Offices where decoders are not grouped could have a maximum of 18, and offices arranged for grouped decoders could have a maximum of 24. Provision has been made for a maximum of 19 foreign area translators and one emergency translator.

4.157 One home translator is directly associated with each decoder in the office. (See Fig. 39.) On every call, once a decoder is seized, it drops a 3-digit card in its own home translator. Any decoder can handle any call because home translators in the office contain identical sets of cards.

4.158 If a 3-digit card fails to drop, the decoder releases and gives a second trial indication to the decoder connector. The connector selects another decoder, and a second attempt is made to drop an identical card. If a card drops, the call goes to completion and the decoder calls in the trouble recorder which records the failure to drop a card on the first attempt. However, if a card fails to drop on second trial, the decoder assumes that this is a blank code and routes the call to a VCA trunk.

4.159 The home translator does two things:

(a) Provides switching information for calls requiring 3-digit translation to both home and foreign areas.

(b) Directs decoders to foreign area translators for calls requiring 4-, 5-, or 6-digit translations.

Foreign Area Translator

4.160 Each foreign area translator contains all the 6-digit cards required for completion of calls to several particular foreign areas which require 6-digit translations. For example, one translator may contain all the cards required for three foreign areas, and another for five foreign areas. Therefore, unlike home translators, the choice of foreign translator used on each call is limited. On a particular call, the foreign area translators are available to all decoders through connectors. The card dropped in the home translator directs the decoder to a specific foreign area translator.

4.161 These foreign area translators can be arranged in two ways. They can be paired and nonpaired, or they can all be nonpaired.

4.162 Nonpaired translators contain 6-digit cards for calls which, if routing is not obtained (no card drops, out of service, etc,) at the foreign area translator, can be routed by principal city routing from the home translator without second trial.

4.163 If there is no principal city routing for certain calls, then some of the foreign area translators in an office are paired. Both members of a pair of translators have identical sets of cards.

4.164 If a 6-digit card fails to drop for any reason in one paired translator, the decoder releases and gives the decoder connector a second trial indication. This connector selects another decoder which goes to the other translator in the pair and attempts to drop a duplicate 6D card. If the card drops, the call goes to completion and the decoder calls in the trouble recorder which records the failure of the paired translator to drop a card on the first attempt. However, if a card fails to drop on second trial, the decoder assumes that this is a blank code and routes the call to a vacant code announcement trunk.

4.165 The number of paired and nonpaired foreign area translators depends on the needs of an individual office. Each translator is numbered, starting with 01 and going up to 19.

Emergency Translator

4.166 One emergency translator is furnished in each office. This translator can, when necessary, replace any translator in the office.

4.167 Whenever a translator has to be taken out of service, its cards are transferred to the emergency translator.

4.168 In the following discussion of the basic functions of the card translator, it is not necessary to distinguish between these three types.

Dropping a Card

4.169 In the translator, the stack of cards rests on 40 code bars which correspond to the 40 card tabs. Thirty-eight of the card tabs are coded but the outside two are never coded. A card resting on these code bars when the card translator is unoperated is shown in Fig. 44. When the decoder connects to its card translator, it operates certain code bars in the card translator to drop the desired card. The two outside (card support) bars are operated after the other code bars have been set. One card drops, while all the rest return to their original position. Operated code bars as well as how the card with the corresponding tabs drops are shown in Fig. 45. It can be seen by comparing Fig. 44 and 45 that the card with the corresponding tabs drops down to the operated code bars. Since each card in one card translator has a different combination of code tabs, only one card drops at a time.

4.170 There are two holes in each card (Fig. 42) called index holes (IND1 and IND2), which are used to indicate whether the cards are in the proper position during both the operated and unoperated periods. When the card translator is normal (unoperated), the light goes through all the holes on the card, including these IND1 and IND2 holes. If a card is dislocated and the light through either or both of the IND1 and IND2 holes is cut off, the card translator sounds an alarm.

4.171 The IND1 and IND2 holes are never enlarged; therefore when a card drops, the light channels through these holes are always cut off. The cutting off of these light channels signals the decoder that a card is in position to be read; however, if a card does not drop properly, and the light channels through either or both the IND1 and IND2 holes are open, the decoder will trouble record.

Reading the Dropped Card

4.172 When a card drops, there is a shutter effect on all the light channels except the ones in line with the enlarged holes on the dropped card. A dropped card with light channels going through the enlarged holes and cut off from the other holes is shown in Fig. 43. When the card is in a position to be read, the amplifier and detector circuits associated with the phototransistors are energized and they read the coded light channels. The translation information is then obtained by the decoder and the marker. (The gate shown in Fig. 43 is the mounting for the phototransistors.)

4.173 When a card translator is unoperated, the light shines through all the holes in the card. When a translator is operated and a card is dropped, light passes only through the enlarged holes on the dropped card.

Mechanical Sequence of Operation

4.174 A simplified illustration showing the mechanical and optical elements of the card translator is shown in Fig. 46. When a decoder connects to a card translator, the pull-up magnets are energized to lift the card stack about 3/16 of an inch from the code bars. This magnetic action also tends to separate and straighten the cards in the stack. (To assist in lifting the stack of cards, the code bars under the card support tabs [CS1 and CS2, Fig. 42] also raise slightly. These tabs are always left on the card.) The latch supporting the code bars then operates, freeing the code bars for downward motion.

4.175 As shown in Fig. 46, there is a solenoid attached to both ends of each code bar. The solenoids of the code bars corresponding to the called code, are activated by the decoder and pull down the desired bars and the CS1 and CS2 bars. Then the latch releases and holds all code bars in their respective positions. The pull-up magnets are released and the pull-down magnets operate. All the cards now are back in their original position on the unoperated code bars while the selected card drops to the operated code bars.

4.176 When the card has dropped, the cutting off of the light channels through the IND1 and IND2 holes in the face of the card signals the decoder that a card is in position to be read. The amplifier circuits associated with the phototransistors are then energized. The open channels are read and the translation information is passed to the decoder and marker.

4.177 When the card translator is restored to normal, the latches are again operated. The pull-up magnets and the CS1 and CS2 code bars again lift the cards off the code bars which restore to their normal position. The latches also go back to their normal position, the pull-up magnets and the CS1 and CS2 code bars release and the card translator is restored to normal.

4.178 During periods of heavy traffic, the card translator may be reseized immediately. To save time, the pull-up magnets and latches remain operated a short time in order to hold the card stack suspended, thereby eliminating the need to lift the card stack before operating the code bars.

Light System

4.179 The light (or optical system) is arranged in the following way (Fig. 46). A lamp is mounted between two slotted wheels (attached to a motor) that are constantly chopping the light at 400-Hz. Mirrors (A) and (B) reflect the light to two lenses (C) which are mounted in front of the card stack. (Each lens covers half the card.)

Equipment and Maintenance Features

4.180 The card translator equipment is mounted in a shop-wired metal floor cabinet. This cabinet contains the detectors, tubes, amplifiers, and relay equipment needed in the operation of the card translator. The card translator machine is mounted on top of this cabinet.

4.181 Provision is made for removing or inserting cards into the translator. A card can be selected and removed by a mechanism in the translator which is activated by some controlling keys on the test frames. Cards are added by manually inserting them in the bins.

4.182 The code bars, latches, and solenoids, which are the critical apparatus, are built into a unit which can be removed for maintenance purposes. The lenses are also easily removable for cleaning. The phototransistors can be reached by swinging out the gate on which they are mounted.

Translator Card

4.183 A short discussion of the type of information supplied by the translator card (Fig. 42) is given here.

4.184 The information on a card is divided into two major categories: input information and output information.

4.185 Input information is put into the translator by the decoder in order to drop a card. This information is put on the tabs at the bottom of the card. As mentioned previously, the card is coded by using various combinations of these tabs. The arrangement of these tabs determines:

(a) The kind of card this is: 3-digit, 6-digit, alternate route, route advance, national numbering plan (AC or NAC), overseas numbering plan (TAS1, TAS2, TAS3).

(b) Called code: area code, office code, TX code, service code.

(c) Translation screening to be used (VO, NVO)(not generally used).

4.186 As can be seen by looking at Fig. 42, the CG position identifies the kind of card. A combination of two tabs is used for each kind. For example, a 3-digit NAC card retains tabs 1 and 4, while a 6-digit card retains tabs 2 and 4; in either case the remaining three tabs are removed.

4.187 The A through F positions are used for the various called codes. Using a 2-out-of-5 coding system, two tabs are left in each position, to identify one digit. For example, a card for area 201 would retain tabs 0 and 2 in the A position, 4 and 7 in the B position, and 0 and 1 in the C position. The tabs in the D through F positions can either be removed or specially coded to provide more uniform card support when other cards are being dropped.

4.188 Although not generally used, the VO and NVO tabs can be used to provide two different routings for the same dialed digits, depending on the class mark on the incoming trunk. For example, the tabs can be used to distinguish CAMA and non-CAMA incoming trunks. They can also be used to relate a transmission distinction when route translations differ for VO traffic and NVO traffic.

4.189 Output information, which is used for switching a call, is provided by the holes on the card. In Fig. 42 groups of holes are labeled according to the types of information they furnish. The enlarging of certain holes within each group gives the specific information. Not all groups of holes are used on every call. Various calls require different amounts and kinds of information.

4.190 One of the most important pieces of information provided by the card is the location of the outgoing trunk to be used in the call. This is given by the OGT and the trunk block connector groups of holes. The following are other examples of the sort of information that the card provides:

(a) Pretranslation—If pretranslation is provided, information on the card tells whether three digits are sufficient to perform translation or whether more digits are needed. For example, when the CA6 hole is punched in the pretranslation group, it means that 6-digit translation is necessary. In this case the decoder first checks for a 6-digit registered signal. If six digits are available, translation is made. If not, the decoder releases after instructing the sender to select another decoder when six digits are available. Most senders delay decoder seizure until six digits or the ST pulse have been registered. In this case, the decoder proceeds with 6-digit translation or, if insufficient digits are available, routes the call to reorder.

(b) Routing Instructions—These instruct the decoder how to proceed: card-to-card, relay-to-relay, card-to-relay; follow with second trial, master busy, or overflow; and whether there is principal city routing. For example, a card-to-card routing instruction is shown by punching the RI4 and the RI7 holes.

(c) Variable Spill Control—This tells how many digits are to be spilled forward to the next office. For example, when a called code is to be spilled forward without any change, the NSK (no skip) hole is punched.

4.191 The abbreviations for the various holes and their meanings are shown in the following list.

GROUP	DESIGNATION	SIGNIFICANCE
PRETRANSLATION	NCA CA4-5-6	No come again. Come again with four, five or six digits.
OGT APPEARANCE	IT TC ITC	Outgoing trunk appears on the intertoll train. Outgoing trunk appears on the toll completing train. Outgoing trunk appears on both trains. The decoder must determine the proper train from the location of the incoming trunk.
TRAFFIC SEPARATION PEG COUNT	TS0-2	Outgoing traffic separation class (arbitrary numbers) peg count 0 through 6.
THROUGH TRAFFIC PEG COUNT	TPC	Through traffic peg count.
TRUNK GROUP PEG COUNT AND OVERFLOW	TP0-2	Trunk group peg count and overflow (arbitrary numbers) 0 through 7.
INDEX	IND1-2	Index channels used for checking that card dropped properly.
TANSLATOR BOX NUMBER	HB BT0-1 BU0-7	Home box. Foreign translator box tens digit 0 or 1. Foreign translator box units digit 0 through 9.
INWATS AREA 1 BAND DIGIT	BU0-7	INWATS CAMA originating screening
CLASS	CLT0-1 CLU0-7 CDLC	Class number tens digit 0 or 1. Class number units digit 0 through 9. Cancel delayed loop closure.
AREA CODE CONTROL	NAC AC AHA AFA	No area code. } used on regular Area code. } card. Alternate route terminates in home area. } used on alternate Alternate route terminates in foreign area. } route card.
ALTERNATE ROUTE	ART0-7 ARU0-7	Alternate route pattern number tens digit 0 through 9. Alternate route pattern number units digit 0 through 9.
ROUTING INSTRUCTIONS	RI0-7	Routing instruction number 0 through 9.
CONTINUITY AND DIGIT CONTROL	CDC0-7	Continuity and digit control category 0 through 9.
INWATS SCREENING	WST-, CDC0-7	Terminal Screening band.
CODE CONVERSION	CCHN CCTN CCUN CCH0-7 CCT0-7 CCU0-7	Code conversion hundreds digit none. Code conversion tens digit none. Code conversion units digit none. Code conversion hundreds digit 0 through 9. Code conversion tens digit 0 through 9. Code conversion units digit 0 through 9.

GROUP	DESIGNATION	SIGNIFICANCE
CAMA ROUTING	ACR	Authorized CAMA routing.
	UCR	Unauthorized CAMA routing.
VARIABLE SPILLING CONTROL	NSK	No skip (send as received).
	SK3	Skip the first 3 code digits.
	SK6	Skip the first 6 code digits.
TRUNK BLOCK CONNECTOR	TCT0-2	Trunk block connector number tens digit 0 through 2.
	TCU0-7	Trunk block connector number units digit 0 through 9.
TRUNK BLOCK	TB0-7	Trunk block number 0 through 9.
GROUP START (Arbitrary Numbers)	GST0-1	Group start number tens digit 0 or 1.
	GSU0-7	Group start number units digit 0 through 9.
GROUP END (Arbitrary Numbers)	GET0-1	Group end tens number digit 0 or 1.
	GEU0-7	Group end number units digit 0 through 9.

C. Foreign Translator Connector

4.192 A foreign translator connector connects a decoder and a foreign area translator. Each foreign area translator has an associated connector to which all decoders have access.

4.193 Since a decoder must reach a specific foreign area translator or one of a specific pair of foreign area translators to drop a card, if a particular foreign area translator is busy the decoder must wait its turn.

4.194 A foreign translator connector frame (Fig. 47) accommodates two connectors, each serving a maximum of ten decoders. The addition of two supplementary frames is necessary for an office equipped with the maximum 24 decoders.

D. Emergency Translator Connector

4.195 The emergency translator connector is used to connect a decoder and the emergency translator, which may be substituted for any home or foreign translator (Fig. 48). This frame can serve up to 18 decoders. A supplementary frame is required in offices using over 18 decoders.

E. Alternate Route Traffic Control Frame

4.196 The alternate route traffic control frame provides centralized facilities for interconnecting the route relays of each decoder in accordance with the alternate routing plan of the office. It also provides route transfer relays which will cancel overflow traffic by denying route advance to the next route choice (alternate route). The route transfer relays are under control of alternate route traffic control keys (RT- and CR-) located on the traffic supervisory rack in the operating room.

4.197 The operation of an RT key denies alternate routing to relay-to-relay traffic for the particular route represented by the operated RT key and thus cancels overflow traffic from this route to alternate route. The operation of a CR key denies alternate routing to card-to-relay traffic for the particular route represented by the operated CR key. A maximum of 100 relay-to-relay alternate routes can be denied access to by the RT keys while the CR keys may deny access to 20 card-to-relay alternate routes. Direct traffic is not affected by the operation of the RT or CR keys. Calls that are denied access to alternate routes are routed to a NCA trunk.

4.198 As an example, office A has a direct trunk group to office B and uses a trunk group to office C as an alternate route to reach office B. If it becomes necessary to limit traffic through office C to office B, the RT key (or CR key) associated with the A to C trunk group would be operated in office A. This would deny first alternate relay-to-relay route A to C as an alternate route for calls to office B and would divert the calls to an NCA trunk. Direct routed traffic to office C would not be affected in this case, however.

5. MAINTENANCE FEATURES

5.01 The maintenance of a toll crossbar system requires close coordination of toll line maintenance with maintenance of the switching equipment. Therefore, along with the description of the maintenance facilities provided for the 4A and 4M systems, facilities used for toll line maintenance are also included.

5.02 This part gives a highlight description of all of the maintenance facilities which were designed specifically for 4A and 4M Toll Switching Systems.

5.03 Maintenance facilities are located in two equipment areas: the toll test and terminal room, and the 4A or 4M switchroom.

5.04 The 4A or 4M switching system maintenance equipment is generally concentrated in a section of the floor called the maintenance center.

5.05 To permit coordination of the activities in the toll test and terminal room and in the maintenance center, intercommunicating trunks are provided. Trunks required for communicating with other points are also provided in the toll test and terminal room and in the maintenance center.

5.06 The following is a summary of the maintenance components located in the maintenance center:

(a) Trouble recorder frame (includes trouble recorder, decoder-marker test circuit, controller test circuit)

(b) Incoming sender test frame or incoming sender and register test frame

(c) Outgoing sender test frame

(d) Sender make-busy frame

(e) Automatic outgoing toll connecting trunk test frame (AOCT)

(f) Manual outgoing trunk test frame

(g) Automatic outgoing trunk test frame (AOTT)

(h) Incoming, outgoing, and intertoll trunk test set

(i) Plug-in trunk test set

(j) Frame identification frequency test set

5.07 The following is a summary of maintenance components located in the toll test and terminal room.

(a) 17C or 17D toll testboard

(b) Patching bays

(c) Automatic outgoing intertoll trunk test frame and associated automatic transmission test circuit.

SWITCHING MAINTENANCE EQUIPMENT

A. Trouble Recorder Frame

5.08 The primary functions of the circuits located on the trouble recorder frame are:

(a) Production of card records on test calls and on service calls encountering trouble.

(b) Testing of decoders, markers, card translators, link controllers, and decoder channels

(c) Electrical control of card translator circuits, to permit certain manual operations to be performed.

5.09 This frame mounts the perforator test unit and is also a central location for circuit busy indicating lamps, make-busy jacks, alarm lamps and keys, and the jacks which are used to put the emergency translator in service in place of a regular translator.

5.10 All of the functions listed in 5.08 (a), (b), and (c) are performed by two circuits: the decoder-marker test and trouble recorder circuit and the link controller test circuit. The miscellaneous lamps and jacks are included in the miscellaneous circuit for trouble recorder frame.

5.11 One trouble recorder frame (Fig. 49) is provided in each 4A or 4M installation.

Production of Card Records on Service Calls and Test Calls

5.12 The trouble recorder mechanism, located on the trouble recorder frame, perforates card records on service calls which encounter trouble as they are being set up by the common control equipment. When desired, card records are also perforated on test calls. The same circuit and perforating mechanism is used to perforate both types of records. A single trouble recorder is mounted on the frame. It can perforate one card at a time.

5.13 On service calls encountering trouble, the trouble recorder may be summoned by a decoder, a marker, a link controller, or a decoder channel, depending on where the failure occurred.

5.14 When the trouble recorder is seized, multicontact relays in these circuits operate and extend trouble-indicating leads to the recorder-perforator circuit. In addition, relays may operate in the incoming sender, decoder connector, card translator, and incoming frame to extend leads to the perforator so that a complete story on the failure can be recorded. These latter frames cannot directly summon the trouble recorder.

5.15 The decoders, decoder channels, markers, and link controllers are equipped with timing circuits which permit reasonable intervals for completing certain functions or series of functions. If any of these intervals are exceeded because of some circuit failure, the trouble recorder is summoned by the circuit involved.

5.16 There are various stages of common control circuit actions during which this equipment may call for the trouble recorder.

5.17 ***Controller Stage:*** During the time the link controller is connecting the incoming trunk to an incoming sender, the trouble recorder would be seized by the link controller.

5.18 ***Decoder Stage:*** This stage covers decoder operation from time of seizure to point at which a marker is connected. The decoder would seize the trouble recorder.

5.19 ***Decoder-Marker Stage (CT only):*** This is the interval during which both the decoder and the marker are engaged on a call. The decoder always initiates the trouble record during this stage.

5.20 ***Marker-Stage:*** After the decoder or DCH has released and the marker is connected to the sender, any trouble record will be initiated by the marker.

5.21 As previously noted, when the trouble recorder is seized during any of these stages, other common control equipment may be called in to complete the trouble record.

5.22 A trouble record on a service call or on a test call includes the following typical kinds of information.

(a) The identity of the circuit which seized the trouble recorder (for example — the decoder, decoder channel, link controller, decoder-marker test circuit, etc).

(b) The identity of the major equipment units used on the call (for example — the decoder or decoder channel, marker, incoming sender link frame, etc). The identity of the switching channel between the incoming and outgoing trunks is also recorded on marker trouble records.

(c) How far the decoder or decoder channel, marker and controller had progressed at the time of failure. This is indicated by making a record of the relays which were operated at that time.

(d) The kind of trouble that caused the failure. For example, failure of the two out of five check, which is made when the number of the trunk block relay is transmitted to the marker.

(e) The results of cross-detecting and continuity tests which the decoder or decoder channel and marker make on certain leads.

5.23 A card is always in position in the trouble recorder perforator, ready to receive a record. The two issues of blank cards are shown in Fig. 50, and a card perforated with a trouble record is shown in Fig. 51.

5.24 The trouble recorder can perforate about 30 cards per minute; however, this rate might result in excessive decoder or marker holding time, due to repetition of records on the same trouble.

It might also rapidly exhaust the card bins. For this reason, a counter and timer are provided which can limit the number of records that can be made in a given time. For example, the number of records taken in a minute can be reduced from 30 to as few as five.

Test Circuits on Trouble Recorder Frame

5.25 The test circuits on the trouble recorder frame are manual in the sense that they cannot automatically progress from one circuit unit under test to the next. The keys must be manually set for each unit to be tested. The circuit tests this unit, gives a visual indication as to whether the test was successful or not, and if the test was successful, it releases. If the test encounters a failure the test circuit stops.

5.26 Keys are provided on each test circuit to facilitate the making of card records on all test calls, on only those encountering trouble, or so that no card records will be made on test calls.

5.27 The decoder, marker, and translator tests cannot be made simultaneously since they are made by the same test circuit (the decoder-marker test circuit) and some of the equipment paths are used in common.

5.28 On the other hand, the link controller tests circuit and the decoder-marker test circuit can be operated at the same time, but with certain limitations. If the keys in both test circuits are set up to make card records, they compete with each other and with service calls for the use of the trouble recorder. Under this condition (where both test circuits are making card records), if the recorder is busy on a test call or on a service call, another test call cannot be started until the recorder is available to it. The test keys can be set up and the start key operated, but the tests will not begin until the test circuit has seized the recorder. When it does, it holds the recorder busy until its tests are completed and a card record is made.

5.29 Link controller tests can proceed at the same time that the decoder-marker tests circuit is working provided that the key in the link controller test circuit is operated to cancel the card recording feature. In this case, the link controller does not seize the trouble recorder circuit but operates independently of it, and the results of the test are determined solely from the end result lamps.

5.30 However, the reverse is not true, because even though the key in the decoder-marker test circuit is operated to cancel card records, this test circuit must still seize the recorder circuit before it can start a test call. This is because the leads by which the decoder-marker test circuit gains access to decoders and markers for testing are also used in making card records.

Decoder, Decoder Channel, Marker, and Translator Verification Tests — Manual Operations Control of Translator

5.31 Decoder, decoder channel, marker, and translation verification tests are performed by one circuit — the decoder marker test and trouble recorder circuit. The decoder-marker test circuit has direct access for test purposes, to decoders, decoder channels, markers, and card translators. This access is through the same relays that are used for trouble recording, since most of the leads are used for both functions. For this reason, on test calls, the decoder-marker test circuit must obtain the trouble recorder before the test call can proceed, whether or not a card record is made.

5.32 The test circuit simulates normal service sequences and operations. In all classes of tests, a decoder or decoder channel is selected and the test circuit primes it with information normally received on various types of service calls. A particular marker may be picked for seizure on a test call or the marker may be selected on a regular service basis.

*(a) **Decoder Test:*** The test call is stopped after the marker has received all the information from the decoder and the decoder has released. This checks the operation of the decoder and card translators, and verifies the successful transmission of information from the decoders to markers.

*(b) **Decoder Channel Test:*** The test call is stopped after the marker has received all the information from the decoder channel and the decoder channel has released. This checks the operation of the decoder channel and verifies the successful transmission of

information from decoder channels and distributor registers to markers.

*(c) **Marker Test:*** The test call proceeds until the marker completes all of its functions, including the selection of an outgoing trunk. This test checks the marker's functions, including connections to the trunk block connectors and to the incoming and the outgoing frames.

(d) ***Translation Verification Test:*** The test call is interrupted at the point where the marker has checked the integrity of its information from the decoder or decoder channel. The card translator or distributor register is held operated until a complete record of the translation information is perforated by the trouble recorder. By operating the proper keys, the test circuit can select any subgroup of trunks available to a particular code and have the trouble recorder make a complete record of its information. This feature is useful when new routing information is put into service. A test of all of the 116 output channels in the translator can be made simultaneously. This checks the operation of the phototransistors and translator amplifiers under the worst circuit conditions. A lamp indicates that all 116 channels are satisfactory. If the lamp fails to light, a card record can be made of the particular channel that failed on the test.

*(e) **Manual Operations Control of Translator:*** On the trouble recorder frame, a circuit is provided which performs electrical functions that are necessary when translator cards are added or removed. This circuit is also used when certain types of maintenance jobs must be done, such as replacing a selector bar unit. Keys permit any one of the card translators to be selected. The selected translator is then made busy and the emergency translator is substituted for it while the manual operations are being performed. No records are perforated in connection with these operations.

*(f) **End Result Lamps:*** In addition to the perforated card records which give a complete record of test calls, the important end results of the tests are always recorded on locked-in end result lamps. The indications given by these lamps will make it feasible to dispense with card records on test calls when this is desirable.

Link Controller Tests

5.33 The link controller test circuit, unlike the decoder-marker test circuit, busies only the actual circuit under test — the link controller circuit and controller connector. It can simulate any desired combination of incoming trunk, sender link, and sender, by means of keys located on the trouble recorder frame. The test circuit furnishes all the information the controller would normally receive through the sender link.

5.34 As in the case of the decoder-marker test circuit, certain end result lamps are provided which give some information as to the results of the test. It has been noted that provision is made for making card records on all test calls, only on test calls encountering trouble, or for making no card records at all. This test circuit is optional equipment.

Miscellaneous Alarm and Make-Busy Features

5.35 The trouble recorder frame is a central location for lamps, audible alarms, make-busy jacks, and plant registers, all of which are associated with miscellaneous maintenance features. Many of these have no direct association with the trouble recorder and test circuits on the trouble recorder frame.

5.36 Some of the miscellaneous features are:

(a) Audible and visual alarms, to indicate a 48-volt fuse operation, failure of perforator motor, seizure of trouble recorder due to a trouble on a service call, failure to obtain the trouble recorder on a service call, etc.

(b) Make-busy jacks for making trouble recorder busy to any one or all of the decoders, decoder channels, markers, and translators, for making link controllers busy, etc.

(c) Test battery supply jacks and terminals, frame line jacks, jacks for putting emergency translator in place of any other translator, etc.

(d) In-use lamps to show which decoders, decoder channels, markers, connectors, or link controllers are in use.

(e) Plant registers to count the number of lost display calls, the number of decoder, decoder channel, and marker first trial calls and second trial calls, etc.

(f) Sender link delay lamps.

B. Incoming Sender Test Frame or Incoming Sender and Register Test Frame

5.37 These frames (incoming sender test frame was provided in older non-CAMA offices; incoming sender and register test frame (Fig. 52) is provided in all new offices) are used to make routine and trouble location tests of incoming senders or incoming registers. The sender or register is seized by the test frame and selected codes are transmitted to it on either a multifrequency or a dial pulse basis. The output of the sender or register is automatically checked against the input. Lamps are provided to indicate the progress of the tests and to indicate any failure of the sender on specific tests.

5.38 The test frame can be operated on an automatic progression basis or on a particular circuit basis.

Automatic Tests

5.39 When the frame is operated on an automatic basis, it progresses from one sender or register to another until all the incoming senders or registers in the office have been tested or, on certain tests, until all the senders of a class (that is, dial pulse, multifrequency, or overseas) have been tested. If trouble is encountered, the test frame stops and sounds an alarm.

5.40 Senders or registers that are busy may be passed over automatically. The sender or register under test is identified by lamps at the test frame. Lamps are also provided to indicate the progress of the various tests, and on test failure to indicate the point of failure.

5.41 The test frame can be operated so that it will automatically progress through all the MF senders and DP senders with one key setting. This is useful when no tests of features peculiar to MF or DP are desired. On this type of test, the test frame simulates service calls which may be to any point and which are carried to completion.

5.42 Where distinctive features peculiar to overseas, MF, or DP operation are being tested, the test frame progresses through one class of sender and then stops.

5.43 Various combinations of input and output conditions are checked, many on a marginal basis. The test frame is equipped with a full keyset and a number of lever-type keys for establishing the various test conditions.

Manual Tests

5.44 When desired (for example, for trouble location tests), a particular sender can be selected. This sender or register can then be tested under manual control, or repeated tests can be made automatically. The repeated test feature is of particular value in locating an intermittent trouble condition or for insuring satisfactory operation of a sender before returning it to service.

5.45 The test circuit is arranged for remote control from the sender or register locations, so that the sender or register operation may be observed under controlled conditions.

C. Outgoing Sender Test Frame

5.46 This test frame (Fig. 53) has general functions similar to those of the incoming sender test frame, that is, automatic progression over the outgoing senders, or individual circuit testing; comparison of input with output information, indicating lamps, etc.

D. Sender Make-Busy Frame

5.47 There is a make-busy jack on this frame (Fig. 54) for each incoming and outgoing sender in the office. These jacks are used to remove senders from service. Associated with each make-busy jack are a stuck sender lamp and a priming jack.

5.48 The stuck sender holding control circuit which determines the number of senders that can be held is located on this frame. This holding control which is common to all senders of a type, includes a 3-position key which determines

(a) that no senders are held, (b) that one sender will lock up, or (c) that a predetermined number of senders will lock up, the number being any desired number not greater than ten. A sender that does not lock up, routes its call to reorder.

5.49 When a sender encounters a trouble and times out, it causes an individual stuck sender lamp to light and an audible and visual alarm to operate. A peg count register records the number of these stuck senders. If it is desired to free a stuck sender, a make-busy plug is momentarily inserted into the priming jack. This primes the sender and causes it to make a normal release.

5.50 For each group of senders, a group busy alarm lamp is provided which locks in and operates an alarm when all the senders of a group are busy.

5.51 Also included on this frame are peg count registers which count the number of times trouble occurs in the link controllers.

5.52 A telephone circuit with associated keys and lamps is provided for connection to intercommunicating trunks to other frames.

E. Automatic Outgoing Toll Connecting Trunk Test Frame (AOCT in 4A Offices or ATCT in 4M Offices)

5.53 This frame is used to make overall circuit tests of toll switching trunks to: local dial and manual offices; trunks to operators; and miscellaneous trunks and terminals such as no circuit announcement, reorder announcement, final reorder announcement, sender overload announcement, leave word operator trunks, information trunks, etc. Like other automatic test frames, it can be operated on an automatic progression, particular circuit or manual basis. (See Fig. 55.)

5.54 Toll switching trunks to local dial offices and certain service trunks such as reorder announcement, final reorder announcement, etc, can be tested automatically or manually, as desired.

5.55 Toll switching trunks to manual local offices as well as miscellaneous trunks which appear in front of an operator at the distant end are tested on a manual basis.

5.56 A particular circuit feature on the test frame permits the attendant to select any toll switching trunk and to make single tests or repeated tests, as desired. A remote control feature is provided, so that tests can be made from the position of the trunk relay circuits.

5.57 The test frame obtains access to the outgoing trunks through the regular switching train. A marker is used to route the call through the incoming and outgoing links to the trunk. The marker is then released and the test frame goes ahead with the test.

5.58 Lamps are provided on the test frame which indicate the progress of the tests. When a failure occurs on a trunk, lamps indicate the general nature of the trouble which caused it.

Automatic Tests

5.59 When the test frame is operated on an automatic basis, it progresses from one trunk to another in a predetermined sequence, testing every toll switching trunk to dial local offices and certain service trunks and stopping only when it has tested all the trunks, or when it encounters a trouble.

5.60 On these automatic tests, the test frame directs the toll switching trunk to a test line or to a busy line in the distant office (both of which appear as the customer numbers) by pulsing out the appropriate standard line number. No provision is made for changing these numbers during the course of the testing; if the standard line number is not used at a given distant office, the group of trunks to that office must be tested manually.

5.61 When a test frame encounters a trunk to a manual office, or any operator trunk, it makes a simple continuity test of the four trunk wires as far as the trunk relay circuit, then steps to the next trunk. It does the same thing on trunks which cannot be automatically connected to a test line or to a busy line.

5.62 By means of keys, the test circuit can be set either to wait a predetermined interval for busy trunks to become idle, or to pass by them as desired.

5.63 The test circuit transmits the trunk test line or busy-line number to the incoming trunk or terminating sender in the distant office. This causes the distant incoming trunk to be connected to one of these test lines through the local switches. The tests are made by an exchange of signals between the test frame and the test line.

5.64 Tests to a busy line include a continuity test and a test of the ability of the trunk supervisory relay to follow busy-back flashes.

5.65 Tests to a trunk test line are more complete and include tests of ringing, tripping, and supervisory features of the outgoing trunk and the distant incoming trunk.

Manual Tests

5.66 A 10-button MF keyset and a dial are provided at the test frame, for making manual tests. The attendant operates the proper keys to select the trunk for test, and then obtains the operator at the distant office on a straightforward basis or by dialing or keypulsing. The attendant makes the test in cooperation with the operator.

5.67 Manual tests can be made on toll switching trunks to local dial offices, as well as on trunks to manual offices. On such tests, an outgoing trunk is selected automatically, or by the attendant. Continuity and other tests proceed automatically up to the point where the trunk (SL) relay has been tested and the outgoing trunk is connected to the distant incoming trunk or terminating sender for pulsing. The test frame then stops and the attendant can dial or keypulse any desired customer number. When the off-hook condition occurs at the called number, a lamp lights at the test frame. This test can be used to check the supervisory and transmission performance of the trunk. The attendant manually releases the test frame. If it is set for automatic testing, it will immediately select the next trunk and go through the tests up to the test of the (SL) relay, when it will again stop and wait for the attendant to complete the test.

Transmission Measurements

5.68 For making transmission measurements, the outgoing trunk is connected to a 102 equivalent, or 104 equivalent test line at the distant office which provides a 1-milliwatt source of 1000-hertz tone for a far-to-near transmission loss measurement. Tests to 104 equivalent test lines also give near-to-far transmission measurements and far-end and near-end noise measurements. On trunks to dial offices, the trunk can be directed to a transmission test line on a preset number basis.

5.69 On trunks to manual offices, the test frame attendant obtains an attendant at the distant office over the outgoing trunk and requests a connection to a transmission test line.

5.70 In either case, the control of the test frame and the transmission measurements are manually supervised.

Miscellaneous Features

5.71 A telephone circuit is provided for communication with operators when toll switching or miscellaneous trunks to operators or desks are being tested.

5.72 When two automatic outgoing trunk test frames are provided in an office, the trunks associated with each test frame can be interchanged by means of a transfer arrangement on the test frames, so that either frame may have access to all of the trunks appearing on the other test frame.

F. Manual Outgoing Trunk Test Frame—Test and Make-Busy Frames

5.73 In addition to the test facilities of the automatic test frame just described, a manual test frame (Fig. 56) is provided which has facilities for making additional types of tests on outgoing trunks. For making these tests, the outgoing trunks are equipped with test and make-busy jacks which can be used to patch the trunks to the test frame. These jacks appear on one or more test and make-busy frames which are located adjacent to the outgoing trunk frame.

5.74 The test jacks are bridged to the cable side of the outgoing trunks, thus bypassing the outgoing trunk relay equipment. This permits voltmeter, transmission, and continuity tests to be made directly out on the cables. This type of test is of considerable assistance in locating cable troubles. Other tests can be made which are of value in localizing trunk troubles, for example, determining whether they are in the 4A or 4M switching equipment or in the terminating office equipment.

These include tests of the incoming trunk and selector equipment in the distant office.

5.75 The test circuit includes a voltmeter circuit, a telephone circuit, and sender and supervisory features. Two trunks can be patched to the test frame at a time, but only one of them can be set up for testing. The other trunk can then be used for communicating with an attendant at the distant office, or for making interference tests, by operating a hold key on the first trunk at the proper time.

5.76 Each test and make-busy frame has a capacity for two thousand jack circuits for 2-wire trunks. It has smaller capacities for different combinations of 2-wire, 3-wire and 4-wire trunks. The jacks are arranged by cross-connection in groups by office designations. As many jack bays as required may be provided. Additional test frames may also be furnished.

G. Automatic Outgoing Trunk Test Frame for Toll Completing Trunks (AOOT or AOTT)

5.77 This frame may be provided as one of two versions: the automatic outgoing toll connecting trunk operational test frame (AOOT) or transmission test frame (AOTT). (See Fig. 57.) This circuit is arranged to automatically select certain outgoing toll completing trunk circuits on the outgoing link and connector frame and if they are idle, test them for their principal features.

5.78 The trunk test circuits appear on the incoming link frame as incoming trunks and, by means of a test connector, direct the marker to establish a connection through the incoming and outgoing links to the trunks to be tested.

5.79 The AOOT is used primarily to make automatic or manual operational circuit tests of toll switching trunks to local offices, TX operator trunks, or miscellaneous trunks such as CBA or reorder trunks. Manual transmission tests may also be made at this test frame. The AOOT is equipped with a 35-type receive-only teletypewriter for producing a printout of test results or for perforating a tape showing test results.

5.80 The AOTT is primarily used to make automatic transmission and noise tests on toll switching trunks to local offices. The AOTT basically consists of the same components used with the AOOT plus a frame which mounts automatic transmission measuring system (ATMS) equipment, a transmission test unit, and a teletypewriter program control unit. A 35-type send-receive teletypewriter is associated with the AOTT instead of the receive-only type used with AOOT. The teletypewriter is used to read the tape for trunk selection and testing information. Test results are displayed on page printout, punched tape, or both.

Automatic Operational Tests

5.81 Automatic tests are made on all trunks which have access to local central office test lines and, by means of a tone detector, on other nonoperator type trunks. On an automatic operation, the test circuit will start with the lowest numbered trunk and progressively select trunks upward to the highest numbered trunk. The test circuit may also be instructed to start at a particular numbered trunk and end at a particular numbered trunk.

5.82 Test to a busy line is a rapid test of the ability of the trunk to switch a call. The trunk is directed to a busy line at the distant office and the return of busy tone satisfies the test.

5.83 Test line supervision tests are intended to test all the operational capabilities of the outgoing trunk and the distant end incoming trunk.

5.84 Reorder tests and early release tests are used to test trunks that require an outgoing sender.

5.85 If announcement trunks are included in the test selection span during automatic testing, the test circuit will test the ability of these trunks to return tone or voice announcement.

5.86 On automatic tests, when the test circuit encounters trouble and a teletypewriter is associated, a typewritten indication of the trouble will be produced and a retest made of the trunk. Trouble on the retest will either cause a second printout and advance to the next trunk or it will sound an alarm and block the test circuit. If no teletypewriter is associated with the test circuit, a trouble will cause an alarm to sound and the test circuit to block.

5.87 Some trunks which are normally tested on a manual control basis are given a lead continuity test when automatic testing is in progress.

Trunks which can only be tested manually are passed by during automatic testing.

Manual Tests

5.88 All trunks selected can be tested on a manual control basis. These tests provide means for making complete tests of trunks which cannot be tested fully on an automatic basis. They are also used to make certain tests such as singing point and return loss tests which cannot be made automatically.

5.89 Dial and MF keysets are provided at the test frame for making manual tests. Timing is discontinued during manual testing so that a trunk may be held indefinitely. The test circuit may be advanced by the operation of a key.

5.90 When trouble is encountered by the test circuit on manual testing, no alarm is sounded. Lamp indications are used to identify the trouble.

Automatic Transmission Tests

5.91 Automatic transmission tests may be made when the test circuit is associated with an automatic transmission measuring system (ATMS) director and a teletypewriter and test control circuit. Two-way transmission and noise tests may be made on all trunks having access to automatic far end transmission measuring equipment (105, 104 type test lines). One-way transmission tests may be made on trunks having access to milliwatt (102-type test line) supply terminations.

5.92 Trunk selection is controlled by the use of an external control tape which is read into the teletypewriter and test control circuit in the form of a punched tape.

5.93 It is necessary to relay the transmission characteristics of the trunk under test to the ATMS director when making automatic transmission tests. These characteristics are normally obtained from the control tape as it is read into the teletypewriter and test control circuit. The test circuit may be arranged to cause a printout to be made of the results of the measurements of all trunks or only those trunks which fail to meet the transmission requirements or deviation limits.

H. Incoming, Outgoing, and Intertoll Trunk Test Set

5.94 This test set consists of a mobile test set, a relay rack-mounted auxiliary test unit, and an arrangement of patching and test line jack appearances at appropriate bays and frames. The test wagon contains the necessary equipment to apply various conditions for testing trunk functions and the equipment to indicate the performance of the trunk functions or to indicate certain trouble conditions.

5.95 The test set is used in 4A and 4M offices for the following purposes:

(a) Test the intertoll and tandem trunks appearing on the intertoll and toll completing switching trains.

(b) Test certain incoming and outgoing trunks for No. 5 toll switchboard.

(c) Test 2-way overseas trunks and overseas assistance trunks.

(d) Perform operational tests on the sender link and connector and the link controller by originating calls on incoming (tandem) or intertoll trunks.

5.96 By means of patching trunks and test lines, the tests are made with the test set either at the circuit patching bay or in proximity to the equipment of the circuit being tested.

I. Plug-in Trunk Test Set

5.97 This is a portable test set for use in testing the new miniature plug-in trunk units. The plug-in trunks are removed from the frame and plugged into the test set where tests and adjustments may be made. A special extension cord is provided for connecting a trunk that has been removed to its assigned facility on the frame. This will allow maintenance personnel to observe the operation of the trunk components. For example, relay operation can be observed while the trunk is being tested by the AOCT or AOTT.

J. Frame Identification Frequency Test Set

5.98 This is a portable test set provided to test the multifrequency supply system used for link frame identification and to facilitate the location of circuit troubles involving crosses or attenuated signals. The test set consists of eight filters corresponding to the frame identification frequencies, an amplifier, and a rectifying meter. Keys are provided so that with a given input signal the meter may be associated with any one of the filter circuits to provide an indication of the magnitude and frequency components of the signal.

TOLL LINE MAINTENANCE EQUIPMENT

5.99 The toll test and terminal room equipment for testing and maintaining the intertoll trunks which are part of the toll crossbar system is similar in general to that used in other toll systems, with the exception of some changes that have been made to work with crossbar automatic switching.

A. No. 17-Type Toll Testboard

5.100 The No. 17C toll testboard is the principal point of access for testing non-TASI intertoll trunks. The No. 17D toll testboard is the principal point of access for testing TASI intertoll trunks. From these testboards, operational tests can be made on incoming and outgoing trunks.

5.101 The testboard serves to centralize overall maintenance of these trunks, to localize troubles in the toll circuits, and to expedite the restoration of service when failures occur. It is the central point for receiving trouble reports from operators or maintenance personnel. All intertoll trunks have jack appearances at the testboard.

B. Patching Bays

5.102 There are many types of patching bays in the toll test and terminal room of a crossbar toll switching office. These bays are used for building up toll lines from facilities located in the office, and for increasing the size of trunk groups or rearranging them, to care for emergencies or for changes in traffic requirements and to permit ready access for testing. They are also used for substituting spare outside plant cables, and inside plant equipment, such as signaling circuits, repeaters, trunk relay circuits, etc, when failure occurs.

5.103 Tests are made at these bays to localize troubles between the line and drop sides of the toll circuits and to determine the nature of such trouble.

C. Automatic Outgoing Intertoll Trunk Test Frame

5.104 This test frame (Fig. 58) is provided to make overall tests of outgoing intertoll trunks and the outward paths of 2-way intertoll trunks to other toll offices. The tests are made automatically or manually, depending on whether or not the trunks can be terminated on an intertoll trunk test line.

5.105 The general operation and arrangement of the test frame is similar to that of the automatic outgoing toll connecting trunk test frame (AOCT) which has already been described. As on that frame, access to the outgoing trunks is through the regular switch train. The same general types of tests are made, with the exception that there is no equivalent of the test to a busy line in the distant office.

Automatic Tests

5.106 On automatic tests a 3-digit code, 103, is pulsed forward to reach the intertoll trunk test line termination at the distant office.

Manual Tests

5.107 A manual key is provided for testing intertoll trunks which appear in front of an operator at the distant office. On DP or MF trunks, the attendant dials or keys the code to reach an operator or the distant toll testboard. On straight-forward trunks, a key is operated to reach the distant operator. In either case, the tests are made in cooperation with the operator or testboard attendant in the distant office.

5.108 A particular trunk can be selected for test and tested repeatedly as many times as desired. This feature is of value in locating a trouble or in testing a new trunk prior to putting it into service.

Transmission Tests

5.109 The automatic transmission test and control frame is a supplementary frame which is provided with the automatic outgoing intertoll trunk test frame to perform 2-way transmission and noise tests on intertoll trunks. These tests are made by means of a 104 test line code pulsed out via the automatic outgoing intertoll trunk test frame.

5.110 The teletypewriter frame is a supplementary frame used in conjunction with the automatic outgoing intertoll trunk test frame in place of the automatic transmission test and control frame where automatic operational testing is desired without transmission and noise testing features. The frame is arranged to print trouble indications on both initial and repeat tests, thereby allowing the trunk test frame to advance and test the next trunk without requiring the service of an attendant.

ALARMS

5.111 Alarm features, in addition to the trouble indicator previously described are provided in a manner similar to other crossbar switching systems. These alarms consist of fuse alarms, time alarms for the sender link and connector circuits, markers, marker connectors, etc. Directing pilot lamps, namely frame aisle pilots, main aisle pilots, floor pilots, and exit pilots are provided, together with distinctive audible alarms. These lamps and signals are so arranged as to indicate audibly the severity of the alarm condition (major, minor, or power failure) and to show visually the type of failure (fuse, time, or test frame alarm) and the aisle location of the individual circuit alarm lamp. Arrangements are provided to extend the alarms from one floor to another.

6. TRAFFIC REGISTERS

6.01 There are numerous traffic registers provided. DFMP, Division H, Section 13e(1) and (2) describe the various types of No. 4A and 4M crossbar registers in detail. These sections also discuss the method of operation and provision recommendations.

6.02 Traffic registers are used to collect data required by the traffic engineers, network administrator, network manager, traffic separations supervisor, and others involved in network design and administration.

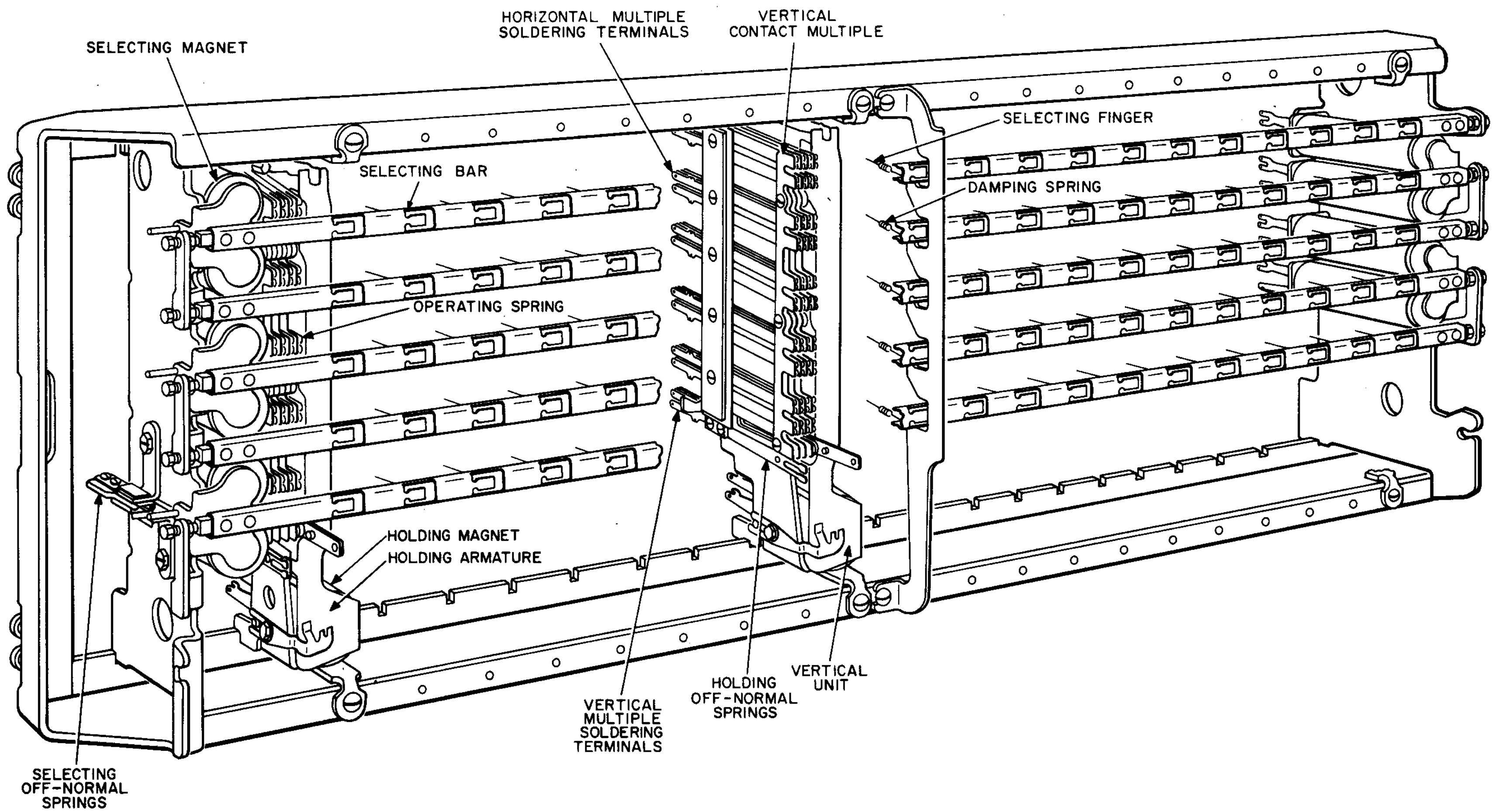


Fig. 1—Partial Perspective View of Unit Crossbar Switch (200 Point) (2.02)

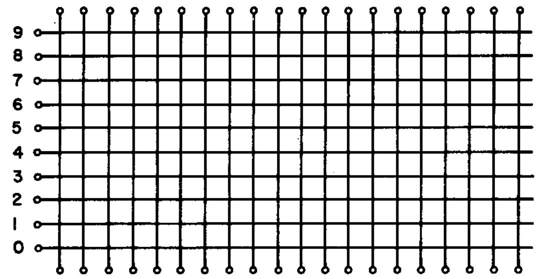


Fig. 2—Schematic of Crossbar Switch (10 Horizontal Paths) (2.03)

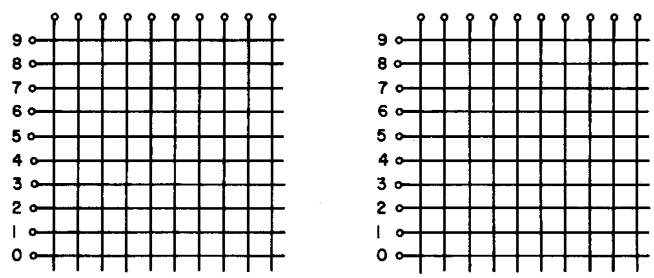
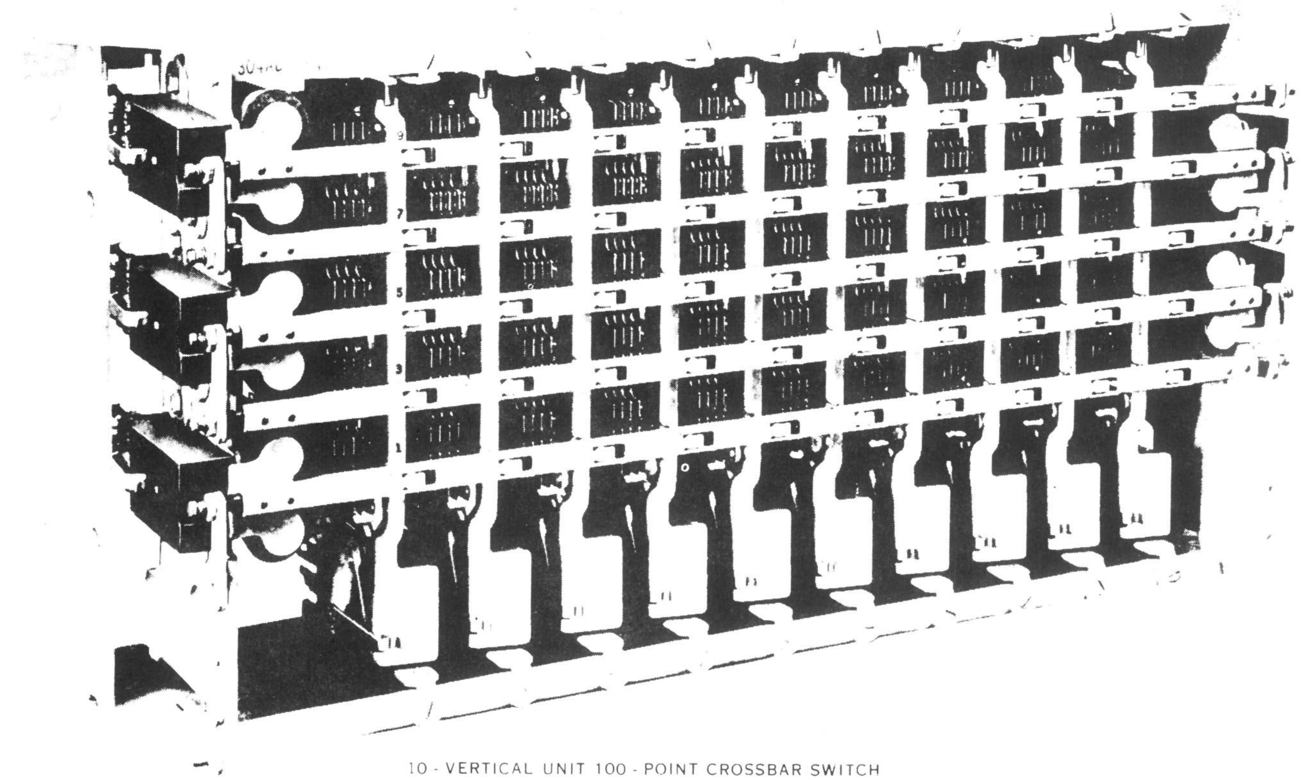
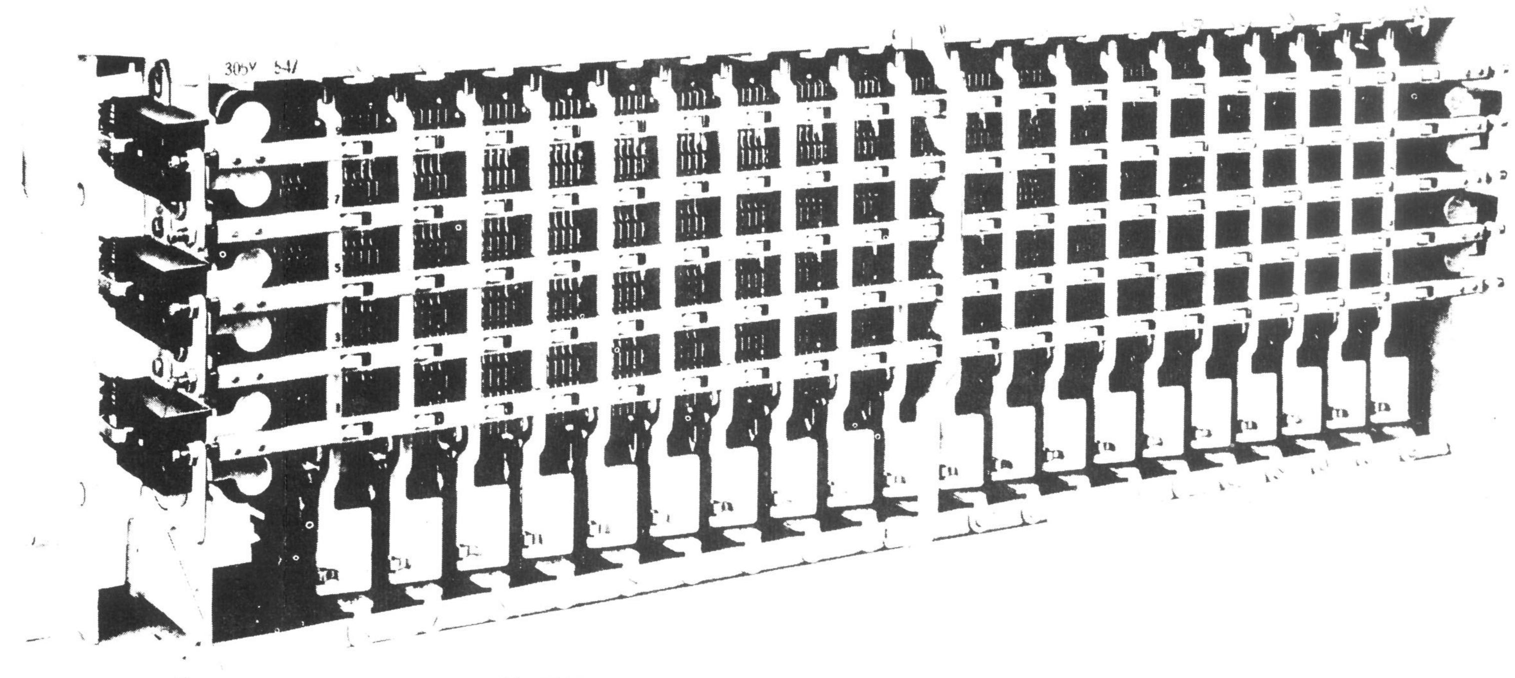


Fig. 3—Schematic of Crossbar Switch (20 Horizontal Paths) (2.04)



10 - VERTICAL UNIT 100 - POINT CROSSBAR SWITCH



20 - VERTICAL UNIT 200 - POINT CROSSBAR SWITCH

Fig. 4—Crossbar Switches (2.05)

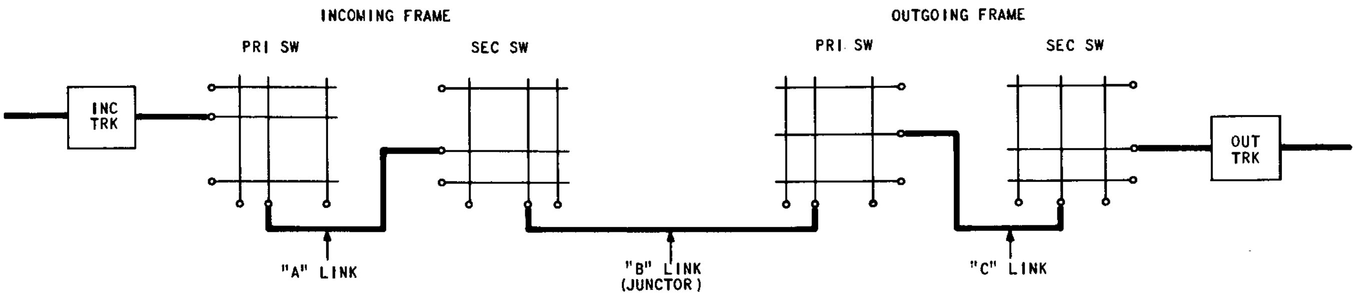


Fig. 5—Channel Between Incoming and Outgoing Trunks (2.07)

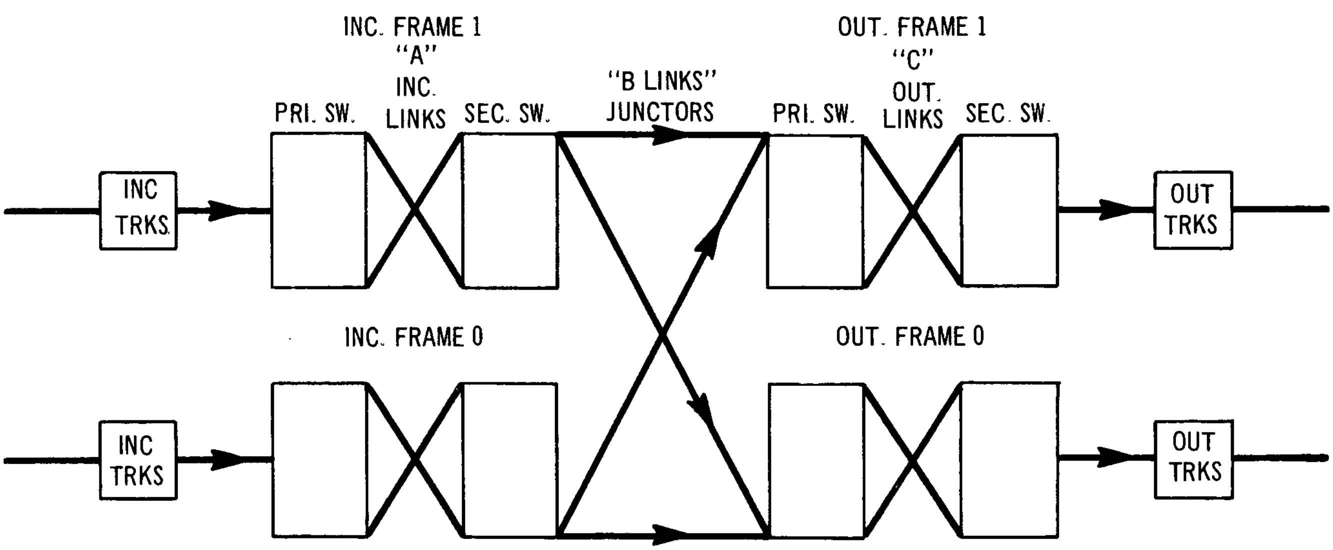


Fig. 6—Path of Call Through Incoming and Outgoing Frames (2.07)

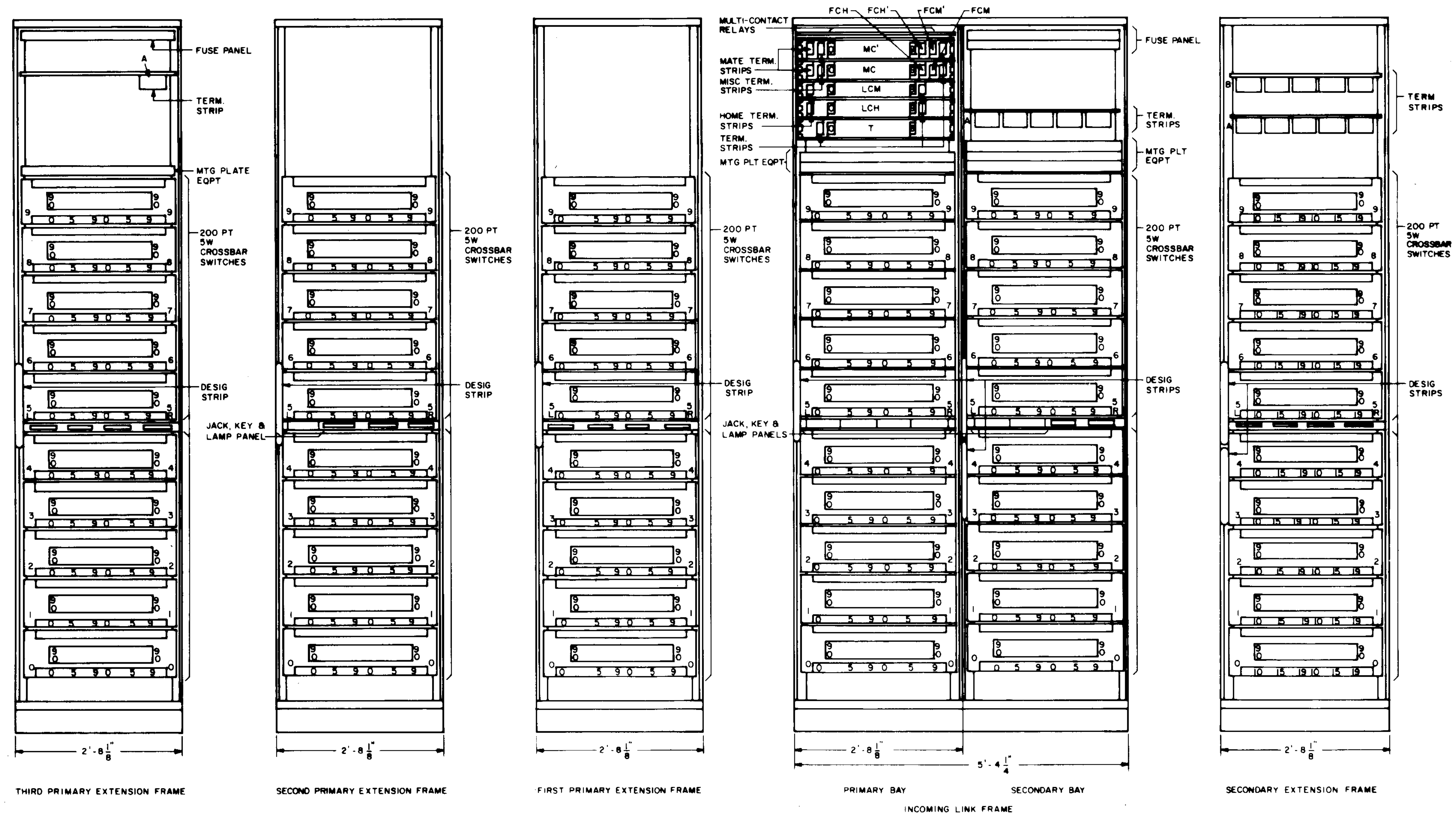


Fig. 7—Incoming Frame (2.10)

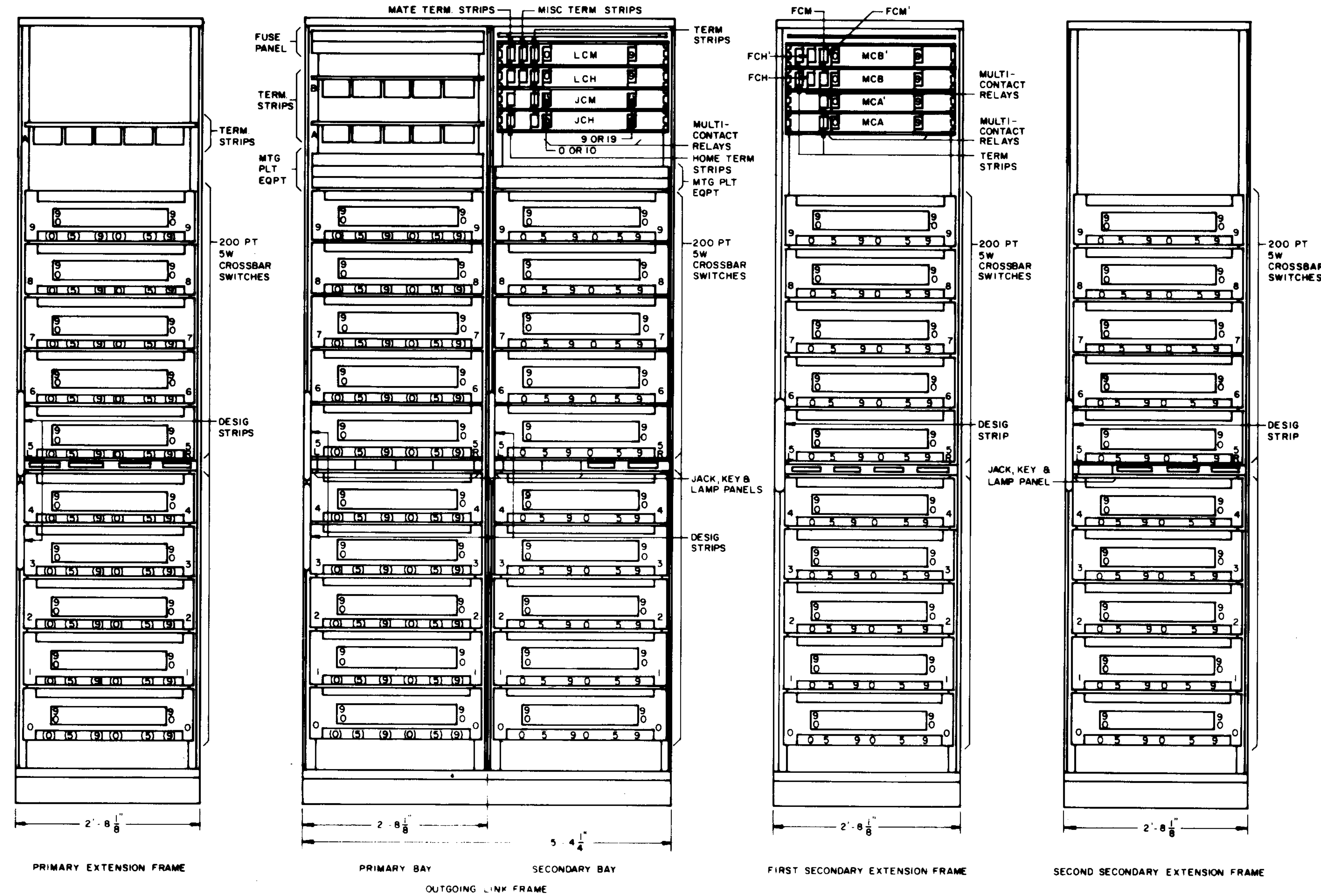


Fig. 8—Outgoing Frame (2.15)

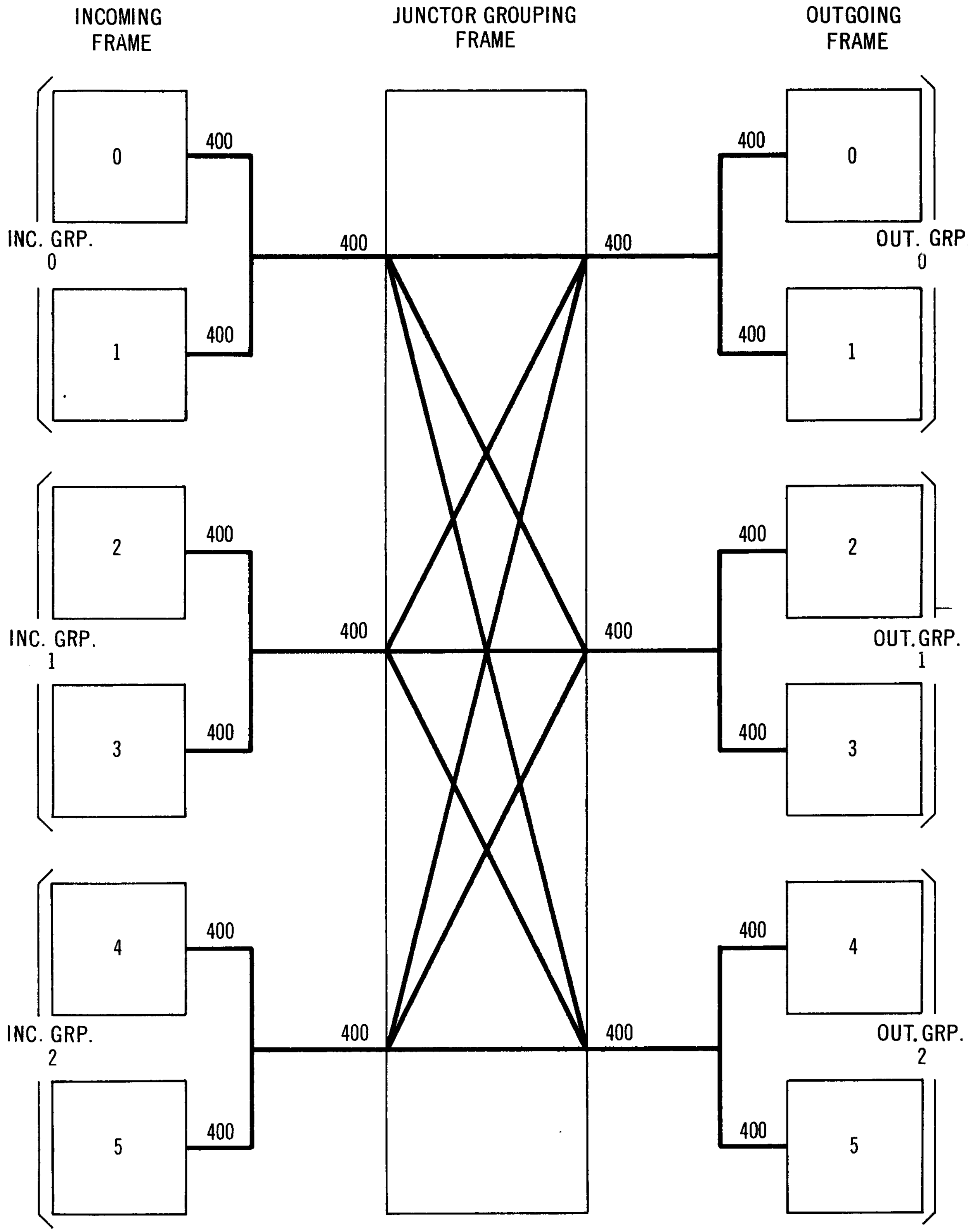


Fig. 9—Junctor Distribution (2.28, 2.40)

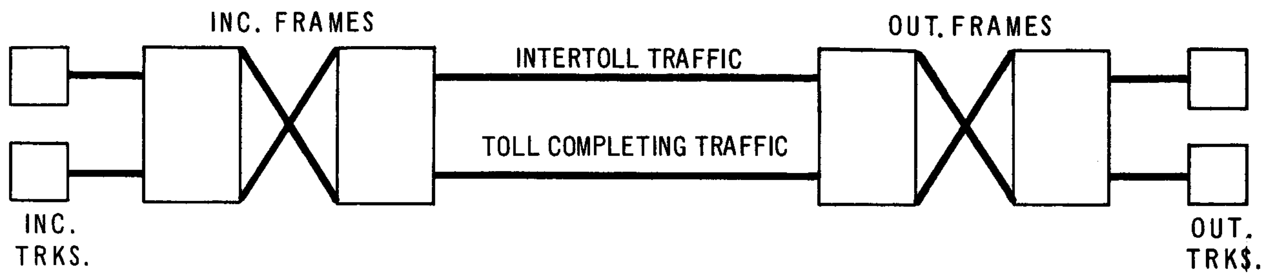


Fig. 10—Single Train-Combined Operation (2.31)

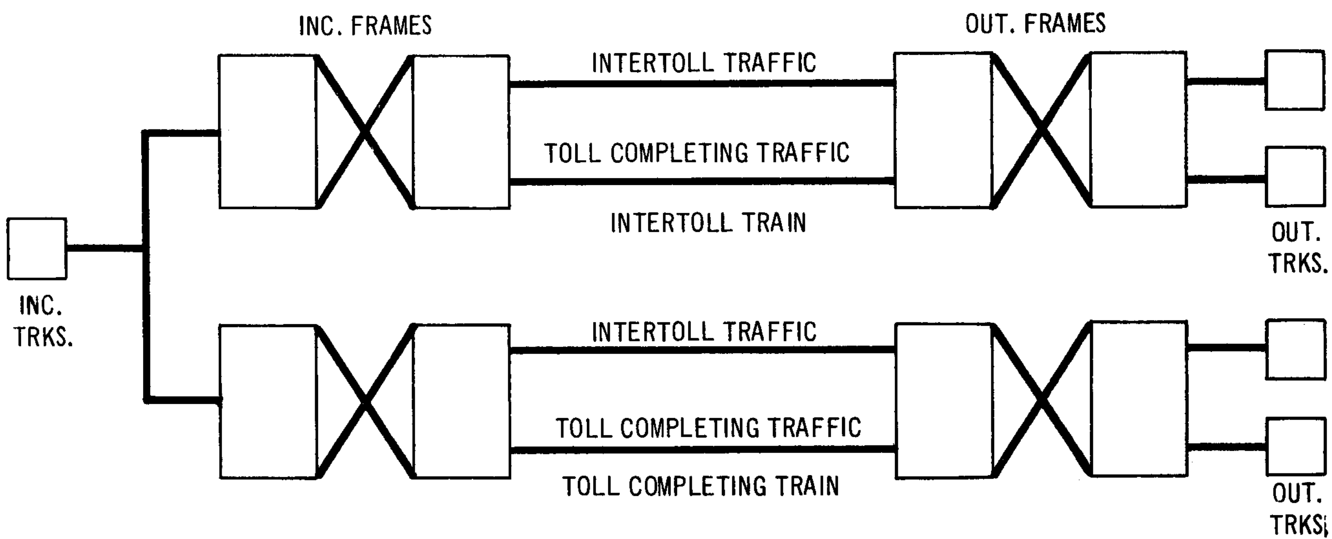


Fig. 11—Separate Train-Combined Operation (2.32)

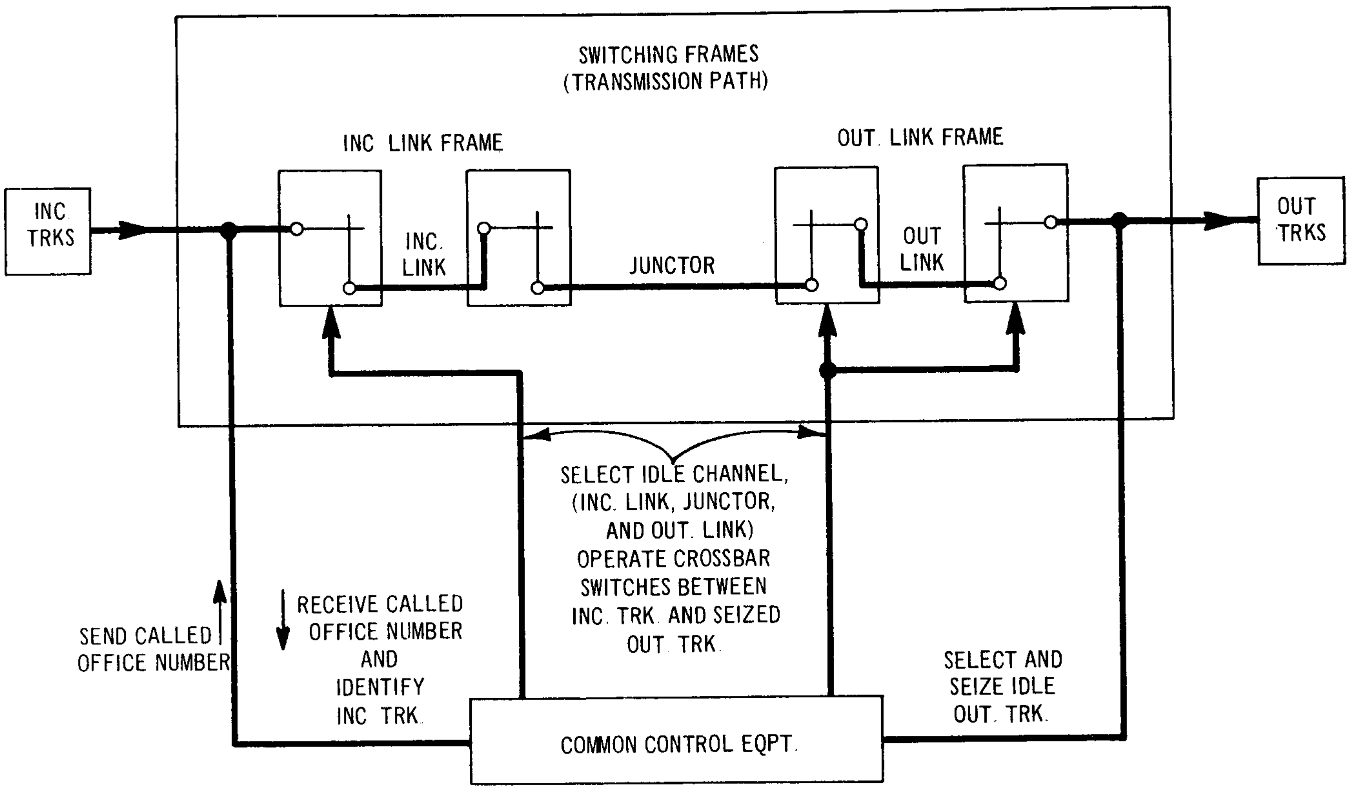


Fig. 12—Relationship Between Common Control Equipment and Switching Frames (2.36)

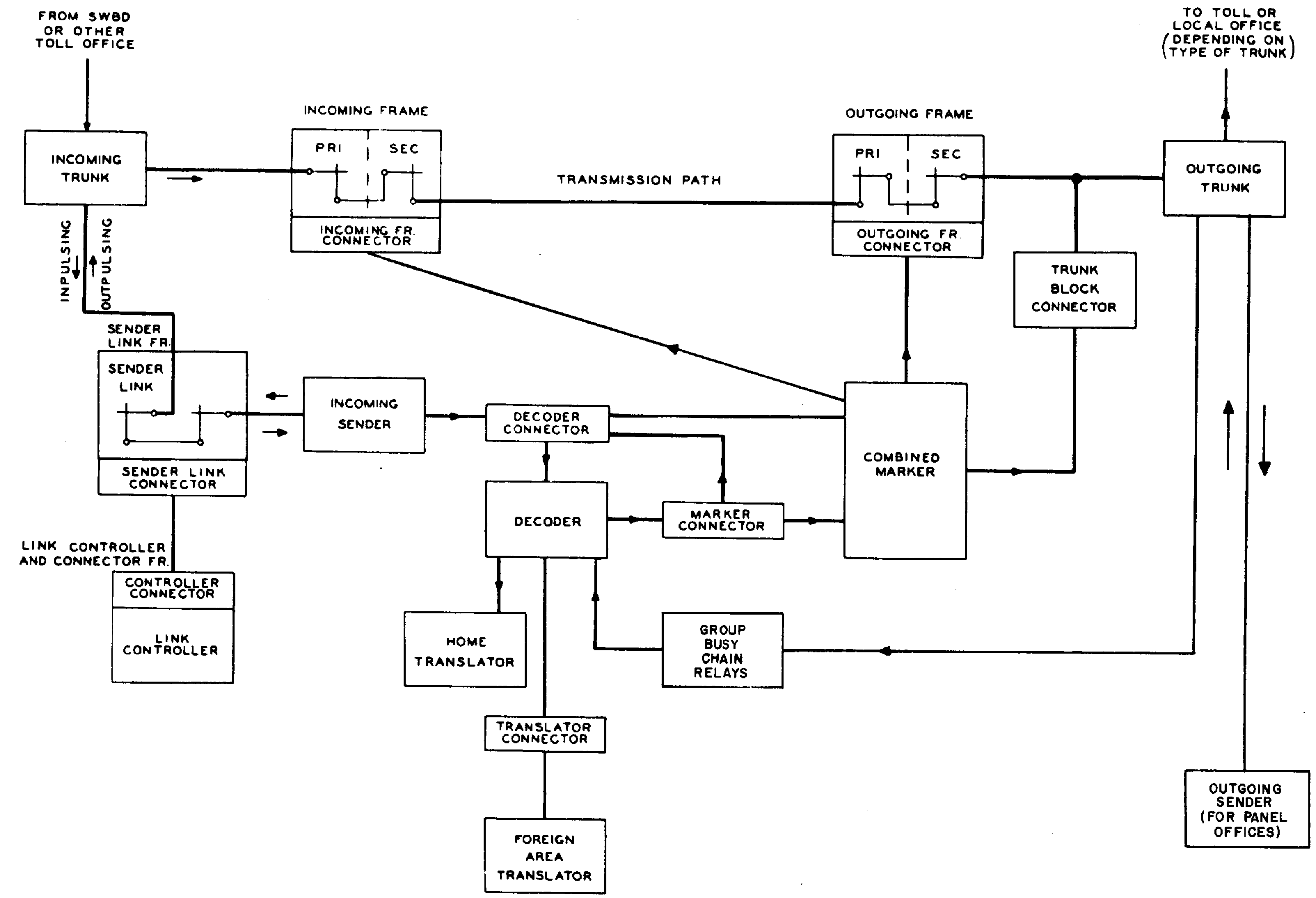


Fig. 13—Call Through a Combined Train CT Office (3.04)

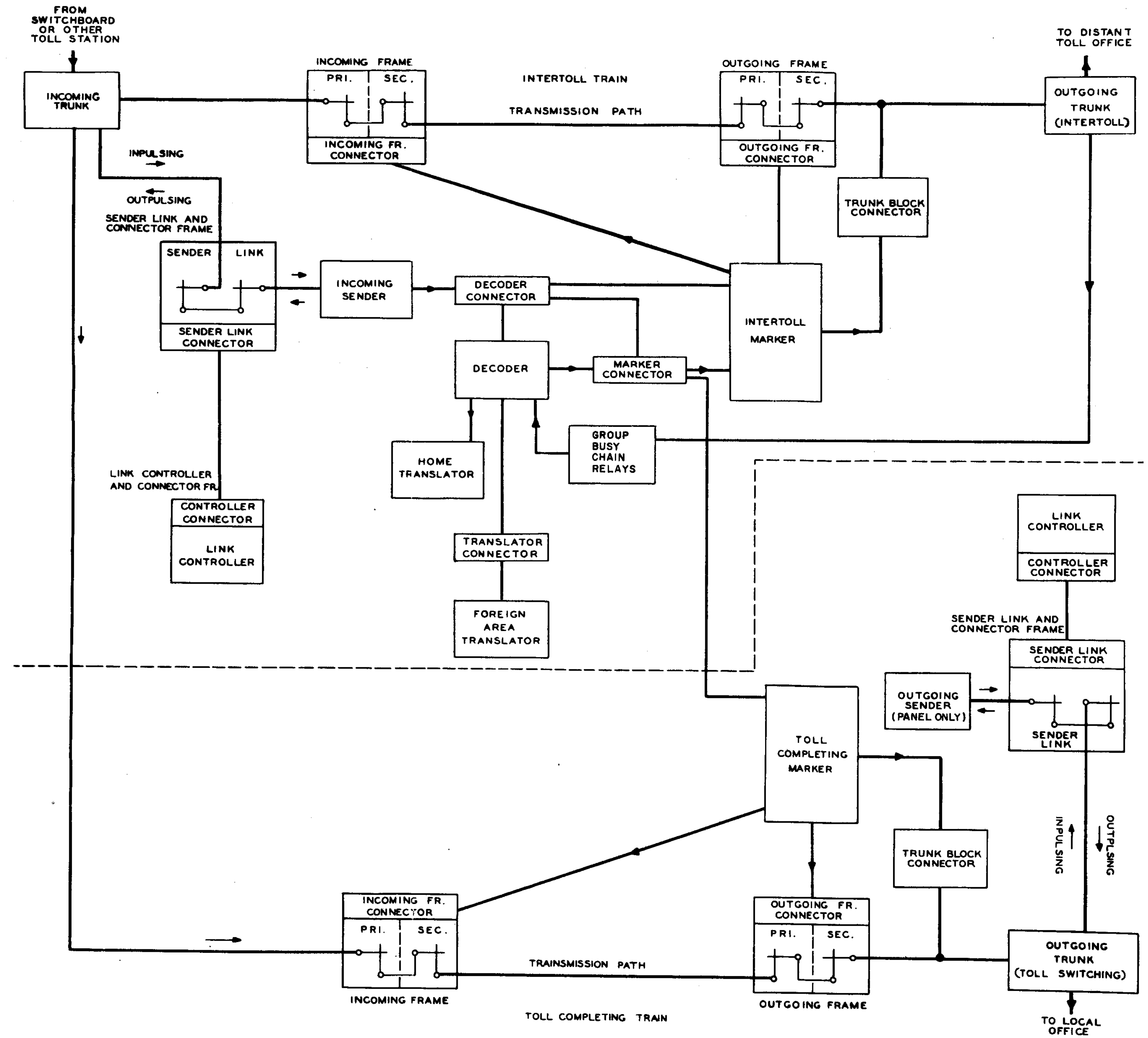


Fig. 14—Call Through a Separate Train CT Office (3.20, 3.30)

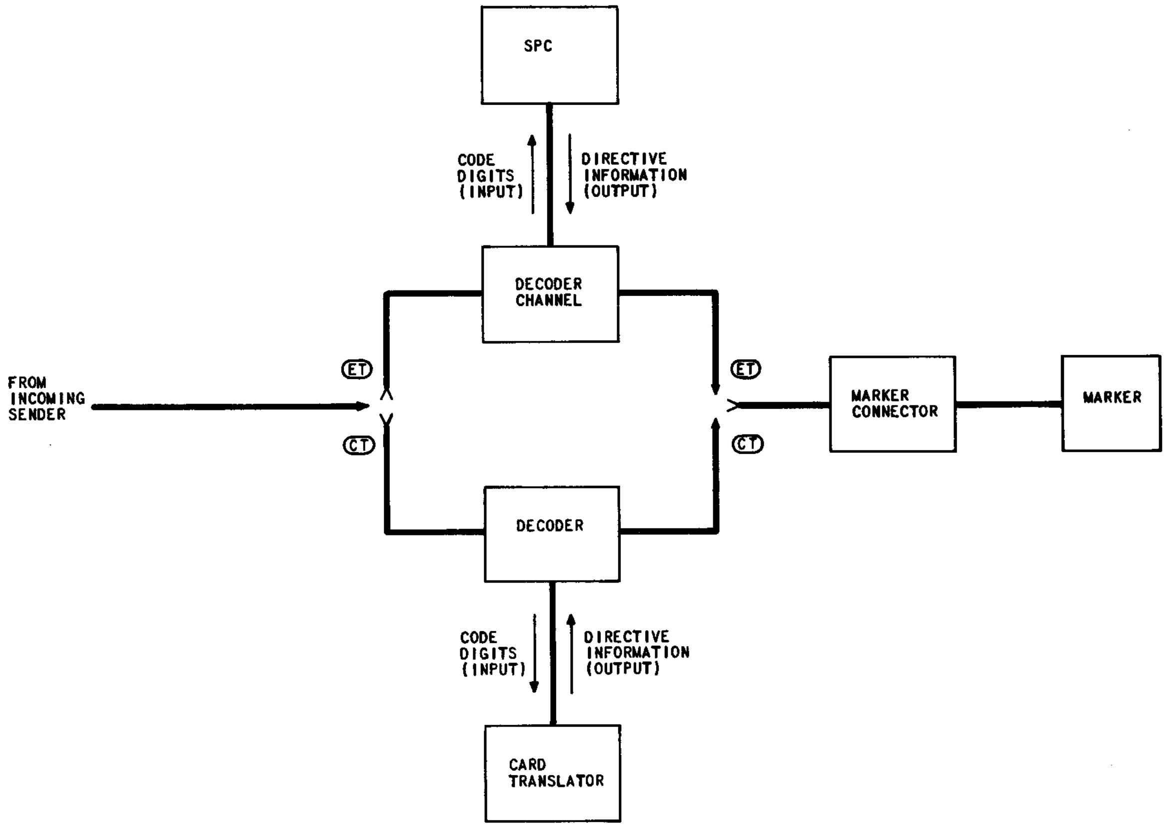


Fig. 15—Information to Marker (4.03)

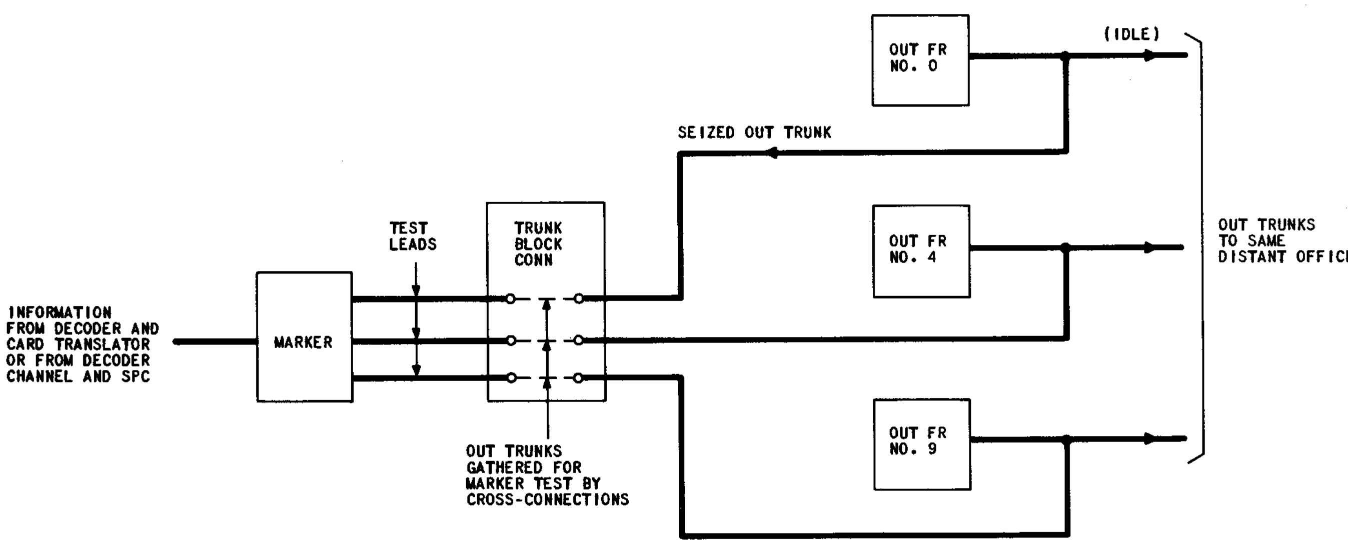


Fig. 16—Seizing an Outgoing Trunk (4.05)

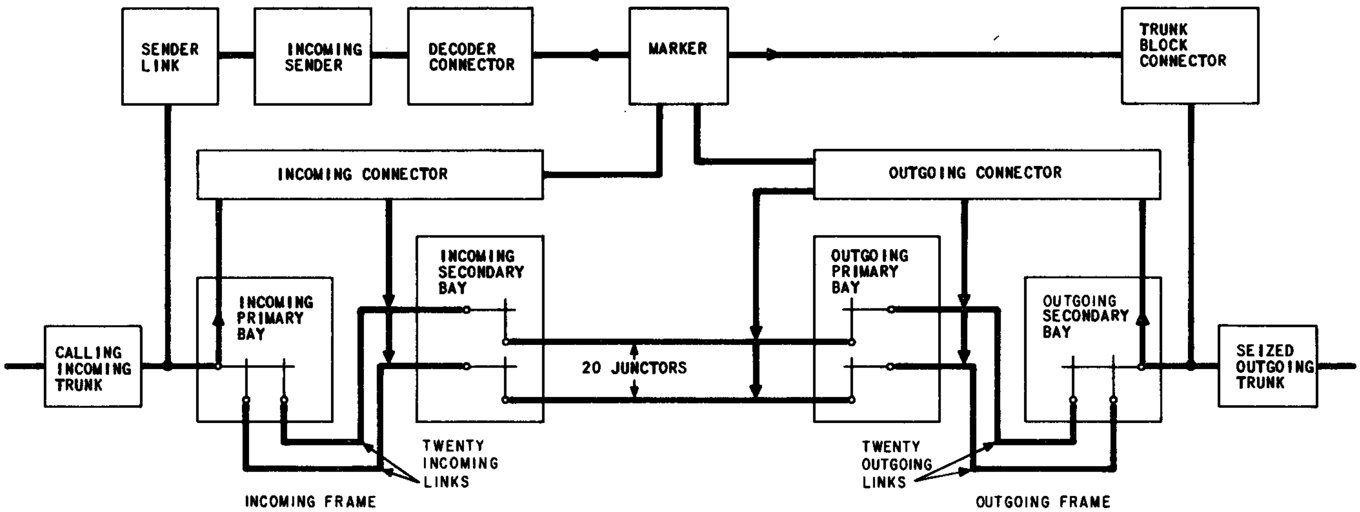


Fig. 17—Establishing a Channel (4.08, 4.09, 4.25)

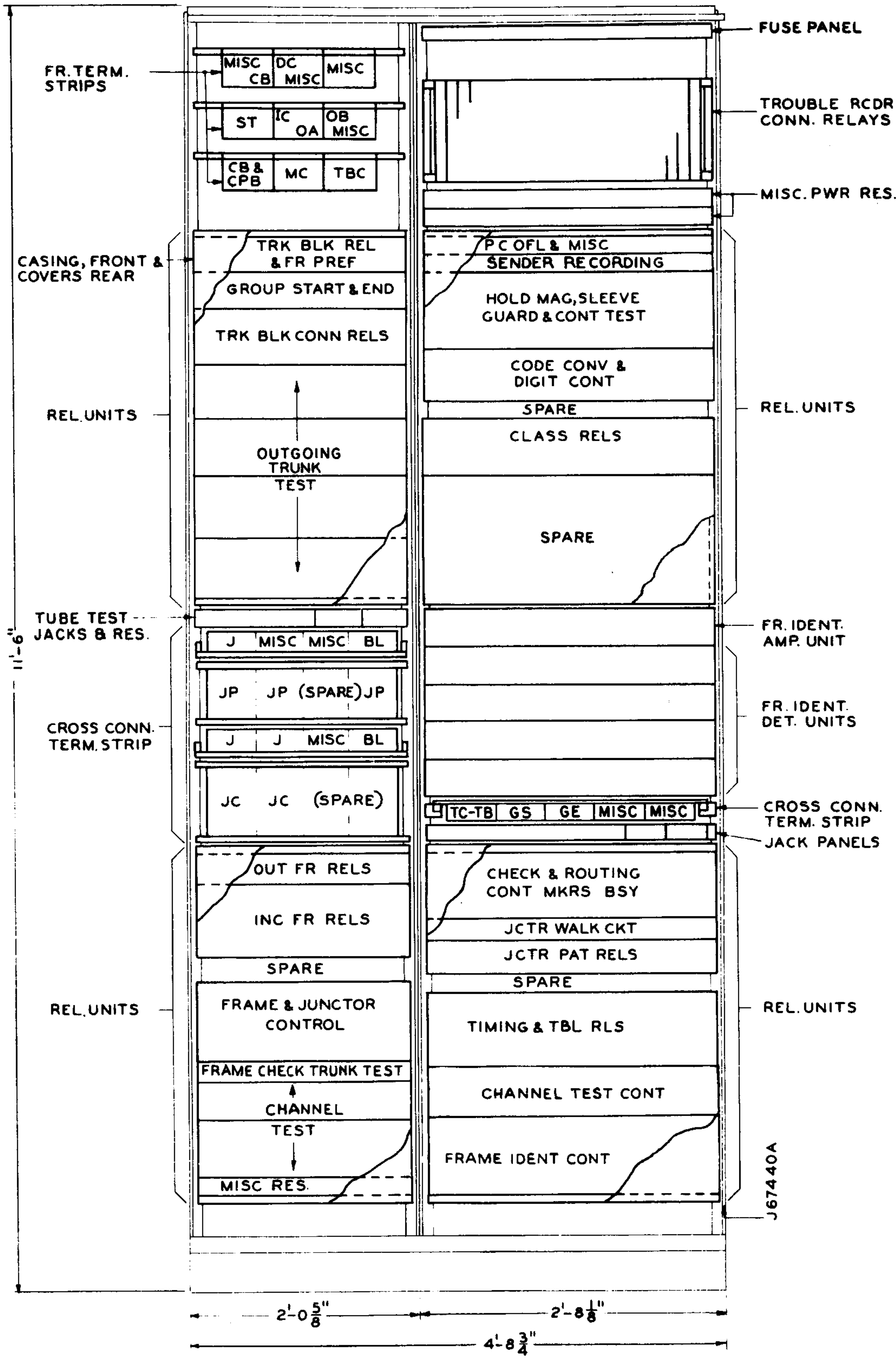


Fig. 18—Marker Frame (4.23)

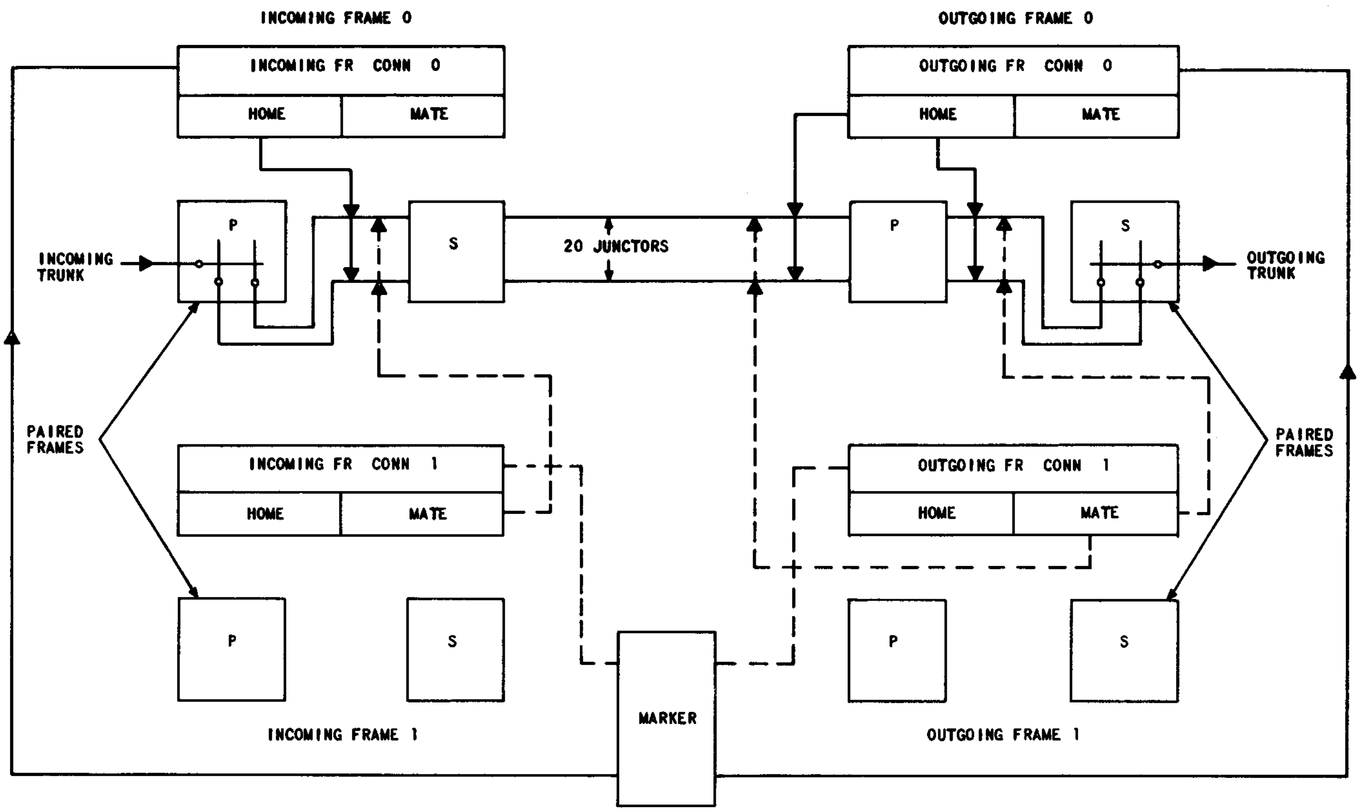


Fig. 19—Pairing Switching Frames (Home and Mate Operation) (4.28)

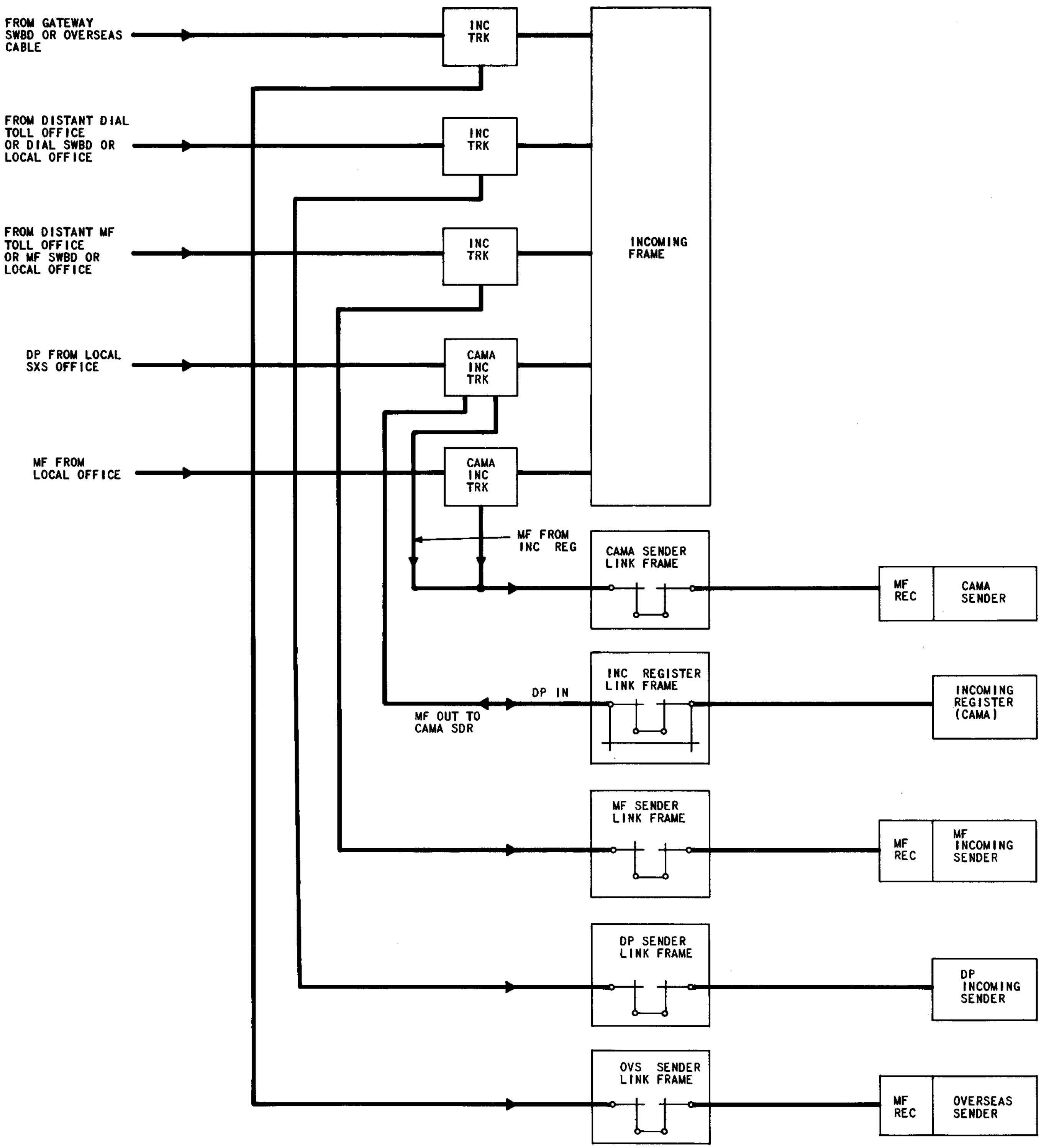


Fig. 20—Access to Incoming Senders—Office Equipped With Flat-Spring MF Incoming Sender (4.30, 4.53)

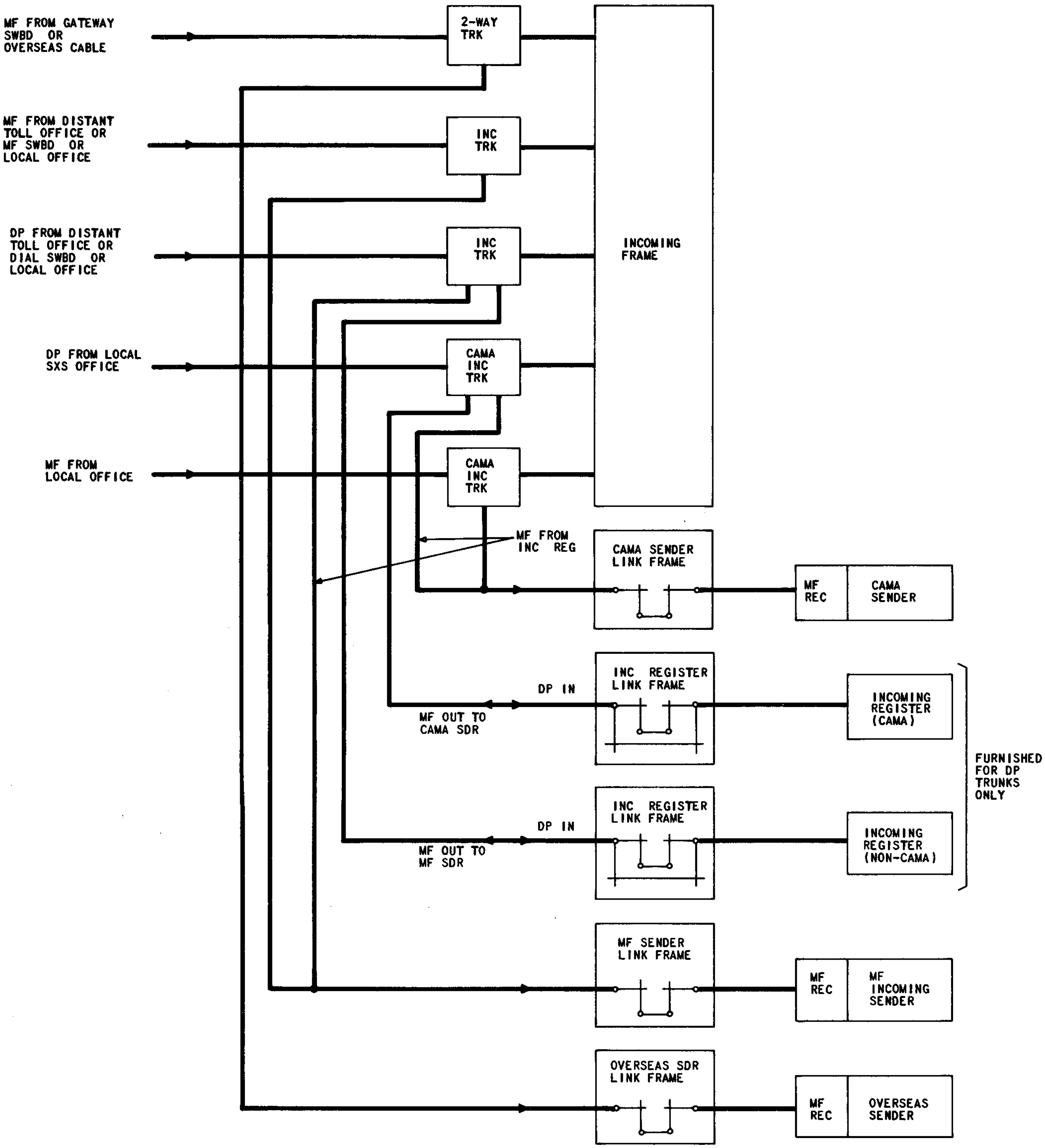
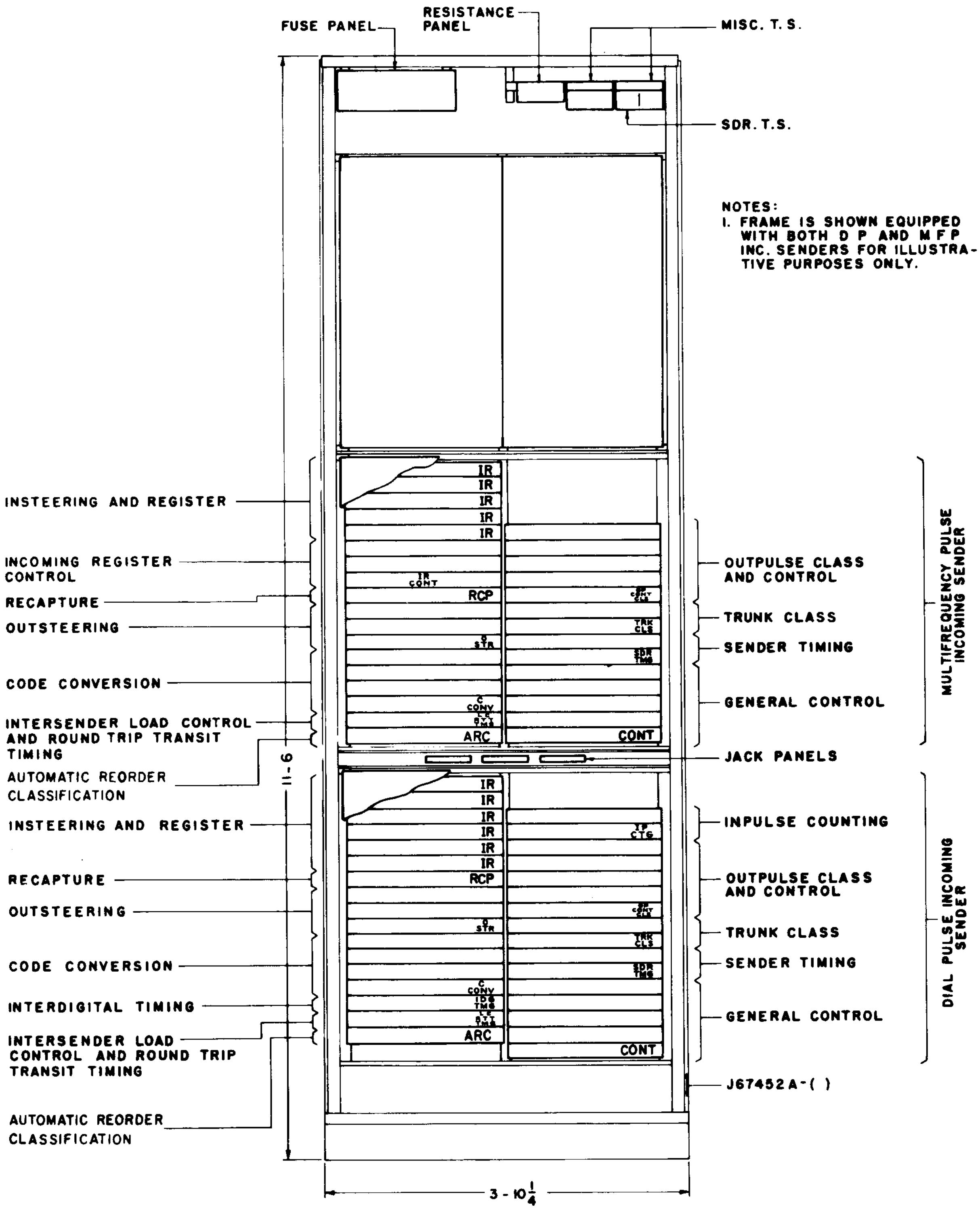


Fig. 21—Access to Incoming Senders—Office Equipped With Wire-Spring MF Incoming Sender (4.30)



FRONT VIEW

Fig. 22—Incoming MF and DP Sender Frame—4M Offices (4.45)

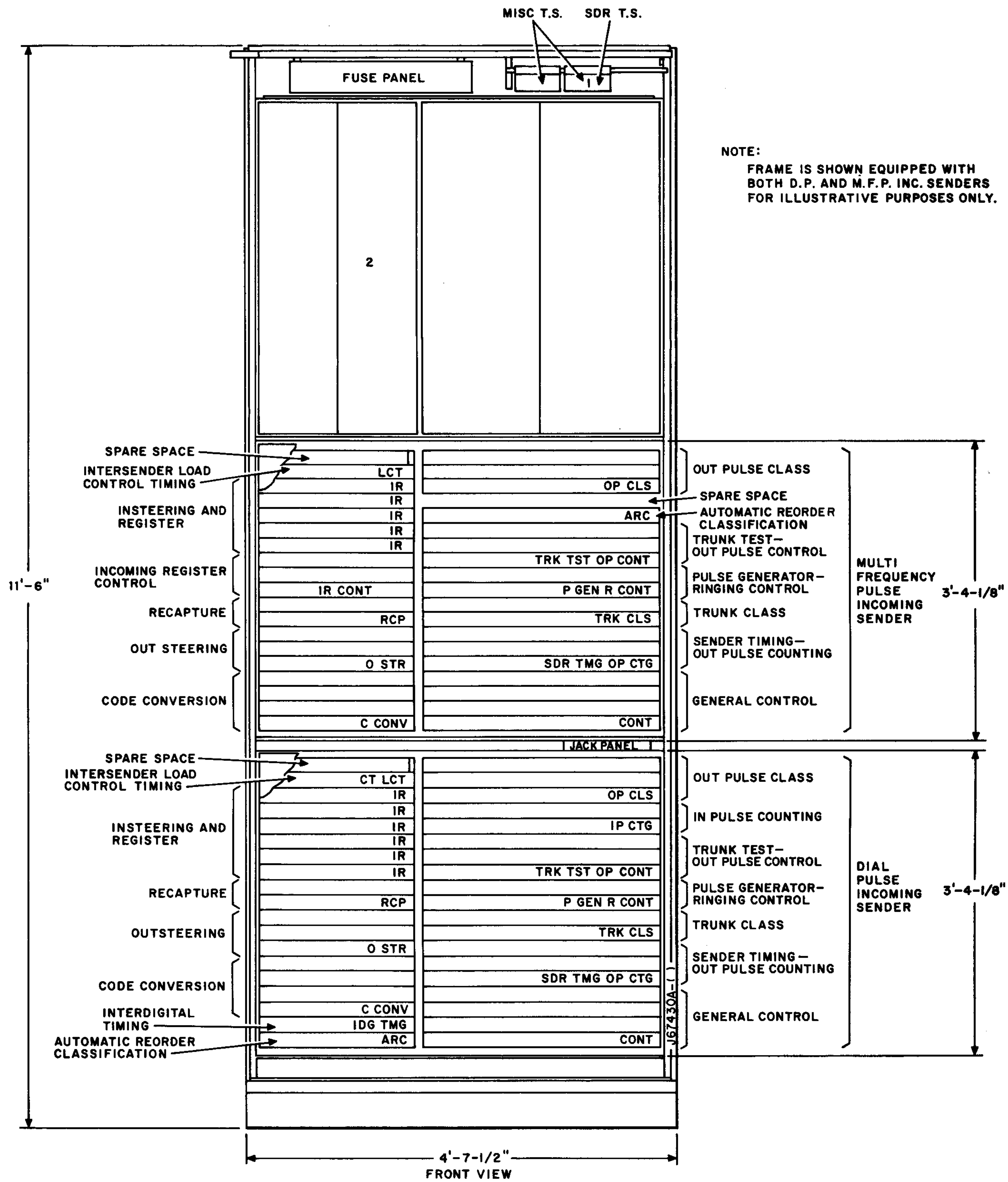


Fig. 23—Incoming MF and DP Sender Frame—4A Offices (4.45)

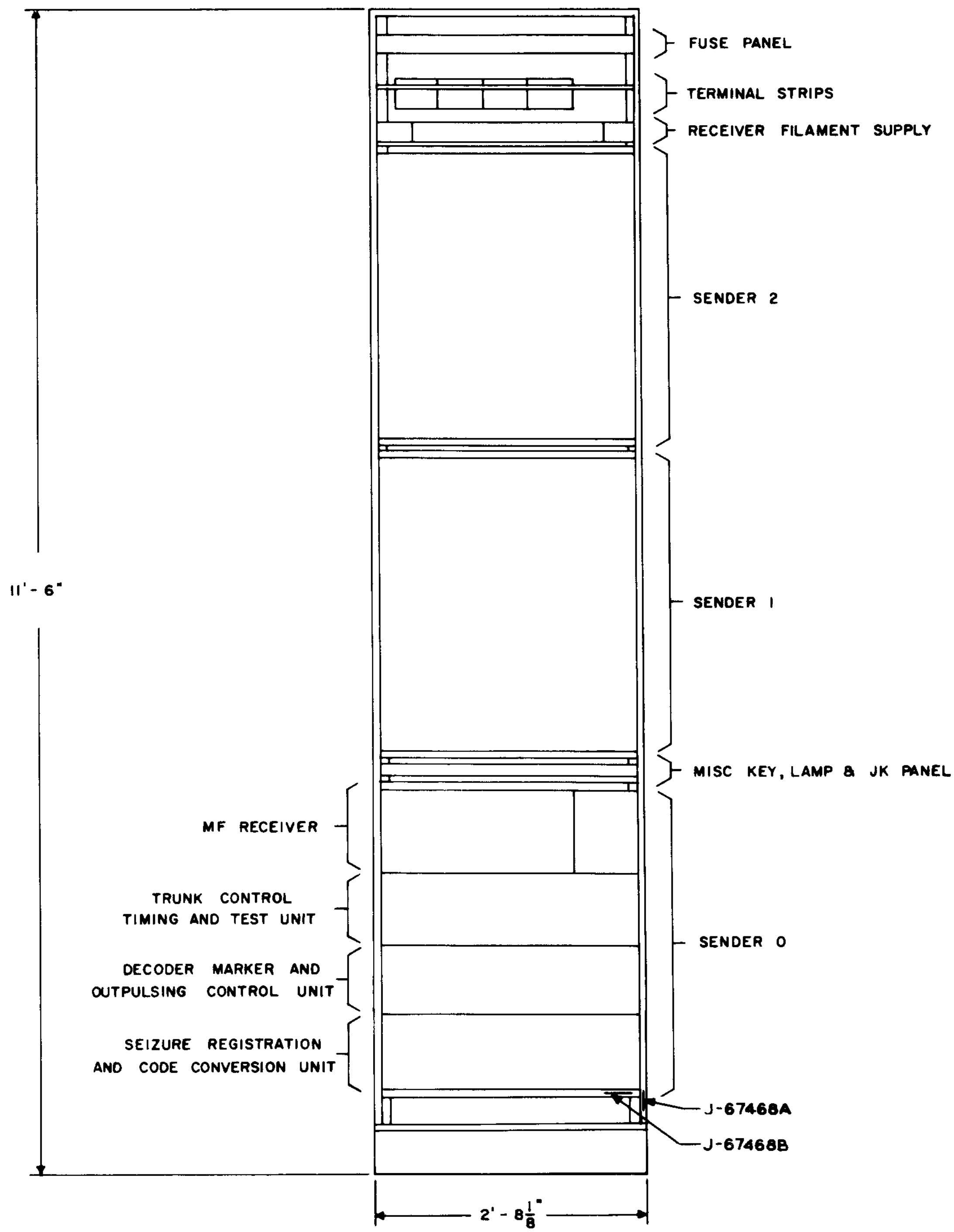


Fig. 24—Incoming Multifrequency Sender Frame—4A Offices (4.45)

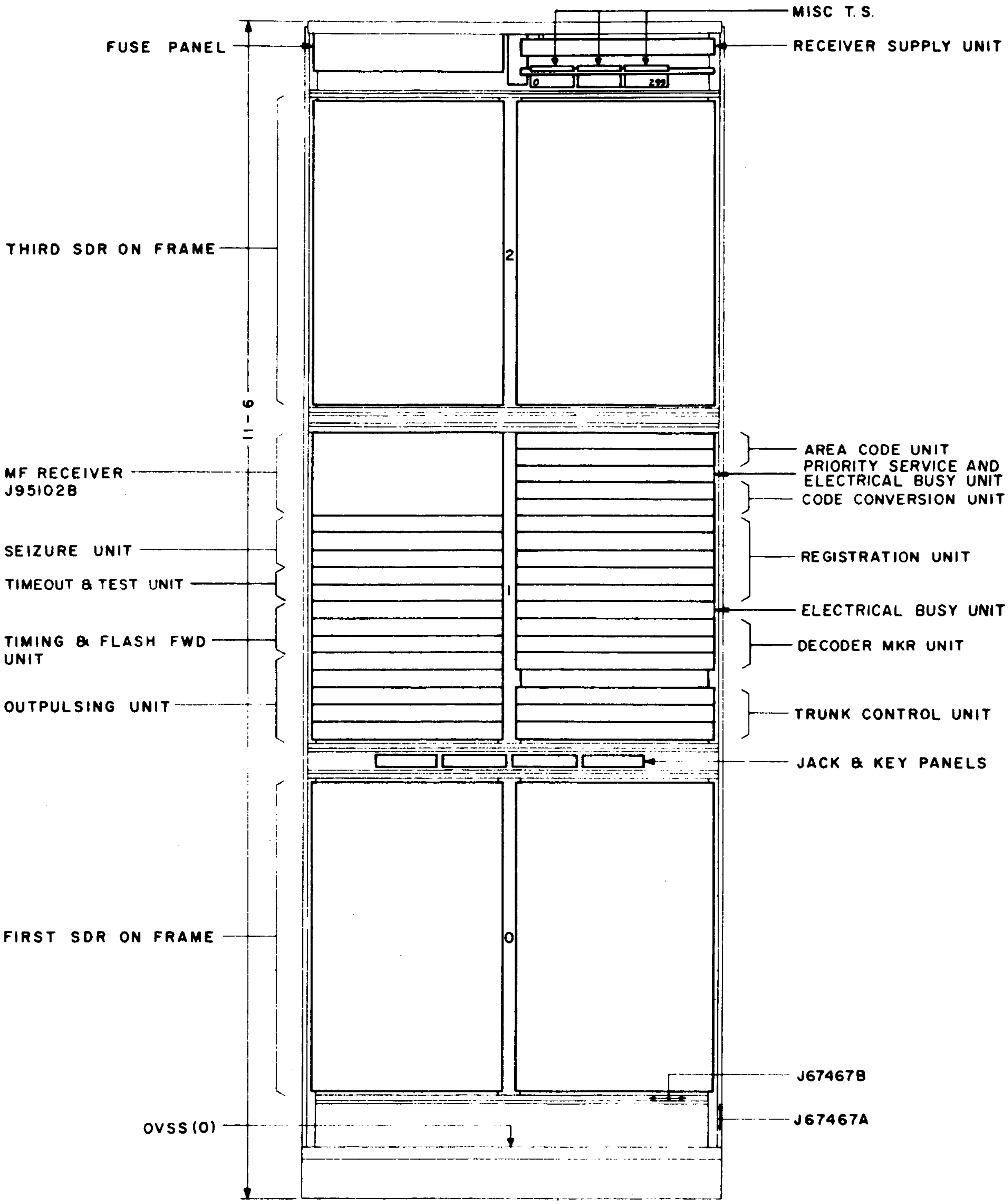


Fig. 25—Overseas Sender (4.45)

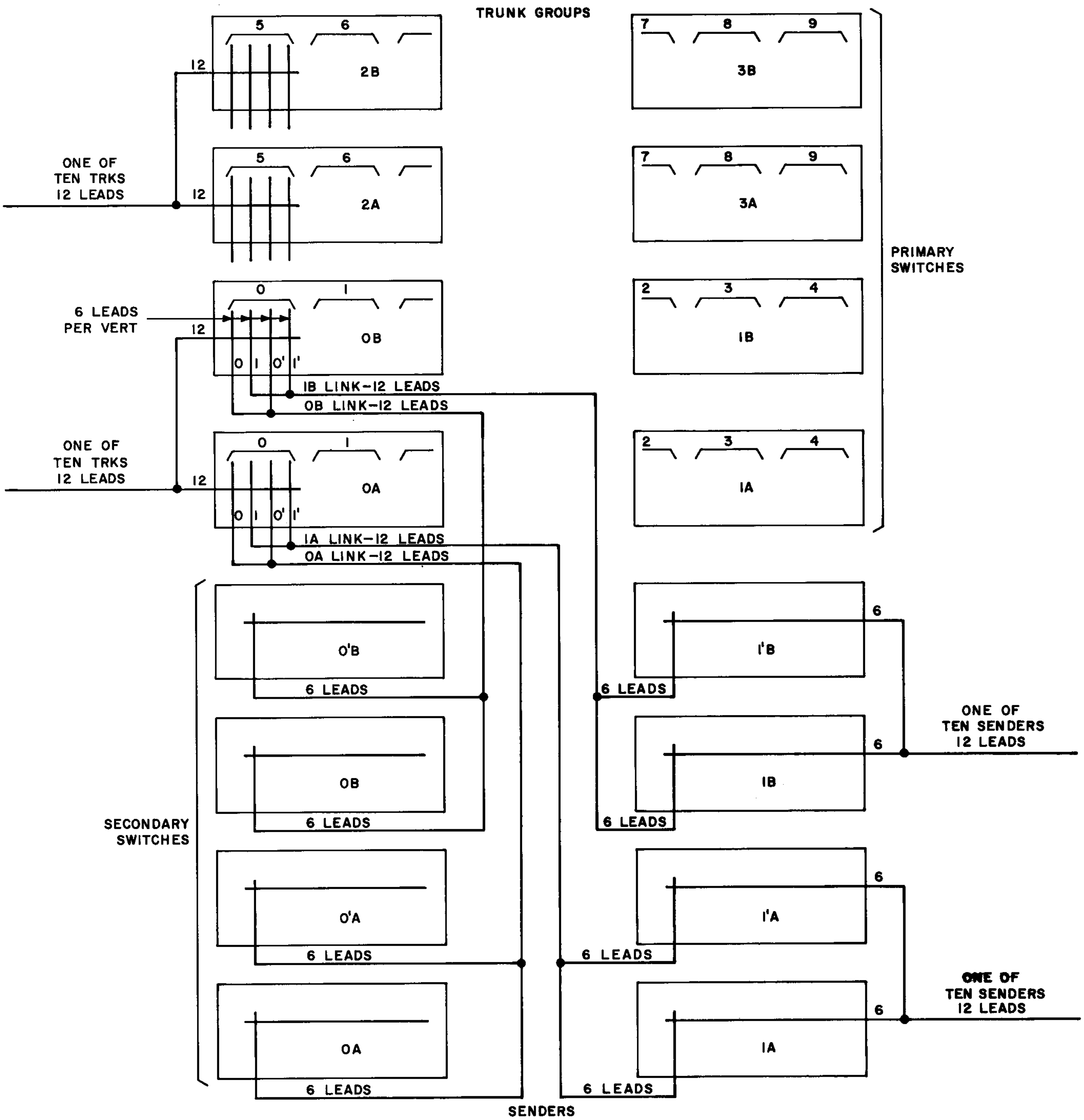


Fig. 26—Sender Link Frame—Sender Link Spread (MF and DP Senders) (4.48, 4.50)

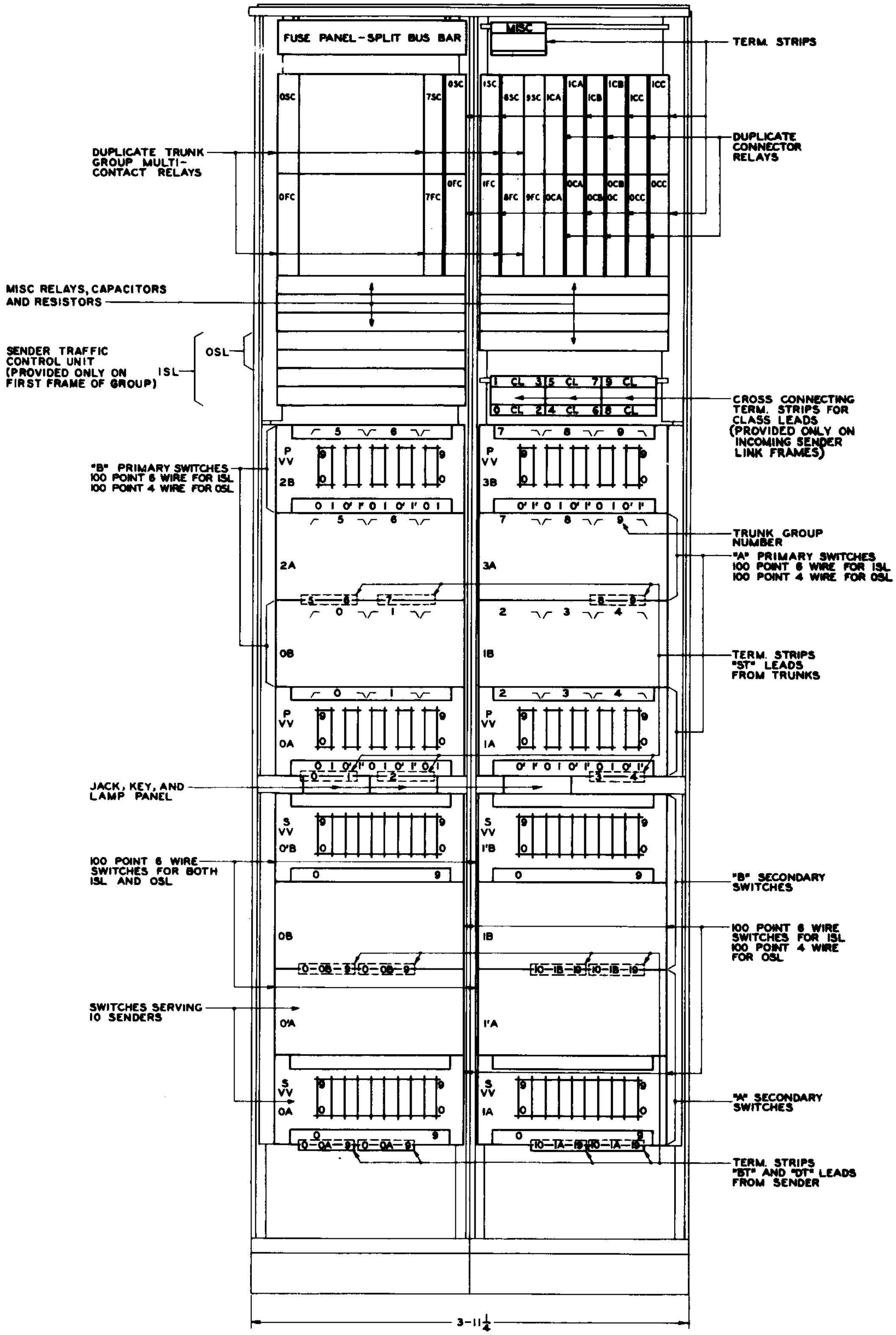


Fig. 27—Incoming or Outgoing Sender Link Frame (4.53)

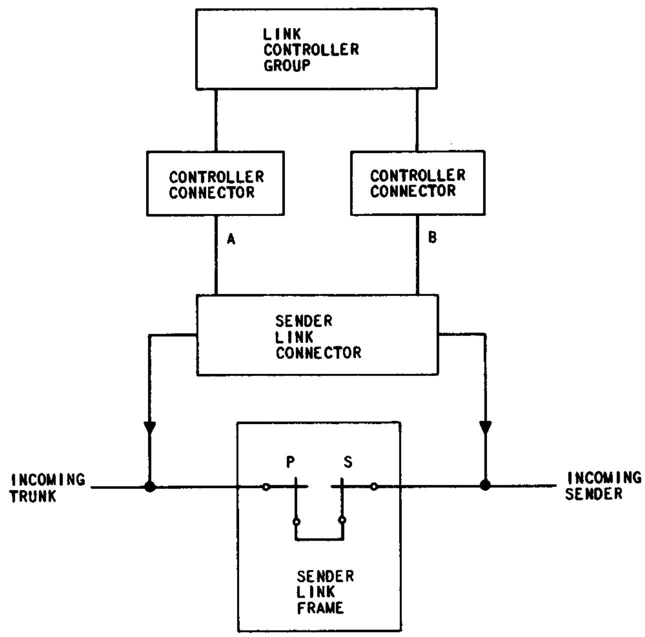


Fig. 28—Link Controller Operation (4.54)

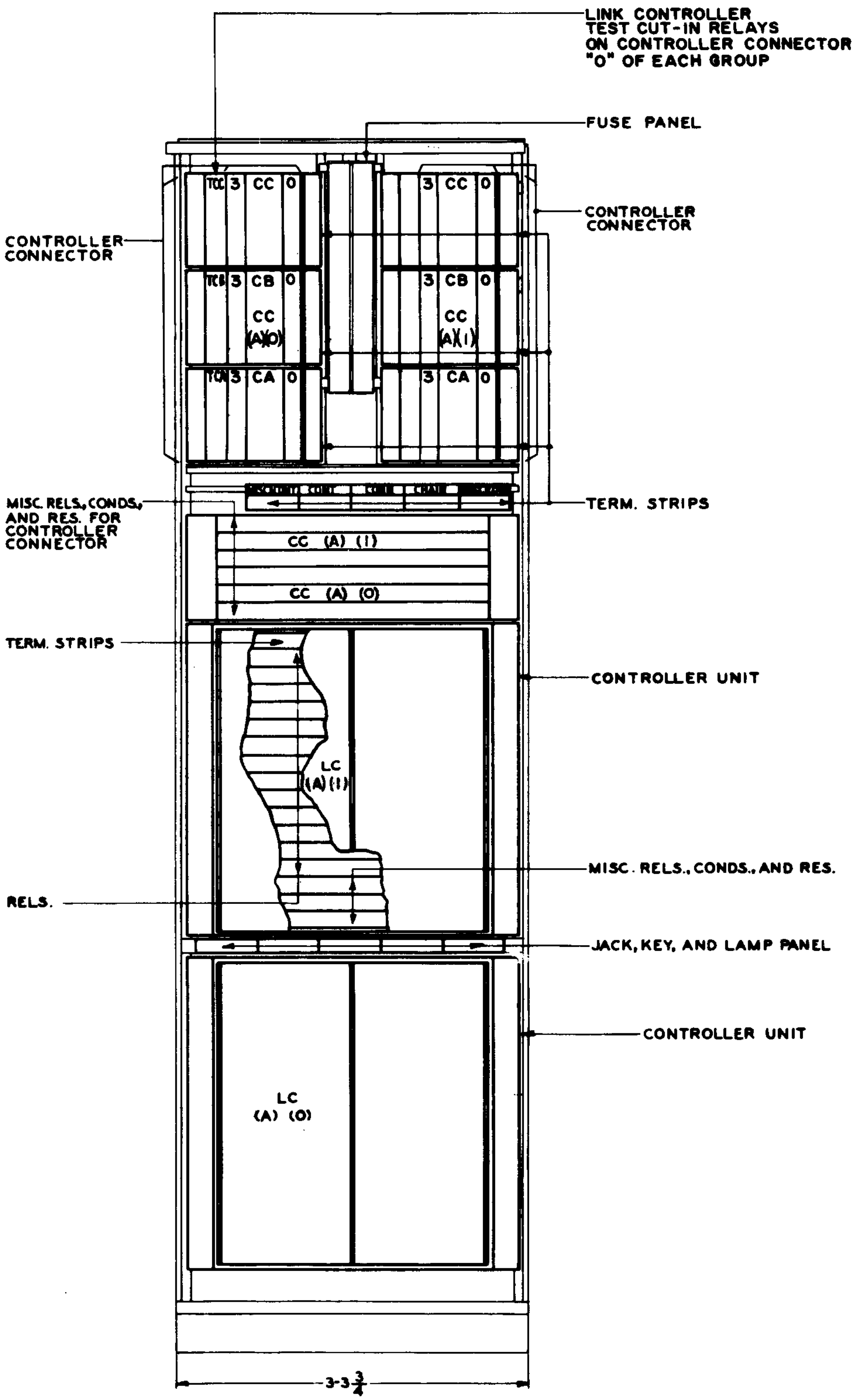


Fig. 29—Link Controller and Connector Frame (4.55, 4.57)

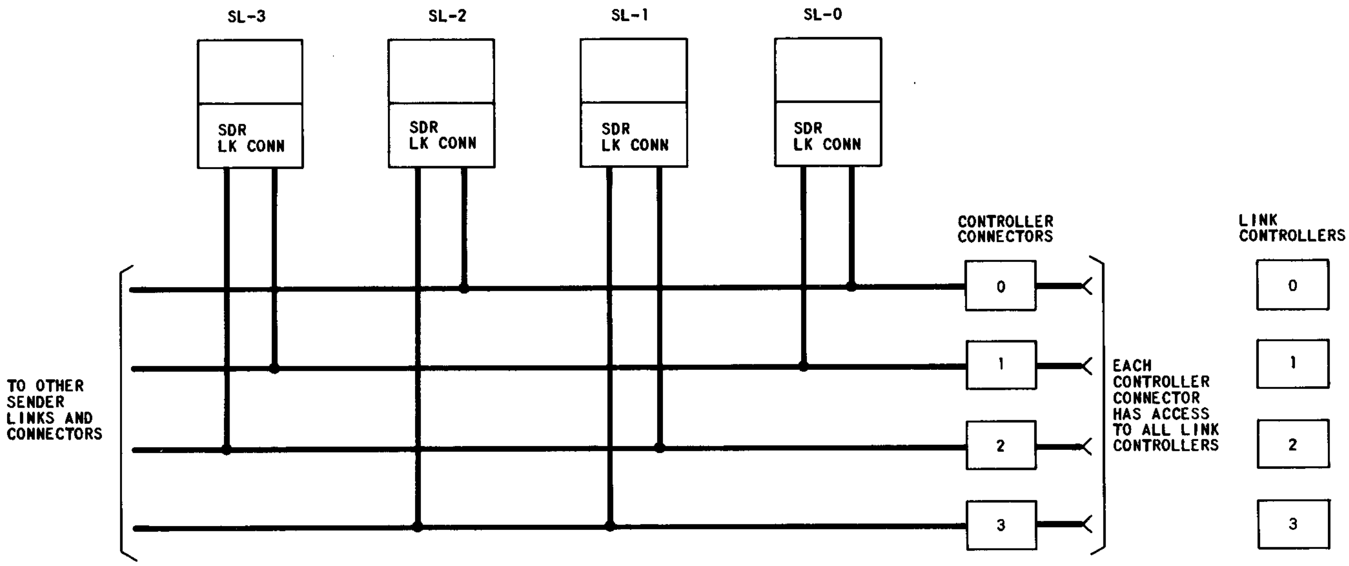


Fig. 30—Sender Link Access to Link Controllers (4.58)

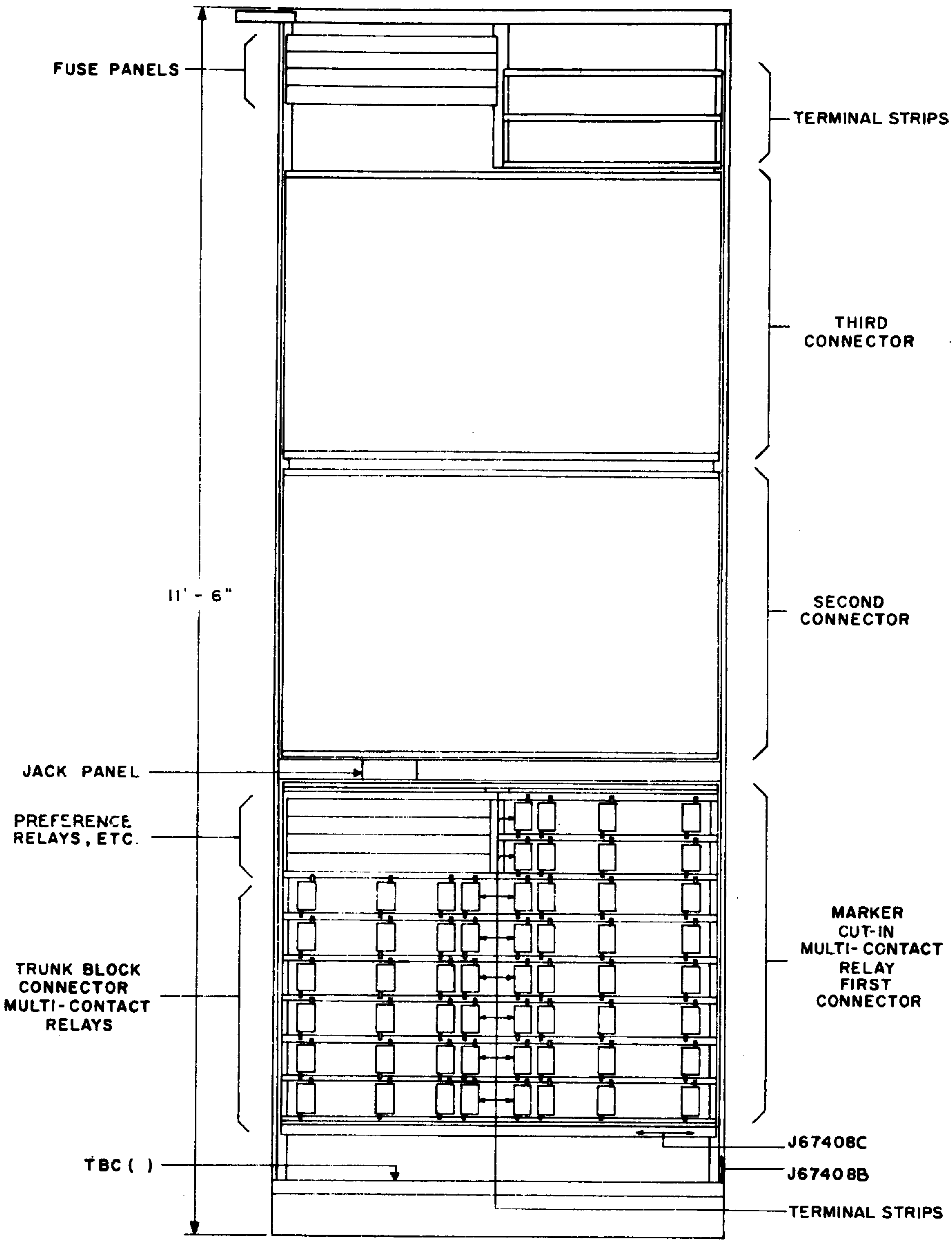


Fig. 31—Block Relay Frame (4.62, 4.66)

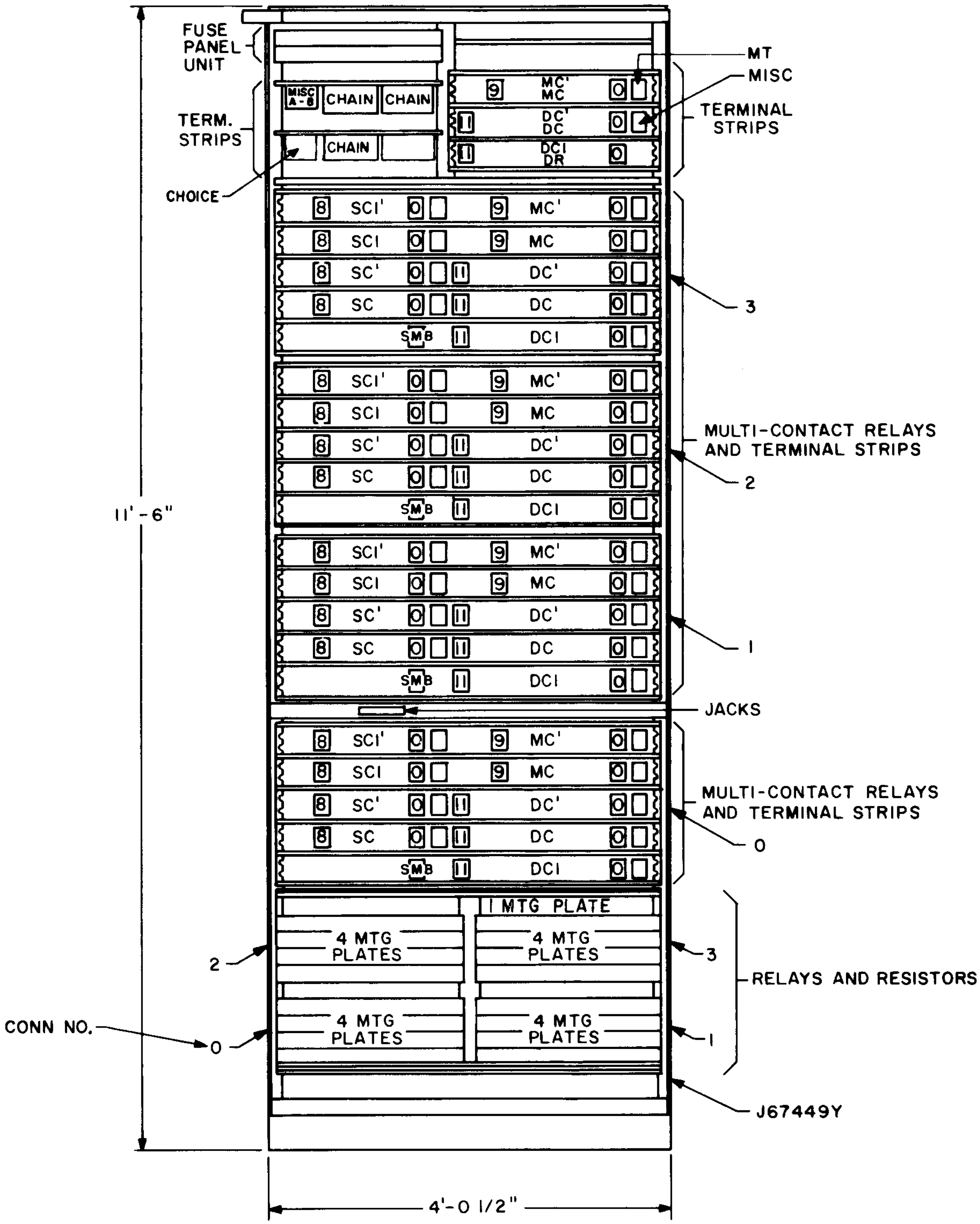


Fig. 32—Decoder Connector Frame for Separate or Combined Train Offices (4.68, 4.70)

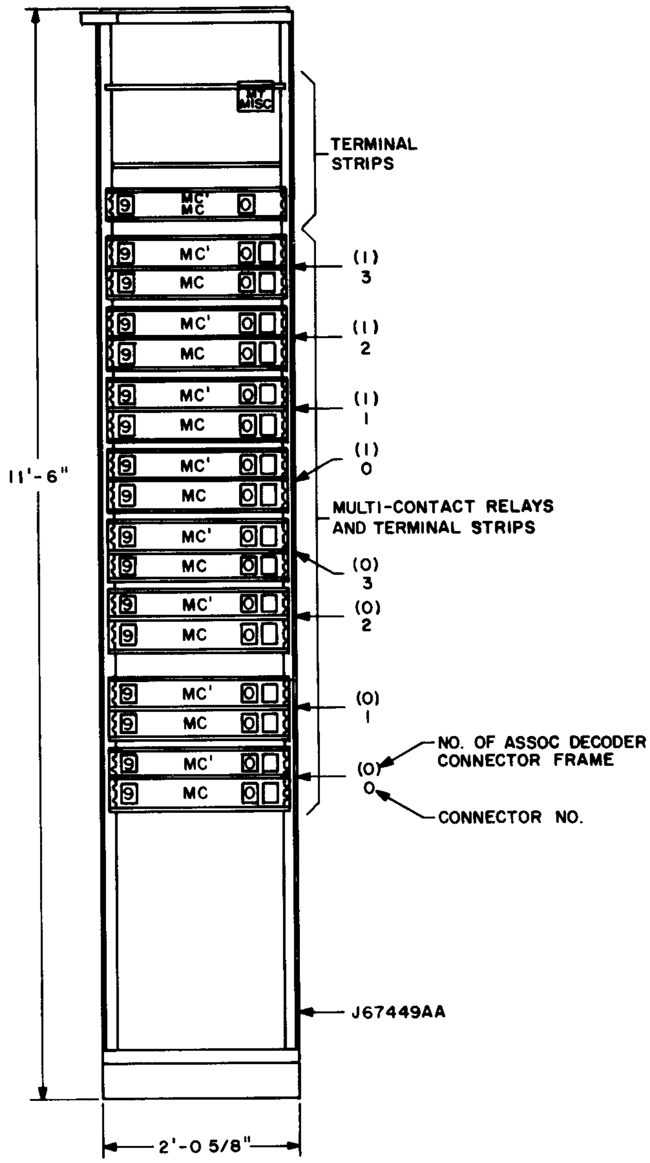


Fig. 33—Supplementary Decoder Connector Frame for Use in Separate Train Offices, Combined Train Offices or Offices Expanded to Separate Train Combined Operations (4.68, 4.70)

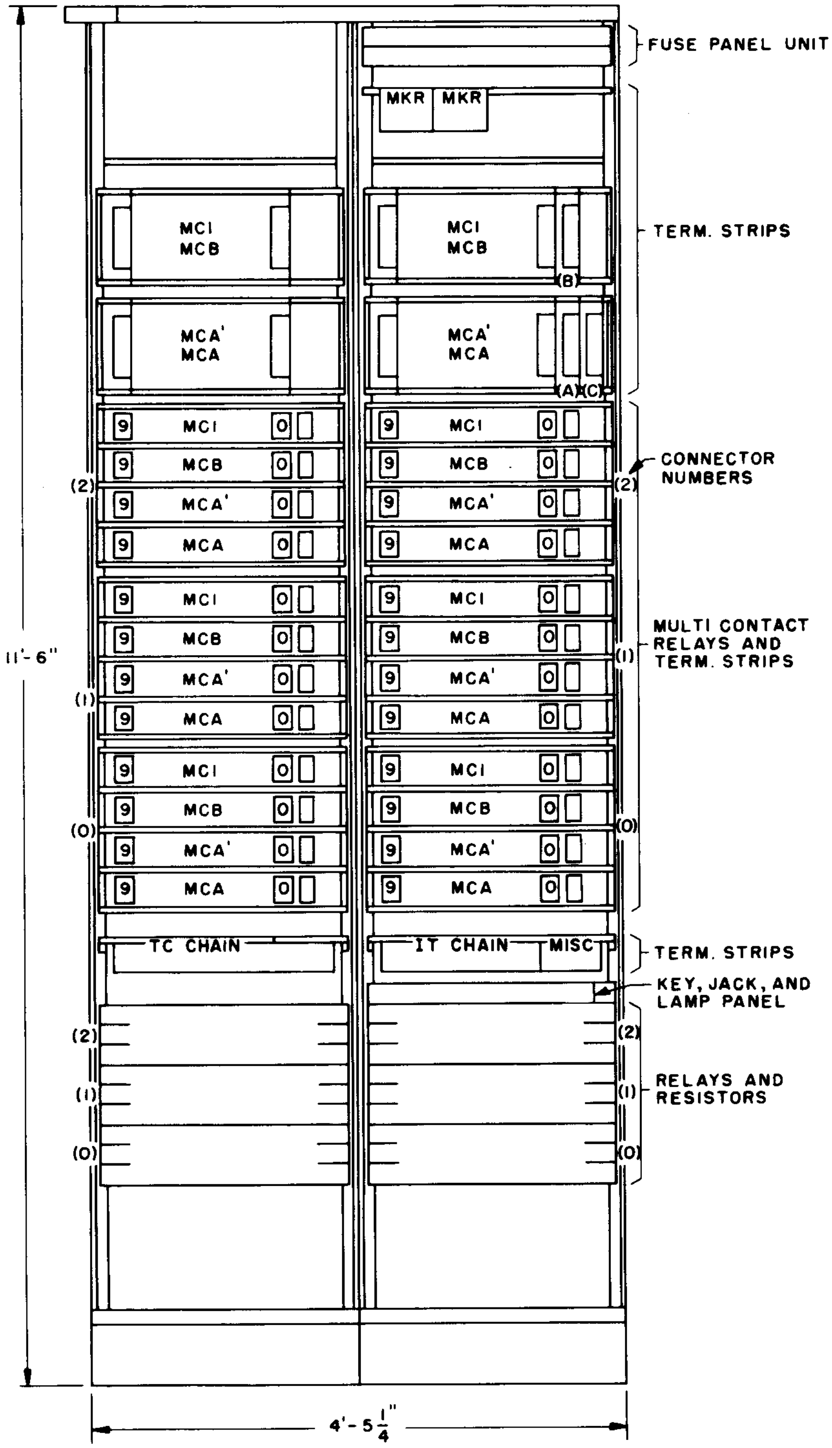


Fig. 34—Marker Connector Frame for Use in Separate Train Offices (4.75)

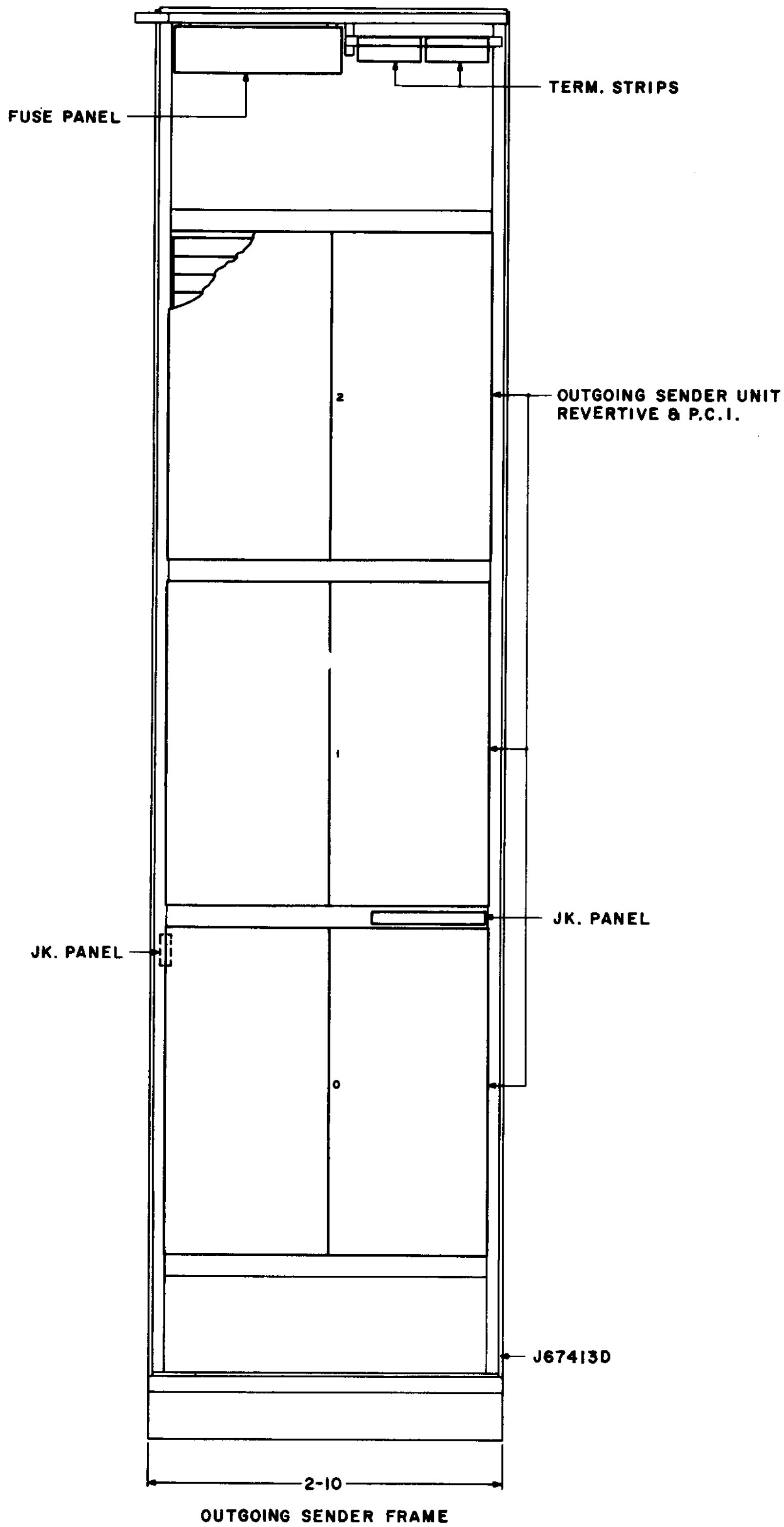


Fig. 35—Outgoing Sender Frame (4.76)

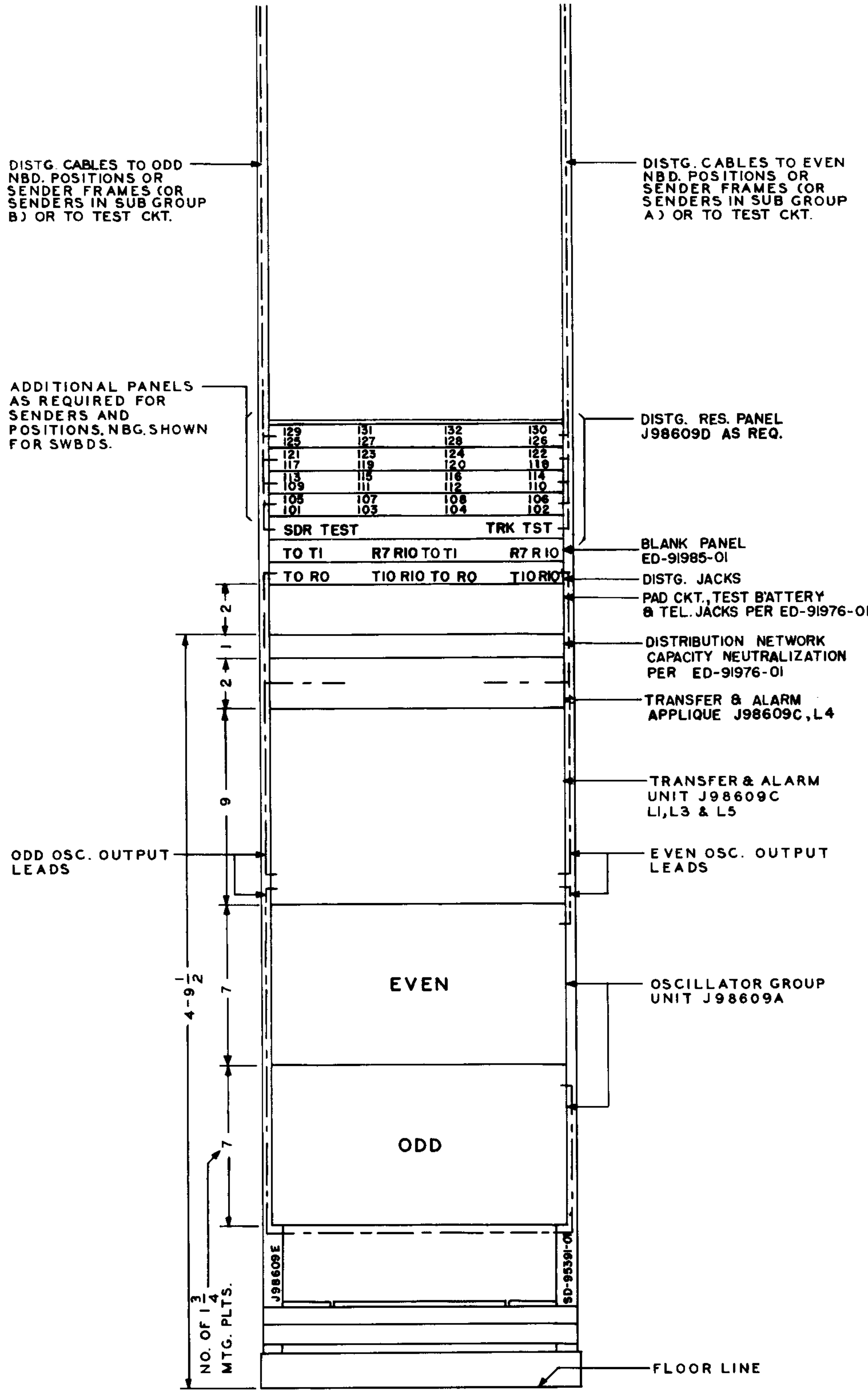


Fig. 36—Multifrequency Current Supply Frame (4.81)

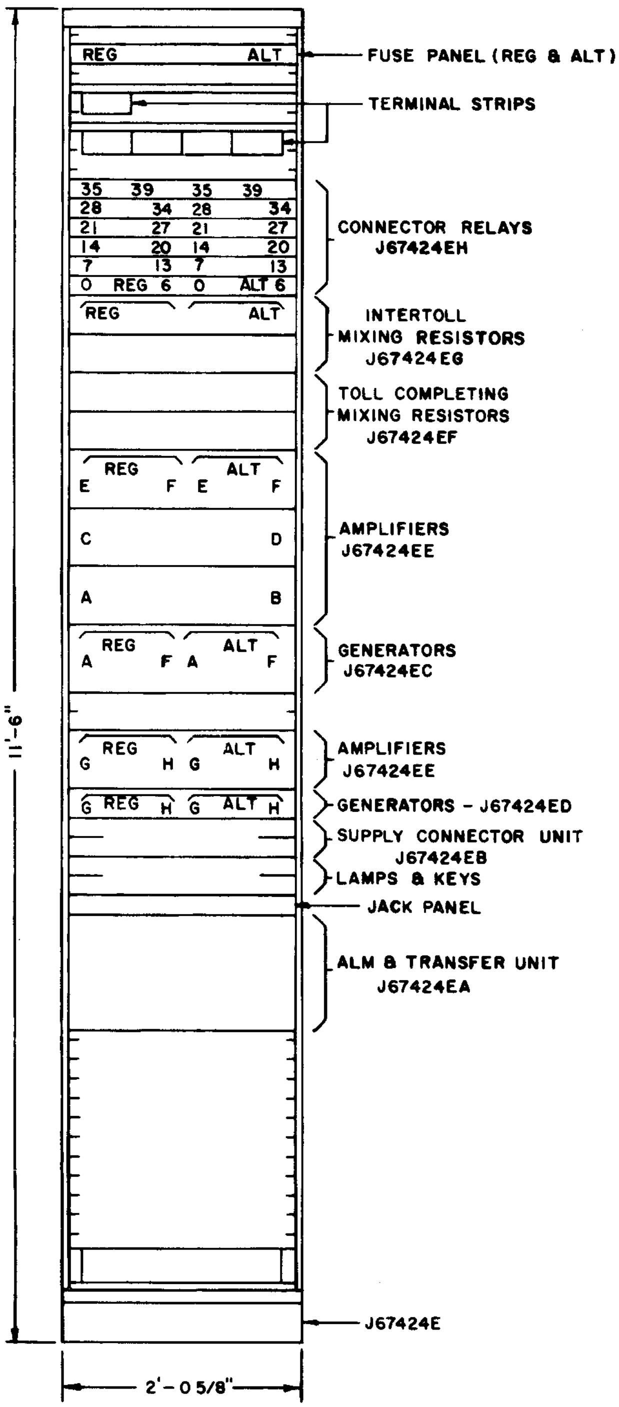


Fig. 37—Frame Identification Frequency Supply and Control Frame (4.82)

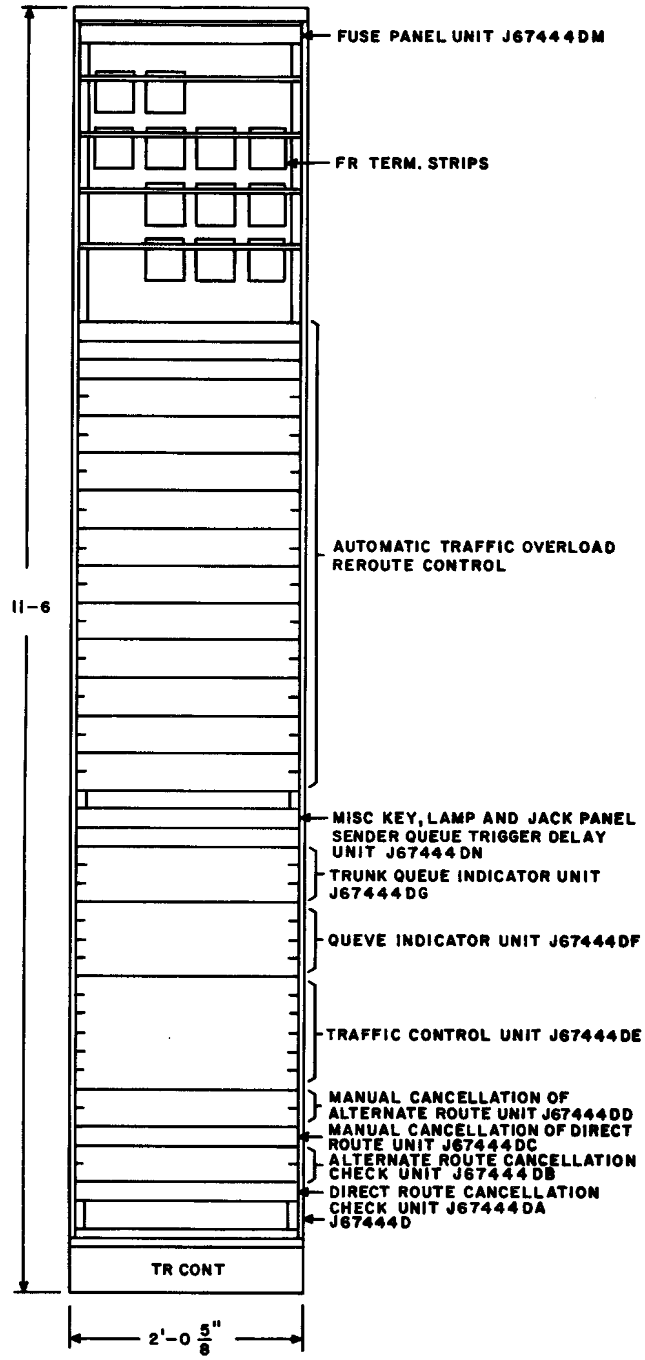


Fig. 38—Traffic Control Frame (4.83)

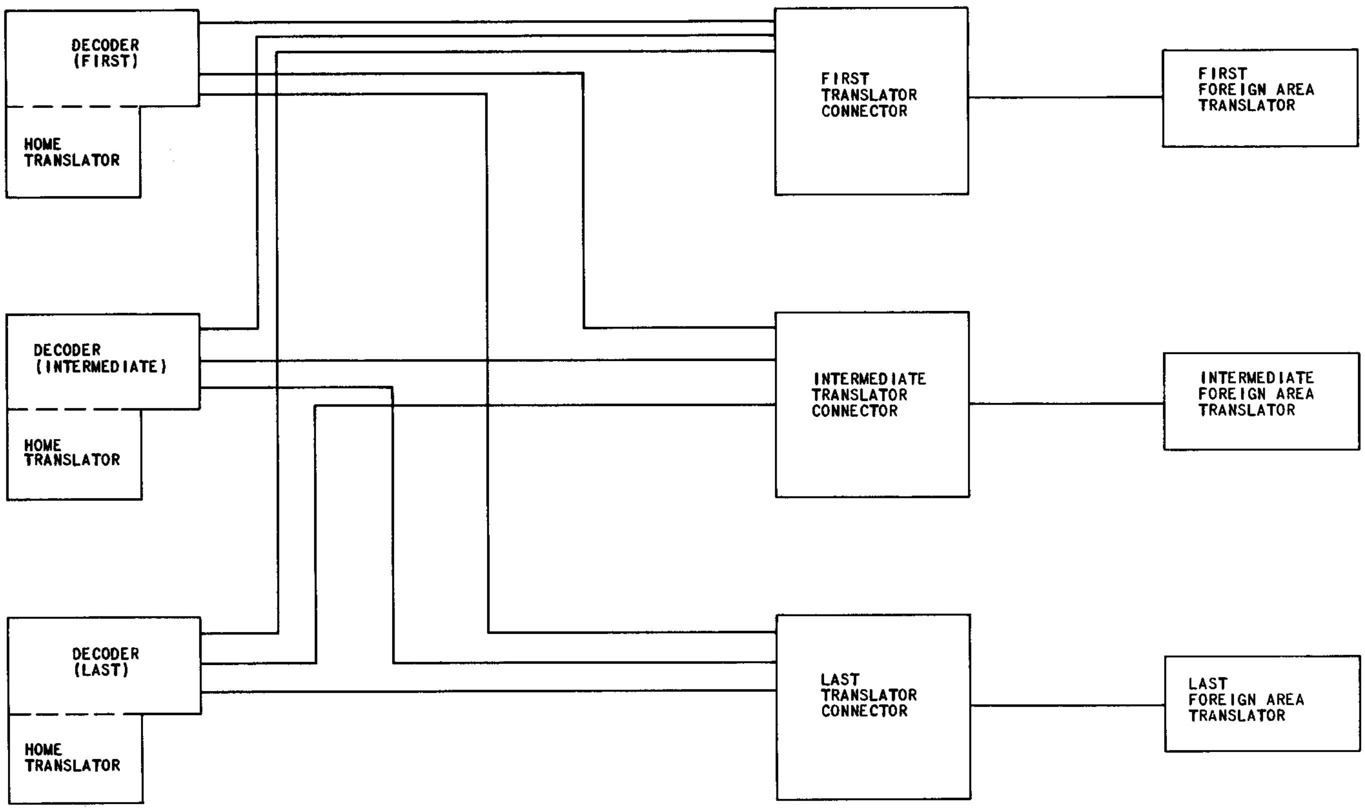


Fig. 39—Decoder Access to Card Translators (4.127, 4.157)

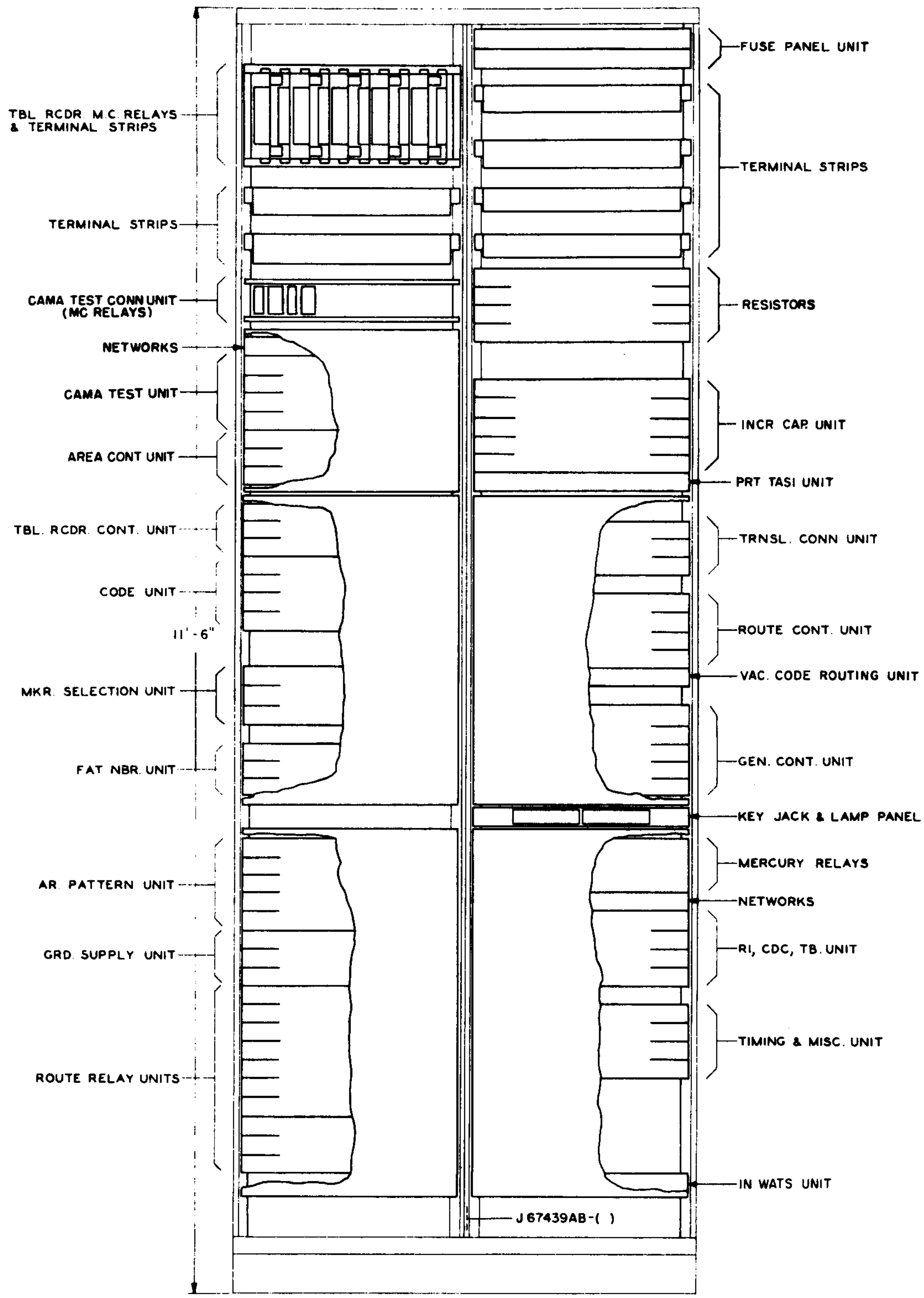


Fig. 40—Decoder Frame (4.147)

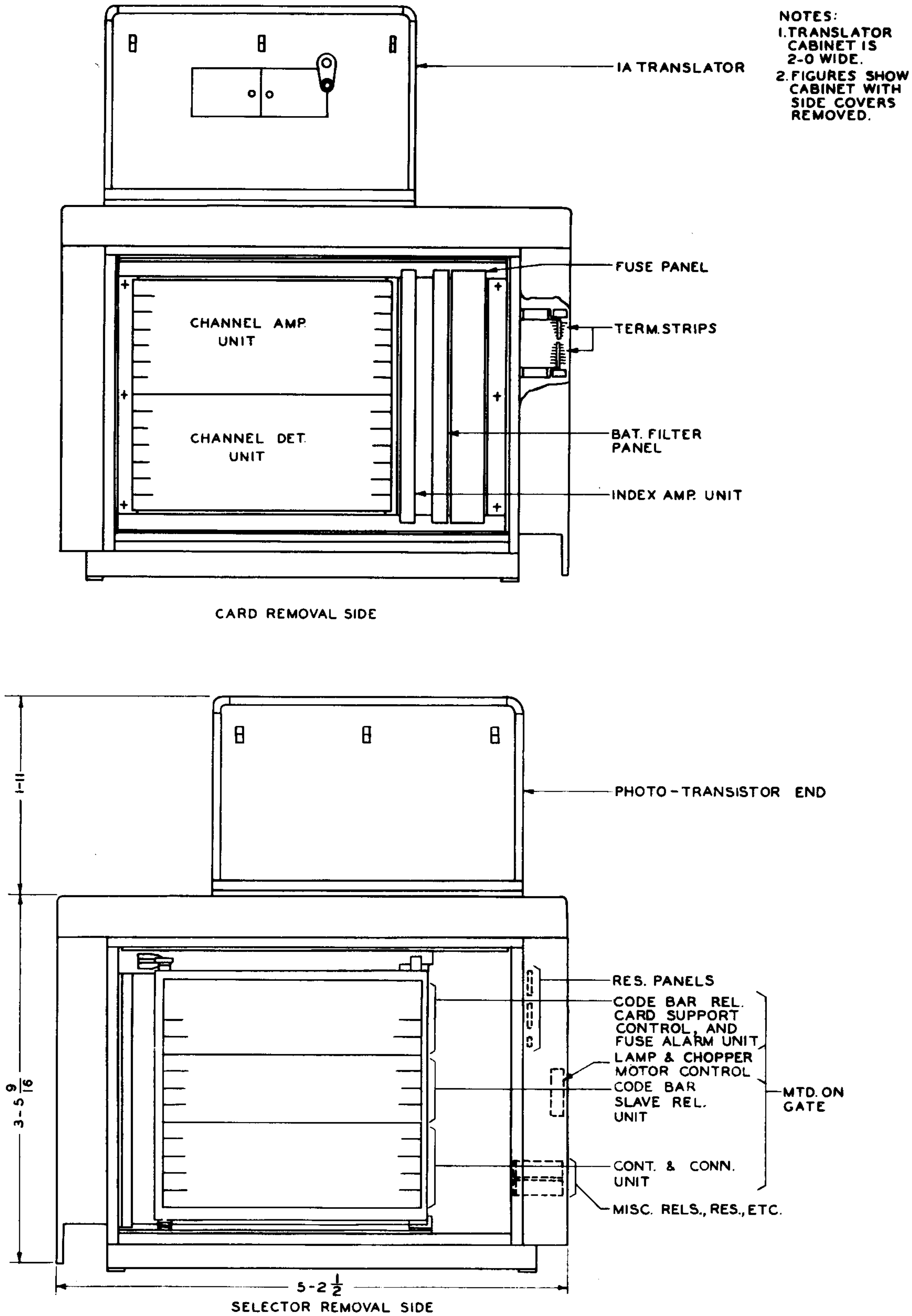


Fig. 41—Card Translator Cabinet (4.148)

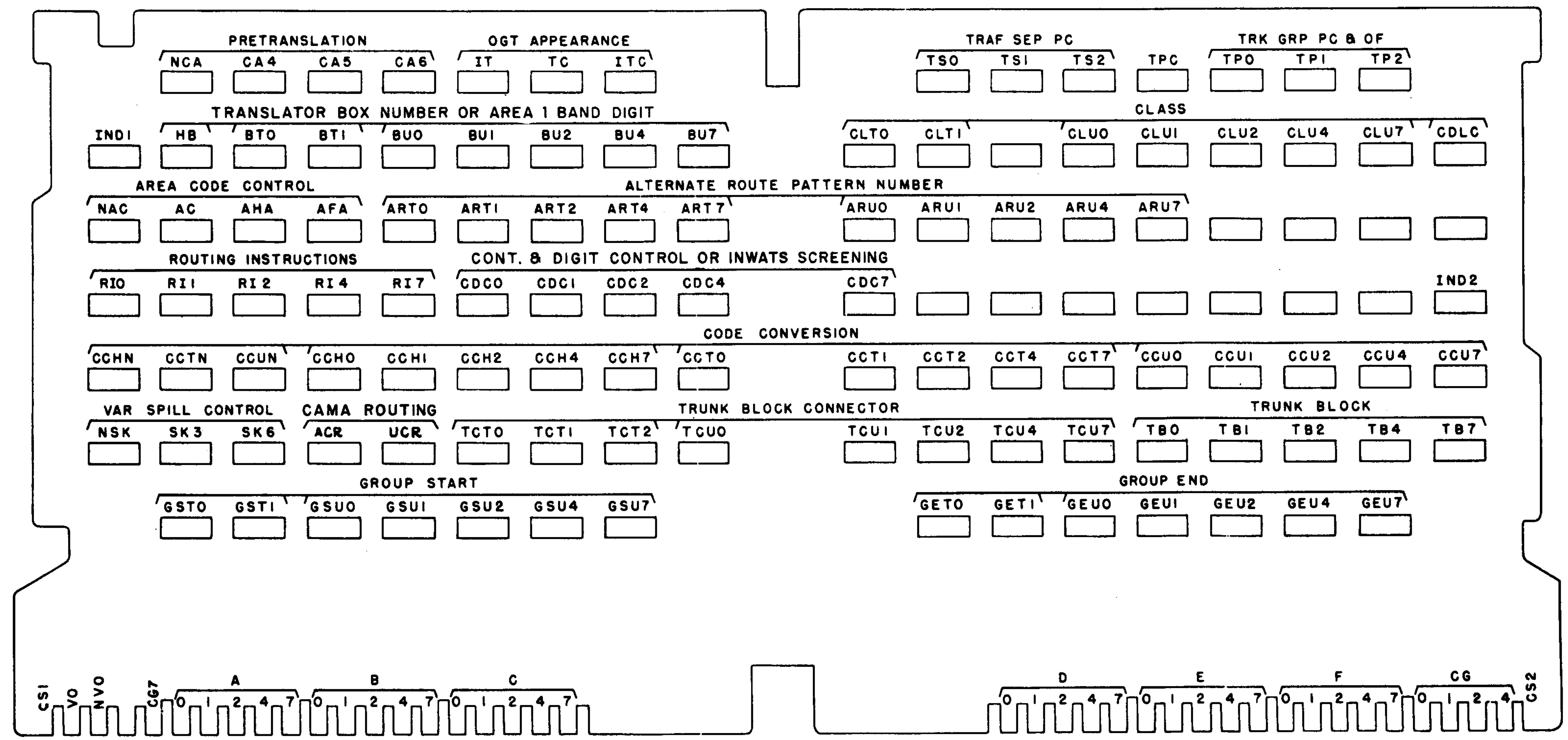


Fig. 42—Translator Card (4.150, 4.151, 4.170, 4.174, 4.183, 4.186, 4.189)

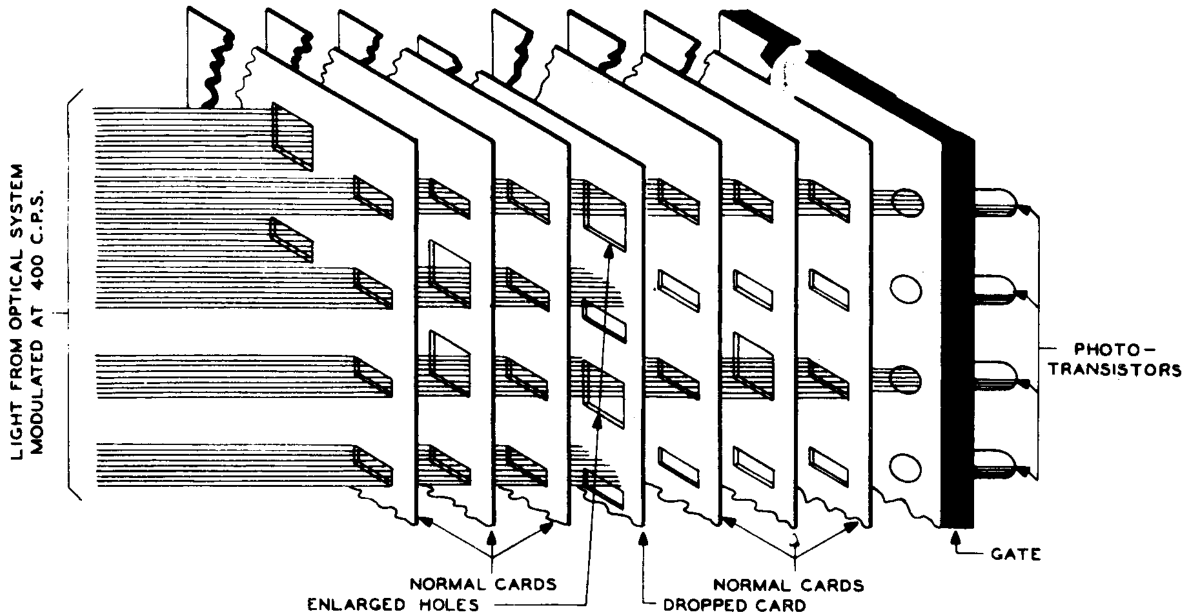


Fig. 43—Effect of Dropped Card on Light Channels (4.152, 4.172)

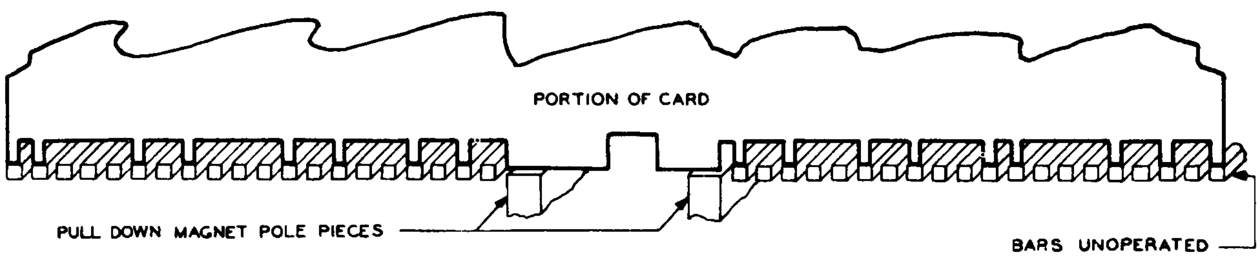


Fig. 44—Card Support and Code Bars Normal (4.169)

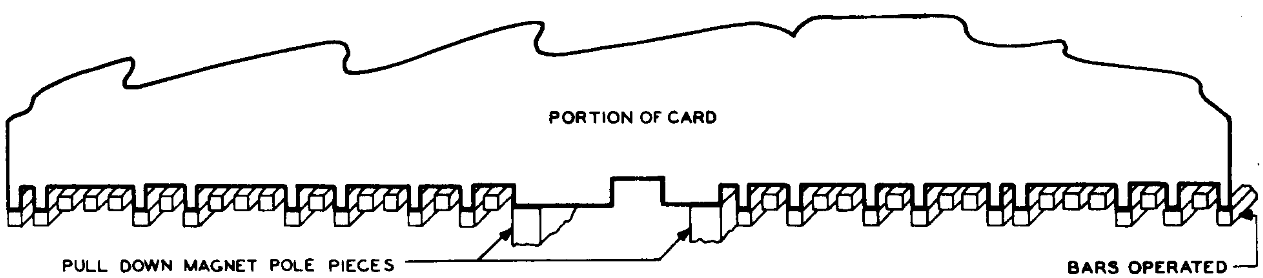


Fig. 45—Card Support and Code Bars Operated (Corresponding Card Drops) (4.169)

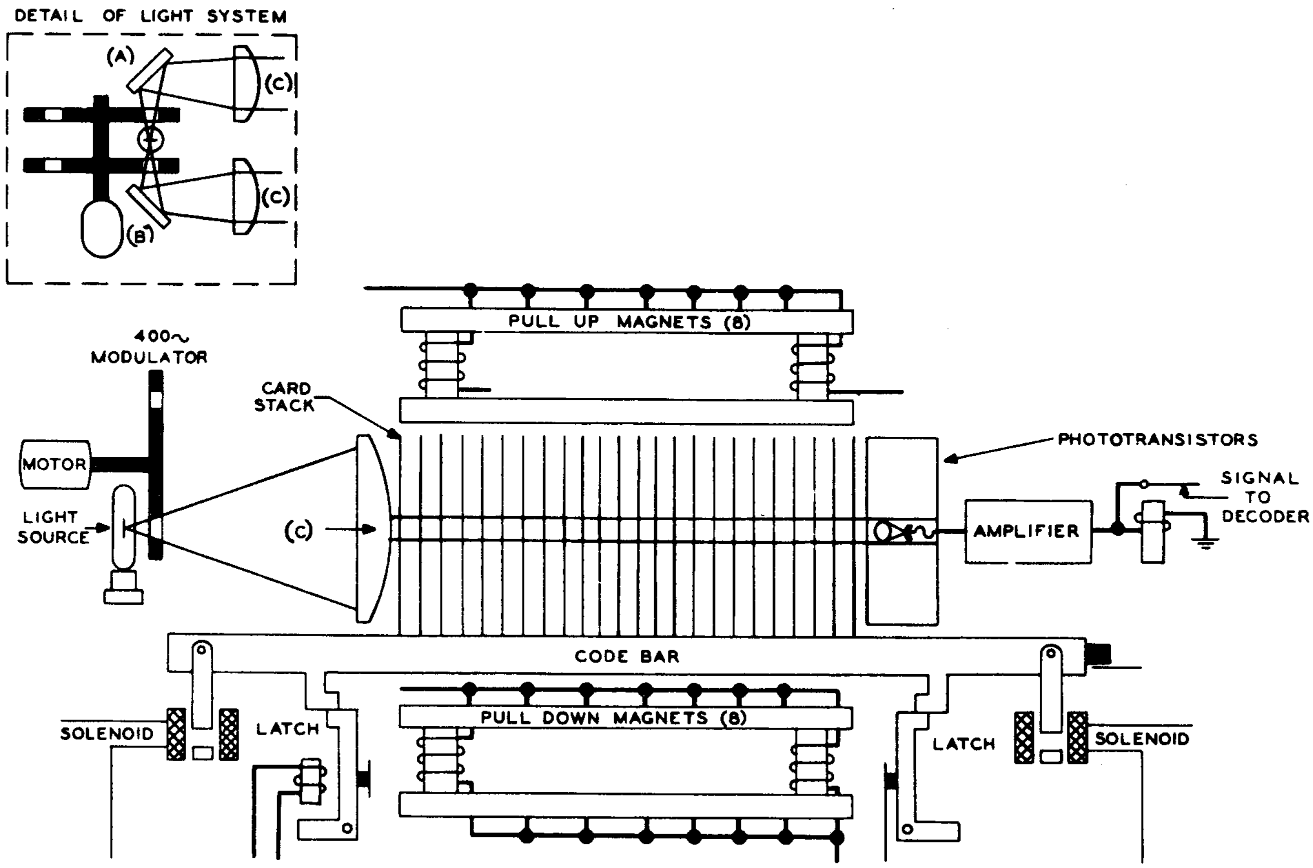


FIG. 32- ELEMENTS OF THE CARD TRANSLATOR

Fig. 46—Elements of Card Translator (4.174, 4.175, 4.179)

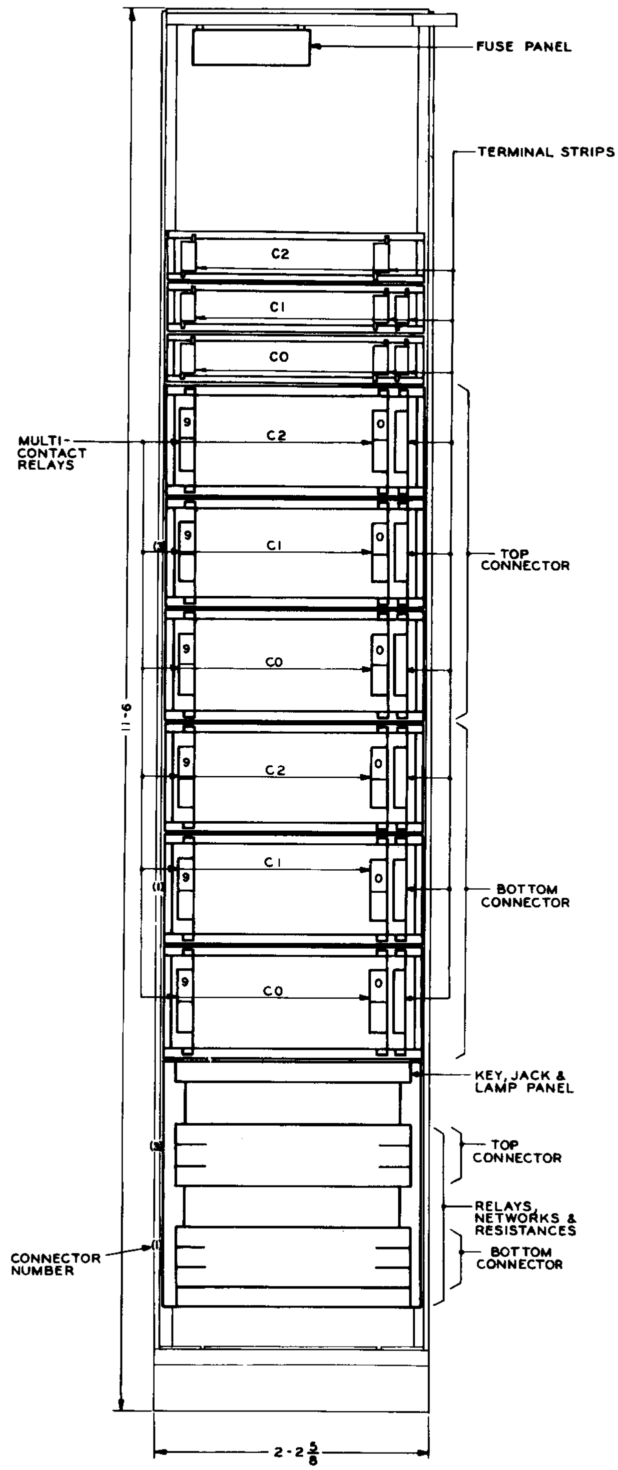


Fig. 47—Foreign Translator Connector Frame (For Supplementary Foreign Translator Connector Frame) (4.194)

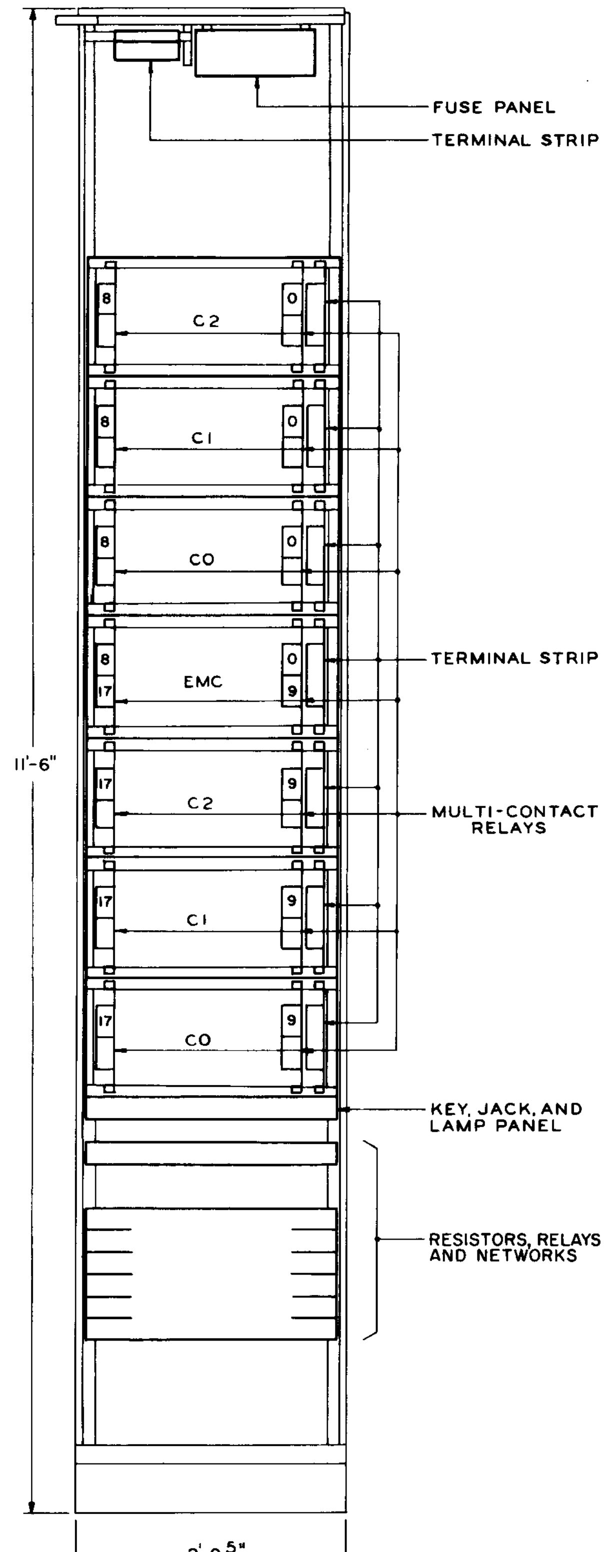


Fig. 48—Emergency Translator Connector Frame (For 18-Decoder Capacity) (4.195)

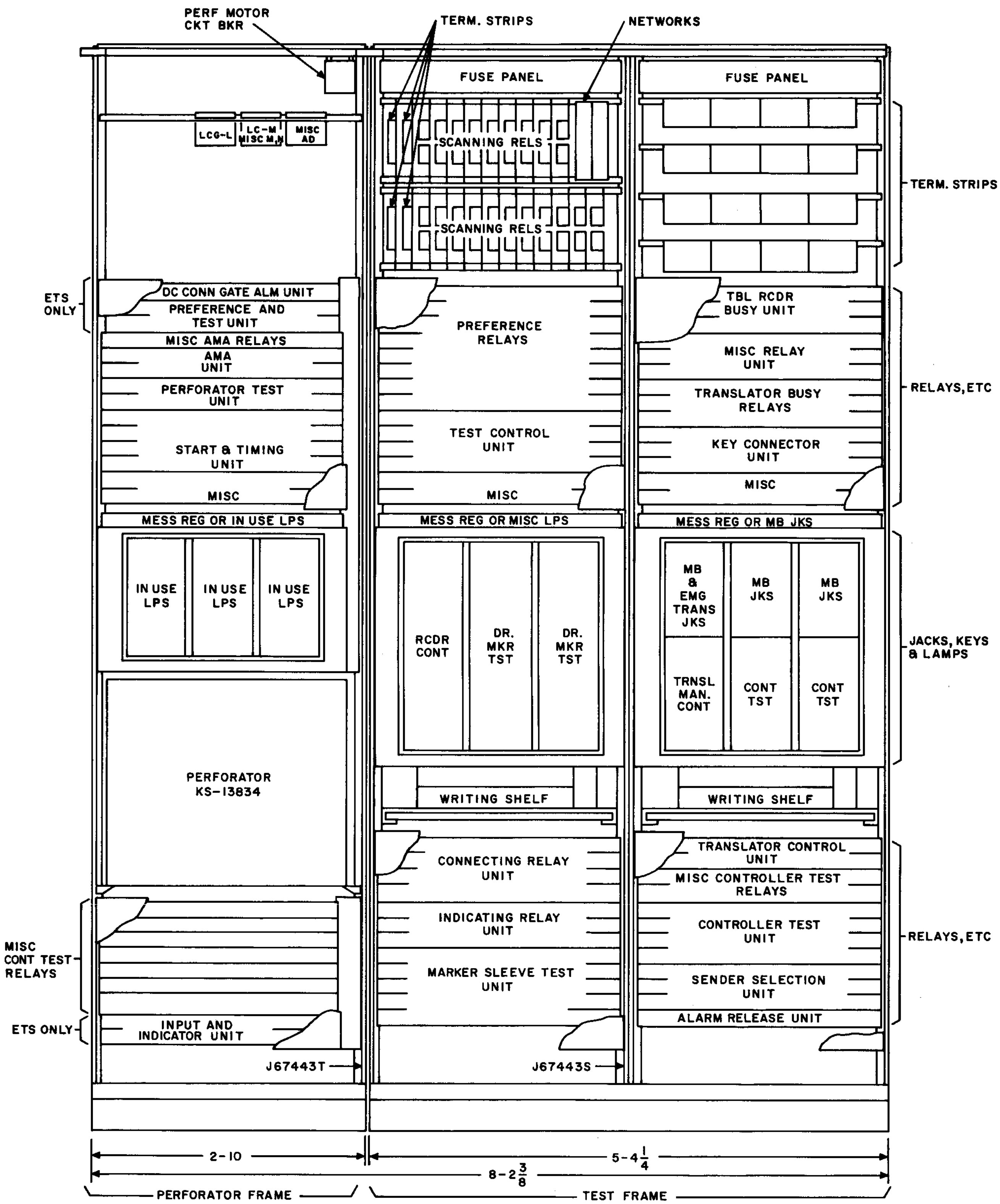
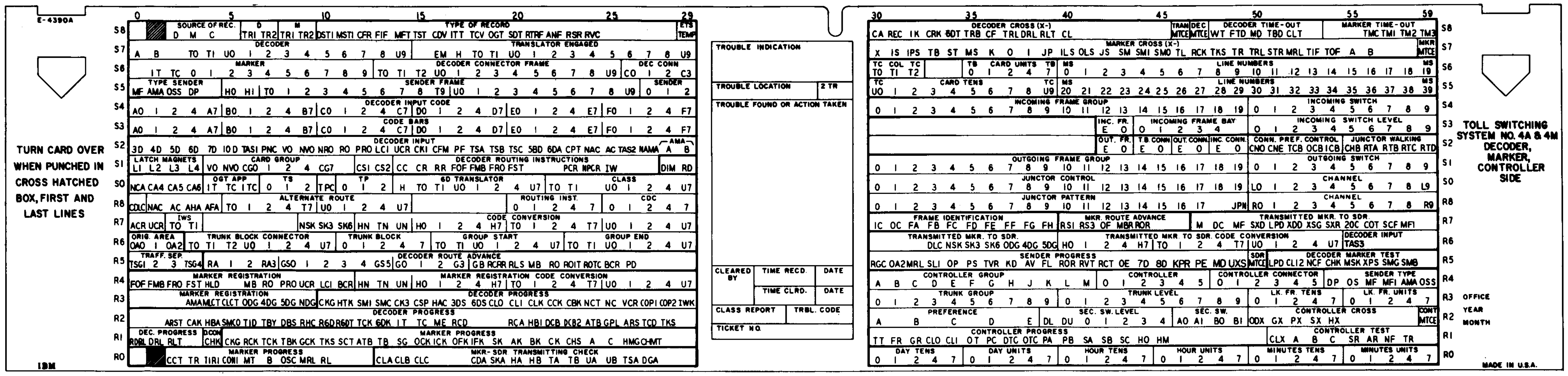
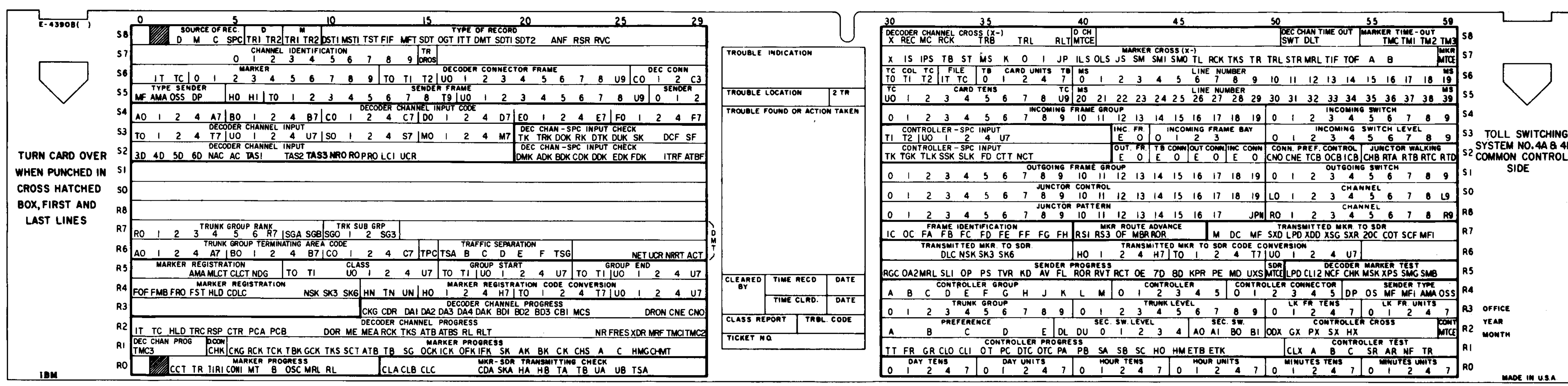


Fig. 49—Trouble Recorder Frame (5.11)



CT OFFICE



ET OFFICE

Fig. 50—Trouble Record Cards (Blank) (5.23)

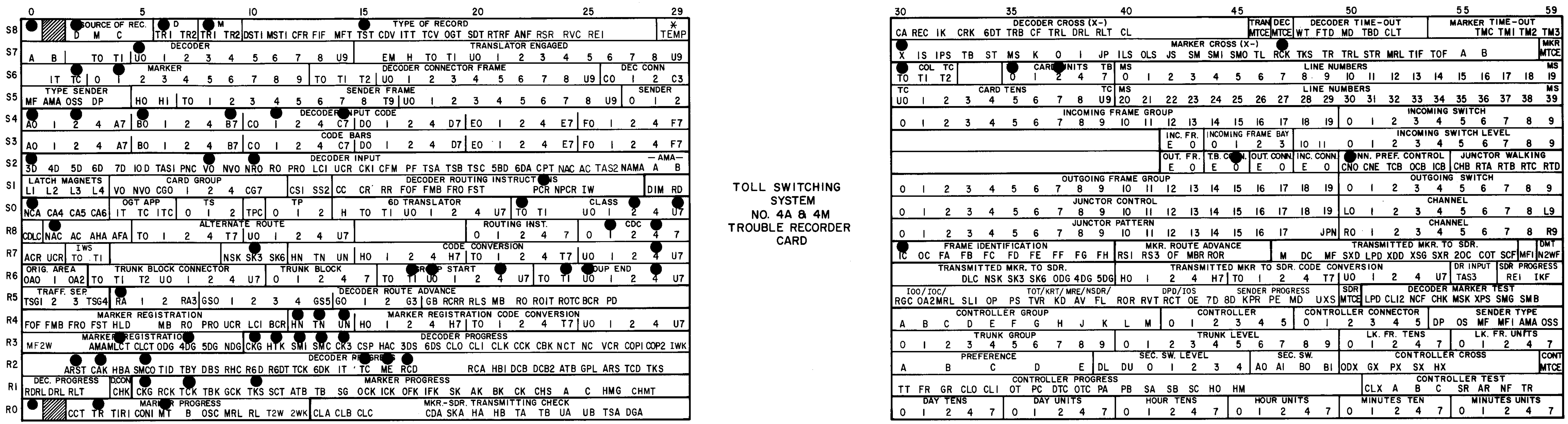


Fig. 51—Trouble Record Card (Punched) (5.23)

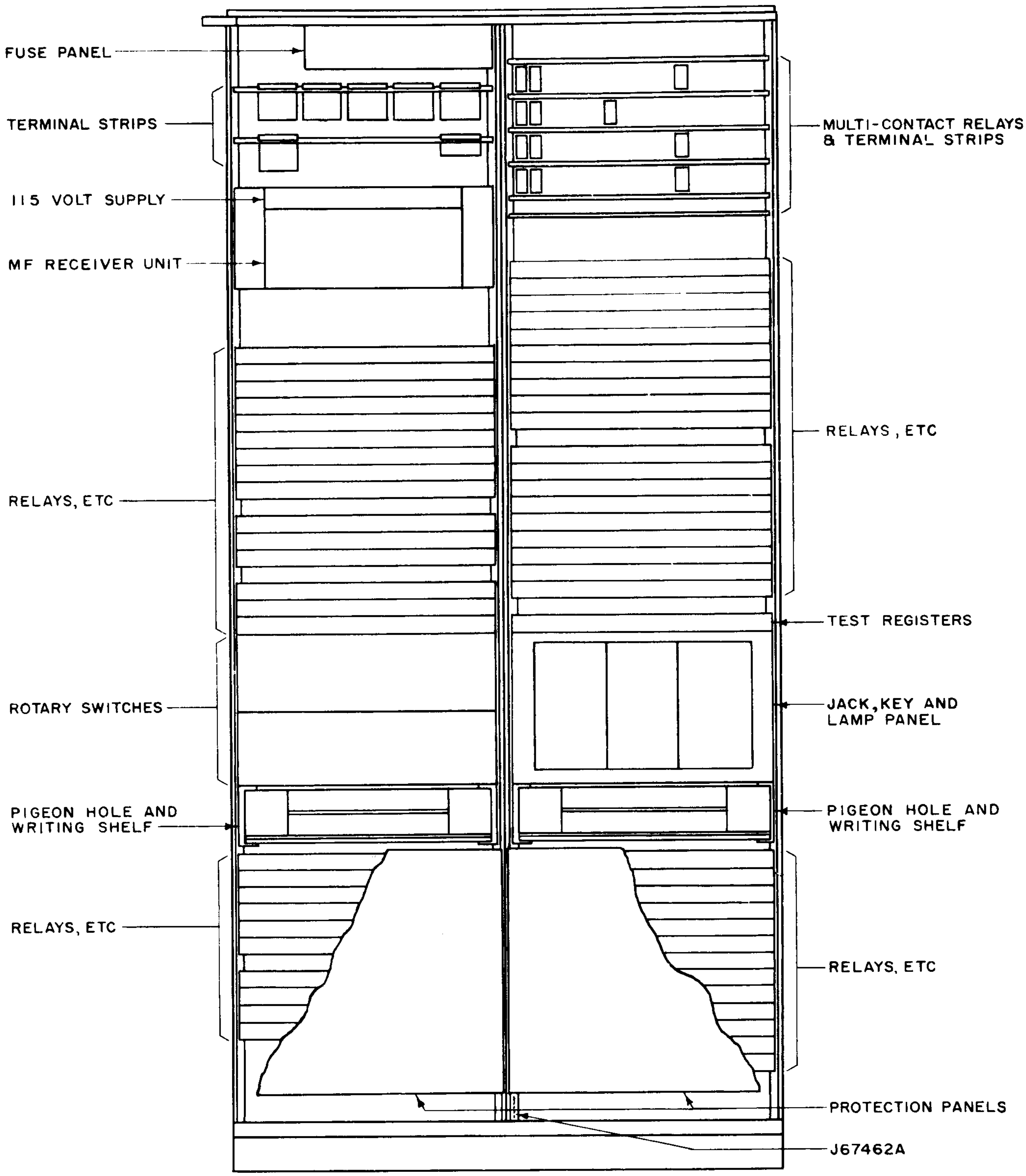


Fig. 52—Incoming Sender and Register Test Frame (5.37)

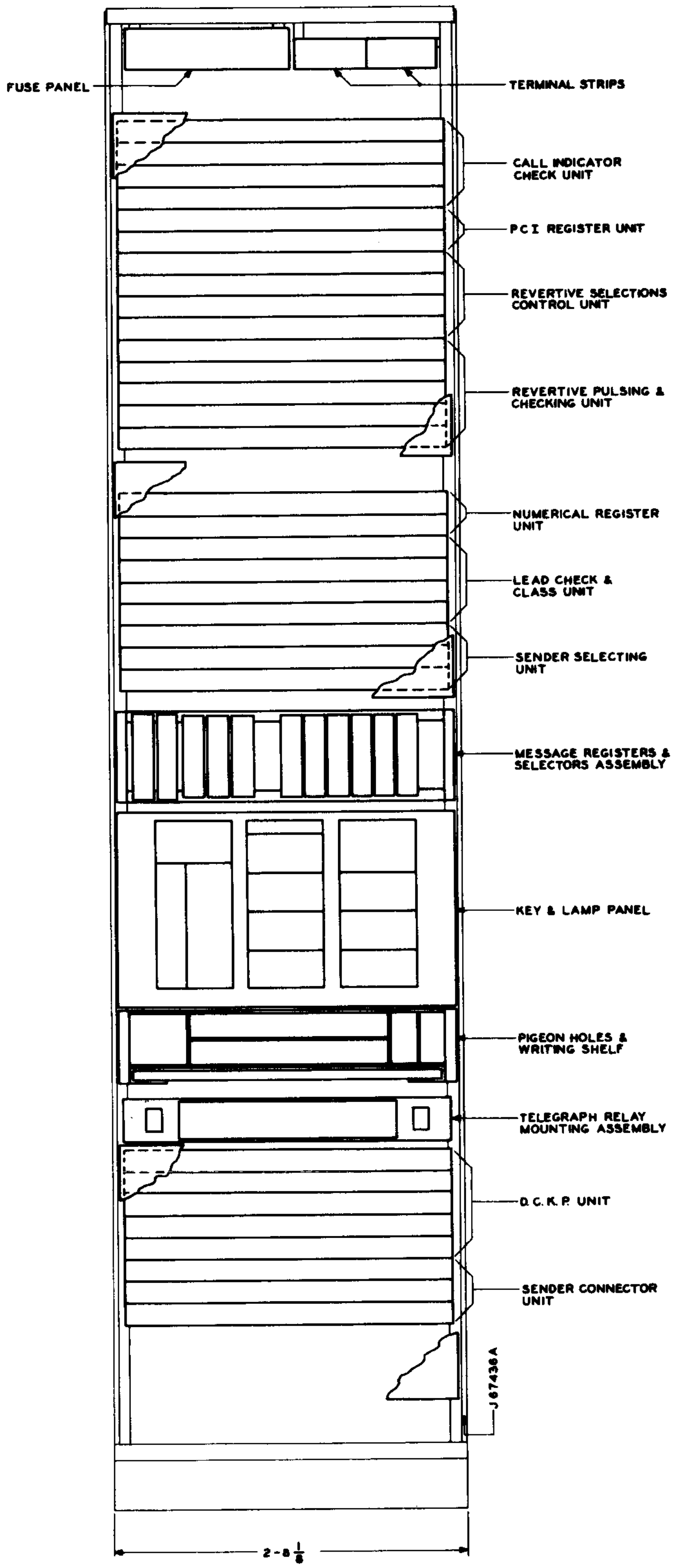


Fig. 53—Outgoing Sender Test Frame (5.46)

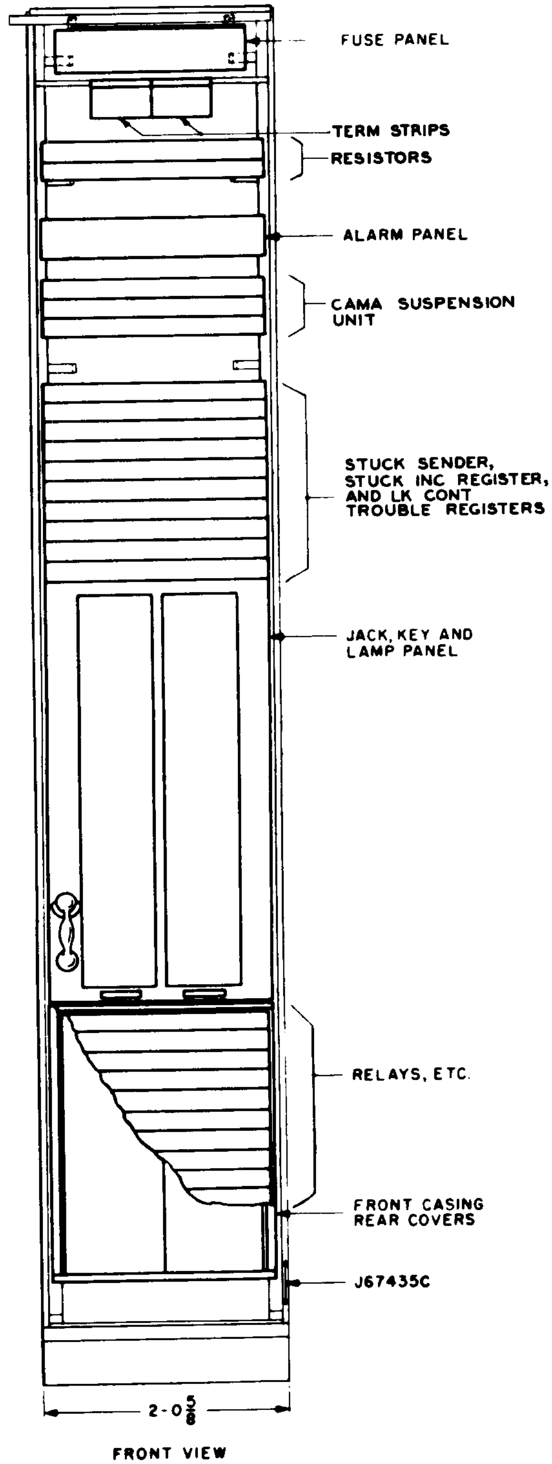


Fig. 54—Sender Make-Busy Frame (5.47)

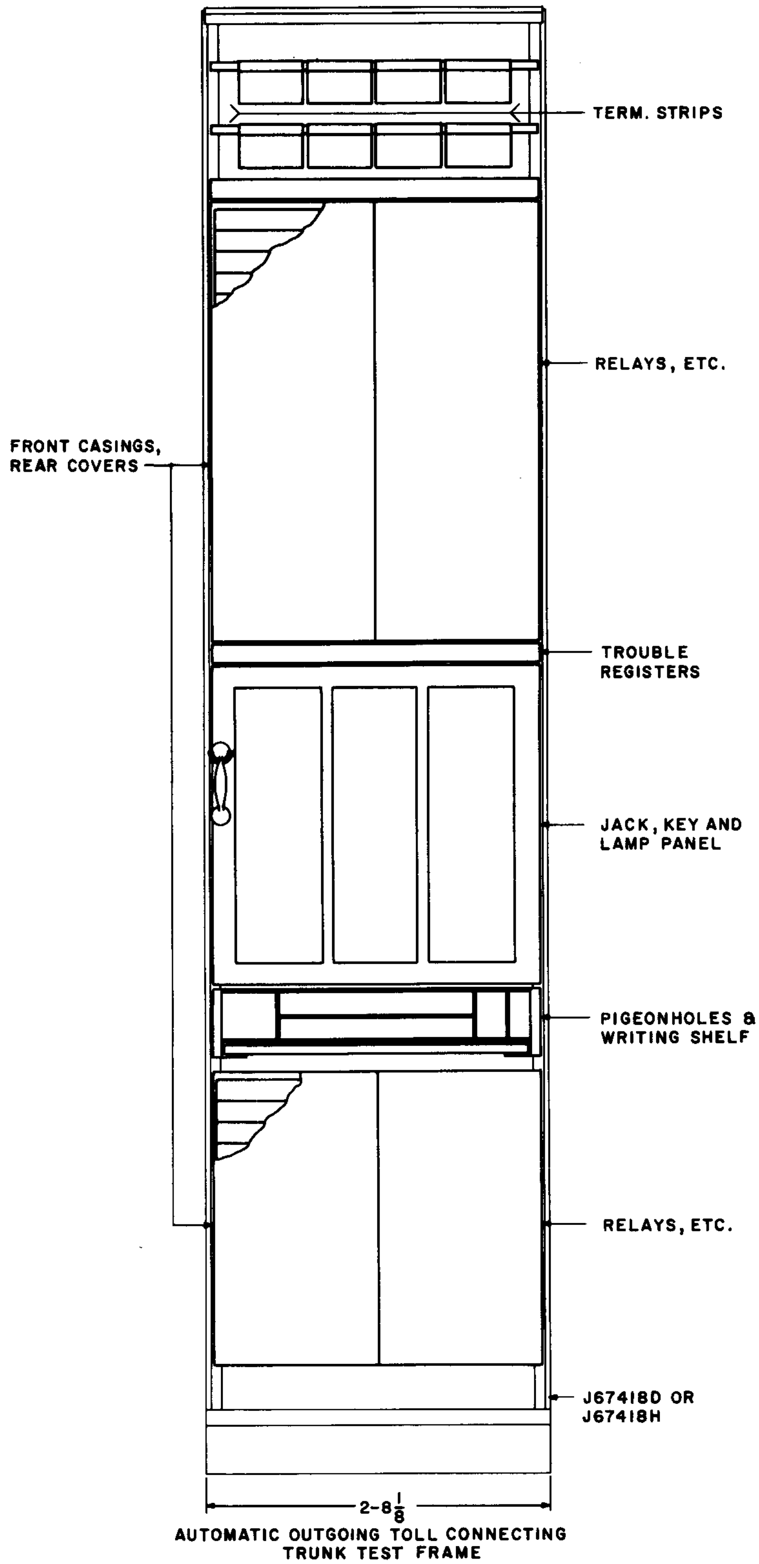


Fig. 55—Automatic Outgoing Toll Connecting Trunk Test Frame (AOCT in 4A Offices or ATCT in 4M Offices) (5.53)

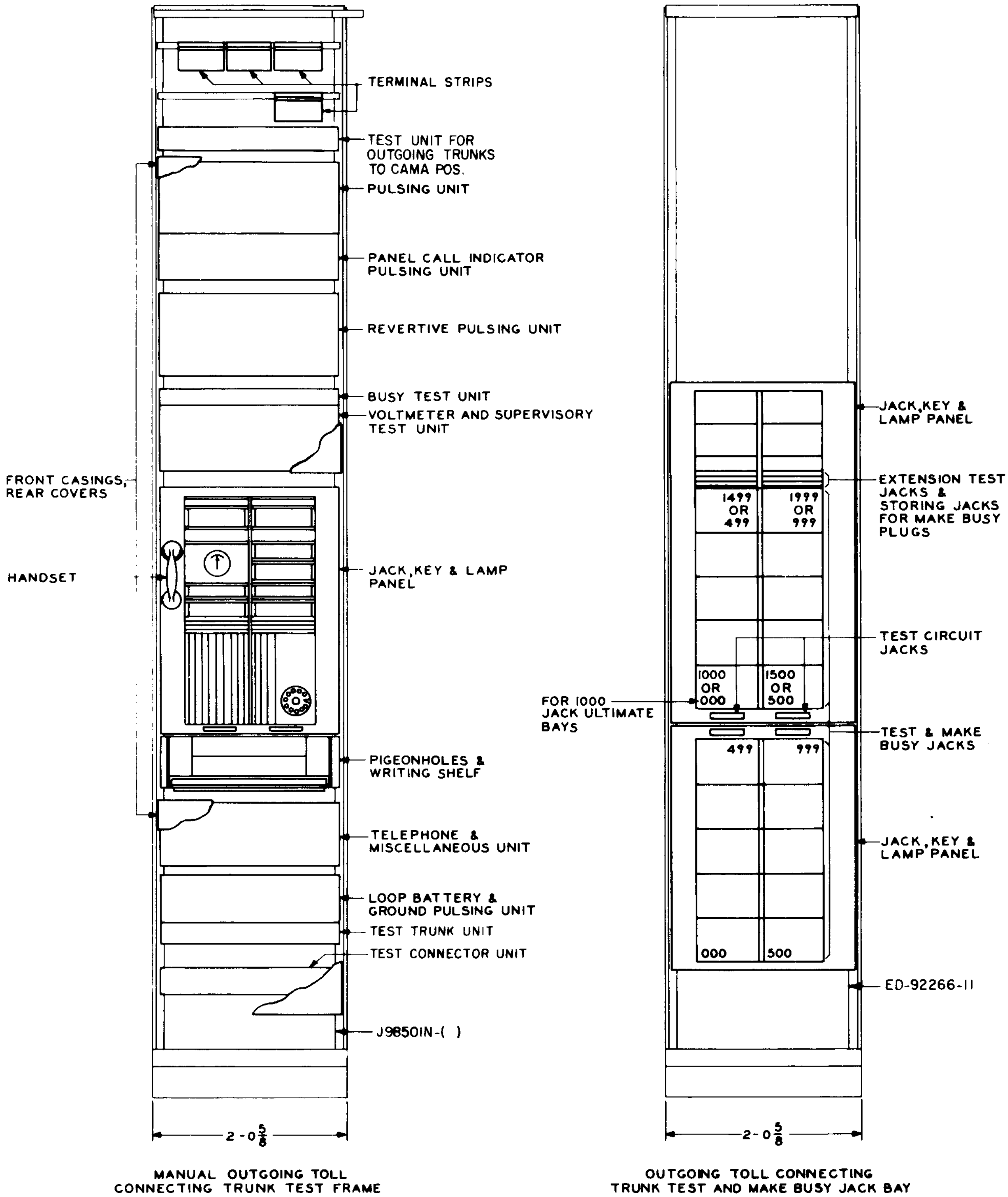


Fig. 56—Manual Outgoing Toll Connecting Trunk Test Frame (5.73)

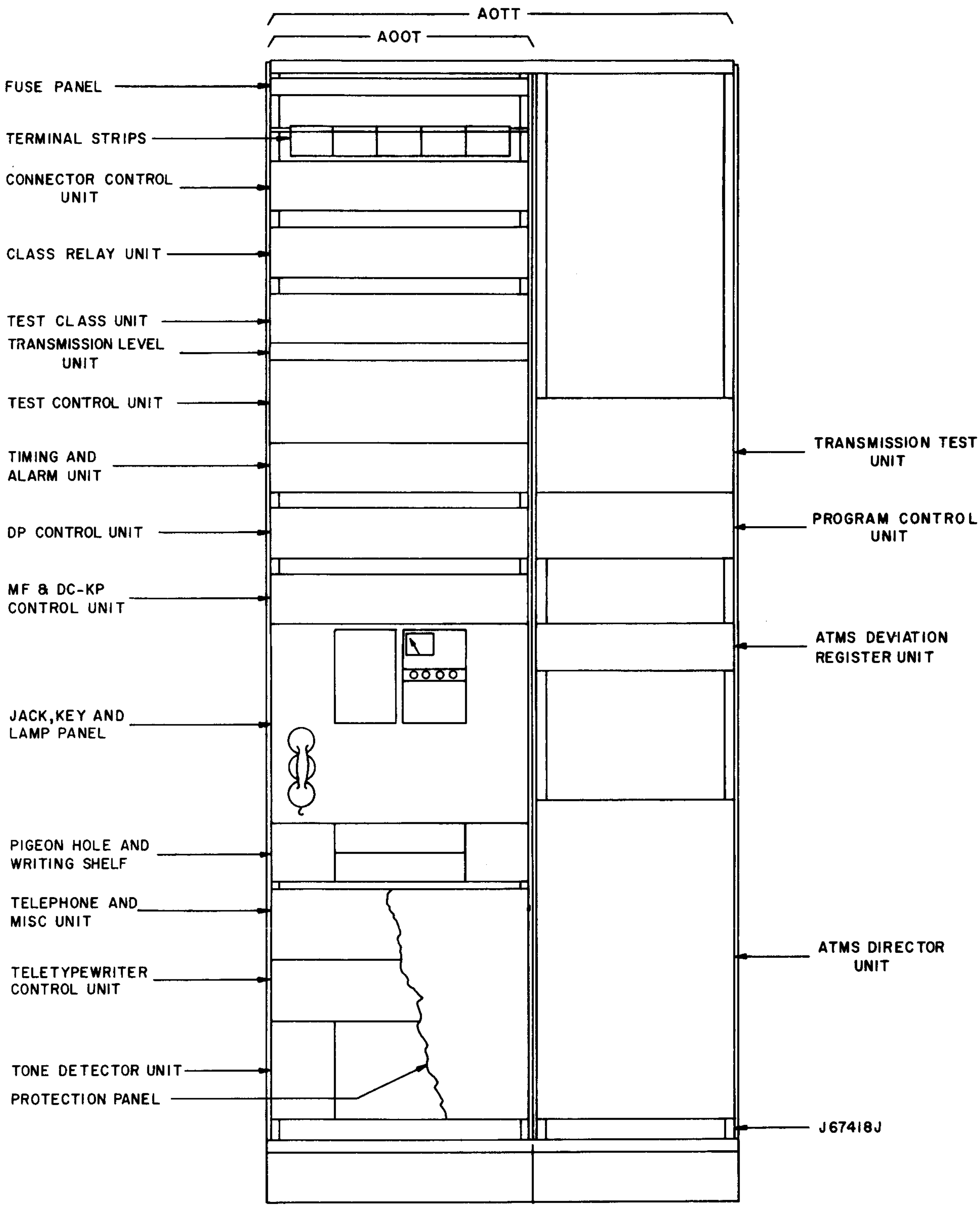


Fig. 57—Automatic Outgoing Toll Connecting Trunk Operational and Transmission Test Frames (AOOT and AOTT) (5.77)

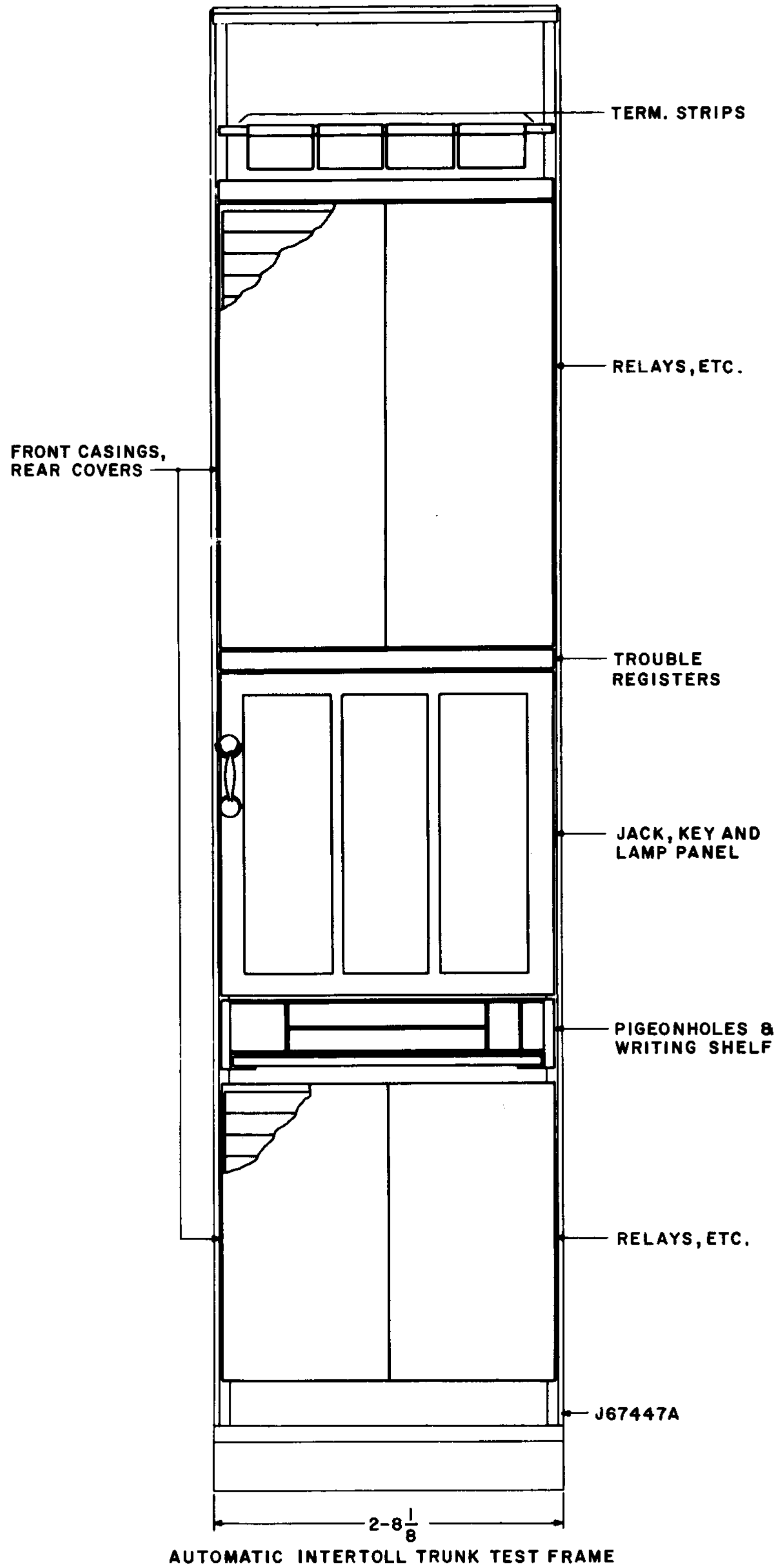


Fig. 58—Automatic Outgoing Intertoll Trunk Test Frame and Associated Transmission Test and Control Frame (5.104)