

**SWITCHING SYSTEMS MANAGEMENT
 CROSSBAR TANDEM SWITCHING SYSTEM
 SYSTEM DESCRIPTION**

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1. GENERAL

1.01 This section describes the crossbar tandem switching system. It covers the system both as a switching system for traffic between local dial offices in the same metropolitan area and as a toll switching system for intertoll traffic.

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 Crossbar tandem equipment is arranged to provide for the switching of calls between central offices situated within cities, between these offices, and those in surrounding exchange areas, and between different offices in the surrounding area. It may also be used to complete inward toll calls to these central offices and likewise to complete outward and through switch calls to other toll centers and their tributaries.

1.05 In addition to its function as a switching facility, the crossbar tandem may be arranged through the application of centralized automatic message accounting (CAMA) equipment to automatically record billing information for multiunit and toll calls. This permits customer dialing of these calls from panel offices where no automatic message accounting (AMA) facilities are available for the local offices, as well as from No. 1 and No. 5 crossbar and step-by-step without AMA in the local offices, and for 4-party and other multiparty customers in these offices for which no AMA facilities are available in the local offices.

1.06 Crossbar tandem also provides for registration of zone or multiunit calls originating at panel offices by means of remote control zone registration trunks at the tandem office. This feature materially reduces the expense of zone registration service in those panel offices where this service was not provided for at the time of installation.

1.07 Crossbar tandem arranged for TSP/S operation provides a means for extending customer direct distance dialing (DDD) to include customer dialing of special toll calls, coin distance dialing (coin DD), and local and toll dial assistance originated as dial zero calls.

1.08 The toll crossbar system is essentially a relay system. The two most distinguishing features of the crossbar system are the crossbar switch which is used for all major switching operations, and the common control system which is used in the establishment of all connections throughout the office.

1.09 Common control means that the switches in the talking connections are set up by certain equipment units which are common to all the switching frames in the office. A common control system has the ability to store and reuse digits which are pulsed into it by a dial or key set. Common control equipment is released and ready to serve another call as soon as a talking connection is established.

2. SWITCHING PRINCIPLES

A. General

2.01 The function of the crossbar tandem system is to switch calls received on incoming trunks (incoming traffic) to various kinds of outgoing trunks (outgoing traffic). The maximum capacity of a crossbar tandem office is 6400 incoming trunk terminations and 6000 outgoing trunk terminations. The following paragraphs describe how any incoming trunk can reach any outgoing trunk.

2.02 The incoming trunks appear on trunk link frames and the outgoing trunks on office link frames. As shown in Fig. 1, these frames are connected by junctors through a junctor grouping frame.

2.03 Each basic trunk link frame consists of two bays of crossbar switches, a primary bay and a secondary bay, which are connected by trunk links. As shown in Fig. 2A, the incoming trunks appear on the primary switches and the junctors on the secondary switches.

2.04 Similarly, each office link frame consists of two bays of crossbar switches, a primary bay and a secondary bay, which are connected by

office links. As shown in Fig. 2B, the junctors appear on the primary switches and the outgoing trunks on the secondary switches.

2.05 Each path or channel through an office consists of a trunk link, a junctor, and an office link connecting an incoming trunk to an outgoing trunk (Fig. 3). Before discussing the switching principles in detail, a description of the crossbar switch is given because an understanding of its operation is essential to an understanding of the system as a whole.

B. Crossbar Switch

2.06 The crossbar switch is an electrically operated relay mechanism consisting of ten horizontal paths and ten or twenty 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. A switch with ten vertical paths has 100 crosspoints and is called a 100-point switch. A switch with twenty vertical paths has 200 crosspoints and is called a 200-point switch. Figure 4 shows a partial perspective view of a crossbar switch. Crossbar switches are used on trunk link frames, office link frames and sender link frames.

Horizontal Paths

2.07 There are five selecting bars mounted horizontally across the front of each switch. Each selecting bar has flexible selecting fingers attached to it; one finger for each vertical path. Each of these selecting bars has a flexible selecting finger for each vertical path. The bar can be slightly rotated by the select magnet to cause the fingers to go either up or down. This arrangement provides two horizontal paths per bar for a total of ten horizontal paths.

Vertical Paths

2.08 Ten or twenty vertical units are mounted on the switch and each unit forms one vertical path. Each unit operates under control of a hold magnet and has ten groups of contacts (one for each horizontal path) associated with it.

2.09 Each group of contacts may consist of three to six pairs of contact springs. A switch is classified according to the number of crosspoints

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and pairs of springs; for example, a 200-point, 5-wire crossbar switch.

Operation of the Crossbar Switch

2.10 The normal position of the select fingers is horizontal, lying between two groups of contacts. When a select magnet operates, the selecting bar is partially rotated either up or down, depending upon which horizontal path has been chosen. The selecting fingers now lie in front of a group of contacts.

2.11 The hold magnet of the vertical path to be connected to this horizontal path then operates its holding bar which, using the selecting finger as a wedge, causes the group of contacts beside the selecting finger to operate, thus connecting the horizontal and vertical paths. Both the select and hold magnets must be operated in order to close a cross-point. The other groups of contacts on this vertical unit do not operate since there is no selecting finger between them and the holding bar.

2.12 After the operation of the hold magnet, the select magnet releases, returning the horizontal bar and all but one of the selecting fingers back to normal. The finger used to establish the connection, being flexible, remains wedged against the contacts by the holding bar and in this way keeps the contacts operated. When the hold magnet releases, the connection is released and the selecting finger returns to normal.

Split Switches

2.13 A crossbar switch usually has all of the vertical units strapped on the horizontal side making ten horizontal paths; as shown in Fig. 5.

2.14 In a split switch, this horizontal strapping is cut in order to provide more than ten horizontal paths. For example, as shown in Fig. 6, a switch can be split between the tenth and eleventh verticals. This provides ten more horizontal paths on the switch.

C. Trunk Frames

2.15 The first equipment of major importance used in establishing a call is the incoming trunk. Incoming trunks (trunk circuits) are mounted on trunk frames. Normally, all the trunk circuits

appearing on a trunk frame are of the same type, each frame being designated according to the type of trunk circuit mounted on the frame. The number of circuits on each frame is governed by the physical size of each circuit. Trunk frames have a capacity of from 10 to 60 circuits depending upon the type (repeated supervision, through supervision, simplex or composite supervision, etc). Each trunk circuit has two permanently cabled terminations in the crossbar tandem. One is on the horizontal of the primary crossbar switch of a trunk link frame, and the other, on the horizontal of the crossbar switch of a sender link frame. The cabling of the trunk circuits to the trunk link frame will be discussed first, and the cabling to the sender link frame will be covered under the discussion of the sender link frames.

D. Trunk Link and Trunk Link Extension Frames

General

2.16 The incoming trunks are terminated on crossbar switches mounted on trunk link frames. A basic trunk link frame consists of two bays, a primary bay and a secondary bay, which are connected by trunk links. Each bay consists of ten crossbar switches. The maximum capacity of a frame is 160 incoming trunk terminations and 200 junctors. (Traffic factors usually limit the frame to something below 160 working trunks.) The maximum capacity of an office is 20 frames which provide terminations for 3200 trunks and 4000 junctors when extension frames are not used.

2.17 A trunk link extension frame is a single-bay frame corresponding in size to the primary bay of the trunk link frame. Each bay accommodates ten 200-point, 6-wire switches, providing for a maximum of 160 trunks to which the trunk links are given access by a multiple between the primary and extension primary switches. By using a trunk link extension frame, the capacity of the trunk link frames in a crossbar tandem office can be increased from 3200 to 6400 terminations as shown in Fig. 7.

Primary Bay

2.18 The primary bay consists of ten 200-point, 6-wire switches which provide terminations for 160 trunks and 200 trunk links. Each switch terminates two trunks on each of eight of its horizontals and one trunk link on each of the 20

verticals. Figure 8 shows the distribution of trunk links.

2.19 As shown in Fig. 9, the 6-wire switches are so arranged that two 3-wire trunks terminate on each of the horizontals 2 through 9. On a given horizontal, one trunk is connected to the even appearance, which is one set of three wires of the horizontal multiple, and the other trunk is connected to the odd appearance, which is the other set of three wires of the horizontal multiple.

2.20 Each vertical consists of six wires, three of which are associated with an even trunk and three with an odd trunk. Each trunk link consists of three wires which may be connected to either set of three wires in the vertical.

2.21 Each connection through a primary switch requires two select magnet operations. A select magnet associated with one of the horizontals 2 through 9 must be operated to connect a pair of trunks to a vertical, and either select magnet 0 or 1 must be operated to connect a trunk link to one of the two sets of three wires of the vertical, thereby connecting to one of the pair of trunks.

Secondary Bay

2.22 The secondary bay consists of ten 200-point, 3-wire switches which provide terminations for the 200 trunk links from the primary bay and 200 junctors to the office link frames. Referring again to Fig. 8, it can be seen that the secondary switches are split in half. This provides twenty horizontals on each switch for terminating 20 trunk links. Each switch also provides 20 verticals for 20 junctors.

E. Office Link Frame and Office Link Extension Frames

2.23 An office link frame consists of two bays, a primary bay and a secondary bay, which are connected by office links. Each bay consists of ten crossbar switches. Each frame has a capacity of 100, or 200 with split switches, outgoing trunk terminations and 200 junctors.

2.24 The trunk termination capacity of an office link frame can be increased to 200 by the addition of an extension frame. The office links between the primary and secondary bay are multiplied to the extension frame as shown in Fig. 7. Twenty

frames, with extension frames, provide a capacity of 4000 outgoing trunk terminations and 4000 junctors.

2.25 The trunk termination capacity of a frame can be increased to 300 by using two extension frames. Twenty frames, with two extension frames, provide the maximum capacity of 6000 outgoing trunk terminations.

2.26 The secondary bay consists of ten 200-point, 3-wire switches which provide terminations for 200 office links and 100 outgoing trunks. (As mentioned in 2.24 and 2.25 the trunk termination capacity can be increased to 200 or 300 by the addition of one or two extension frames consisting of ten additional switches each.)

2.27 As shown in Fig. 10, each switch terminates one trunk on each of the ten horizontals and one office link on each of the 20 verticals. If an extension frame is provided, the verticals of each switch are multiplied to the corresponding verticals of the corresponding switches on the basic frame

Primary Switches

2.28 The primary bay consists of ten 200-point, 3-wire switches which provide terminations for the 200 office links from the secondary bay and 200 junctors to the trunk link frames. Referring again to Fig. 10, it can be seen that the primary switches are split in half, thus providing 20 horizontals per switch on which terminate 20 office links. Each switch also provides 20 verticals for 20 junctors.

F. Junctor Grouping Frame

2.29 As described previously, each trunk link frame and each office link frame has terminations for 200 junctors. These junctors are cabled to a junctor grouping frame where they are cross-connected in groups between the various trunk link and office link frames.

2.30 Crossbar tandem offices may vary in size theoretically from two trunk link frames and two office link frames to 20 trunk link frames with a trunk link extension frame and 20 office link frames with two extension frames. The junctor grouping frame, therefore, has a maximum capacity of 4000 junctors.

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2.31 The junctors between a particular trunk link frame and a particular office link frame are called a group. The number of junctors in a group varies with the size of the office, becoming fewer as the size of the office and the total number of junctors increase.

2.32 The maximum number of junctor terminations available for each junctor group can be determined by dividing the 200 junctors from a trunk link frame by the number of office link frames. The maximum number of junctors, however, is not always cross-connected at the junctor grouping frame, because in the smaller offices the junctor groups are large (and more efficient) and not all of the junctors are required to carry the traffic.

2.33 Since not all of the junctors are required to carry the traffic, some new offices use less than the maximum number of junctors in a group, so that when two trunk link and two office link frames are added, few or none of the existing cross-connections will have to be changed.

2.34 This can be best understood from an example. Figure 11 shows an office with four trunk link and four office link frames. The 200 junctors from a trunk link frame are divided into four groups of 30 each which are cross-connected to the four office link frames and a group of 80 which is terminated but not cross-connected.

2.35 The maximum number of junctors available for a group is 50 ($200 \div 4$). Only 30 are used, however, so that when the office grows to six trunk link and six office link frames, as shown in Fig. 12, none of the existing cross-connections will have to be changed. Sixty of the terminated but previously not cross-connected 80 are now cross-connected to the two new office link frames (30 each) leaving 20 still not cross-connected.

2.36 When two more trunk link and office link frames are added, the number of junctors in a group is reduced to 25 ($200 \div 8$). In this case, five junctors must be removed from each of the six groups. These 30 junctors, along with 20 unassigned junctors, are then assigned, 25 each, to the two new office link frames.

2.37 As mentioned in 2.35, in an office that has grown to six trunk link frames and six office link frames, there are 30 junctors in a group. When an office is initially installed as a 6-by-6

office, only 25 junctors in a group are used. In this case, the growth to 8-by-8 can be made without changing existing cross-connections.

2.38 Table A shows the number of junctors that are cross-connected in each size office, both for new offices and for offices after additions.

Note: The number of trunk link frames may not always equal the number of office link frames. If the numbers are not equal, the larger number is used in determining the pattern. The marker is arranged to test only 20 channels or junctors at one time. In offices where there are more than 20 junctors available, the marker will keep testing, in succession, the different subgroups of junctors that are available until an idle channel has been found or until all have been found busy. Each of these different subgroups of junctors is known as a "junctor test choice," of which there are five.

G. Channels

2.39 A channel consists of a trunk link, a junctor and an office link which connect an incoming trunk to an outgoing trunk. The minimum number of channels provided for connecting a particular incoming trunk and a particular outgoing trunk is 10 for a maximum 20-by-20 size office. The interconnection of the primary bay and the secondary bay is such that every incoming and every outgoing trunk is crossed by 20 links which give each access to 200 junctors. In a maximum size office, the 200 junctors from each trunk link frame are allocated equally to each of the 20 office link frames. This limits the number of channels to 10 in this size office. Since an incoming trunk and an outgoing trunk never have access to more than 20 links, the smaller size offices which have more than 20 junctors, reuse these links when testing over 20 channels.

2.40 Figure 13 shows the 11 channels between a particular incoming trunk and a particular outgoing trunk in an office equipped with 18 trunk link frames.

2.41 On the trunk link frame, the incoming trunk has access to the 20 half switches on the secondary bay. Since for this size office there are 11 junctors in a group, 11 of these secondary half switches will have access to the desired office link

frame. The junctors from these 11 secondary switches terminate, one each, on 11 primary half switches of the office link frame. Each of these primary switches has access to the secondary switch which terminates the desired outgoing trunk.

3. METHOD OF OPERATION

3.01 This section describes the method of operation on typical calls. The crossbar tandem receives calls on incoming trunks from various types of local offices, other toll crossbar offices and toll switchboards. It connects a proper type of sender for inpulsing and records the pulses in the sender. Certain data is transmitted from the sender to the marker. The functions of the marker are to decode or translate the numbering plan area (NPA), or office code, send outpulsing information back to the sender, locate the desired outgoing trunk group, test for an idle trunk, test for an idle path from the trunk link frame to the proper office link frame, mark the channel, and finally test for crosspoint closure of the channel paths. When the outgoing trunk has been seized, the sender outpulses the required digits to the next office. One call is described in detail to introduce the equipment elements and to show their interrelationship as illustrated in Fig. 14. The remaining calls are described briefly merely to illustrate the types of calls that can be handled by crossbar tandem.

Call Requiring 3-Digit Translation

3.02 As shown in Fig. 14 each incoming trunk as two major appearances in a crossbar tandem office; one on the trunk link frame (used for the talking connection) and one on the sender link frame (used for passing information to the common control equipment). The trunks are arranged in decades on the sender link frame to permit the sender link to provide to the sender information which is common to ten trunks.

3.03 The sender link frame is the first of the trunk appearances to be used. It consists of two sets of crossbar switches, primary and secondary. The incoming trunks appear on the primary switches and the senders on the secondary.

3.04 As soon as an incoming trunk is seized, it signals a sender link controller (connection 1) to connect an idle sender for registering the incoming pulses. The sender link controller tests

for and selects an idle sender (connection 2). The controller then sets up the connection through the crossbar switches of the sender link (connection 3). This completes the function of the sender link controller which releases from the connection and is free to serve other calls.

3.05 As soon as the sender is attached, it signals the originating operator or preceding office sender to begin pulsing. When enough digits are received to enable the marker to select an outgoing trunk, the sender signals the marker connector (connection 4) to seize an idle marker (connection 5).

3.06 When the marker is connected, the sender passes the trunk link frame number, class of service, and code digits to the marker. Using these indications, the marker determines the routing information and passes the outpulsing instructions to the sender.

3.07 The marker then seizes the office link connector that has access to the pair of office link frames on which the proper outgoing trunk group is terminated (connection 6). As soon as it is connected to the pair of office link frames, the marker does two things simultaneously. It seizes the trunk link connector that serves the trunk link frame on which the incoming trunk is terminated (connection 7) and starts testing for an idle outgoing trunk as described in 3.08. (The marker knows the number of the trunk link frame from information stored in the sender which was obtained from cross-connections associated with the sender link decade arrangement). The marker then instructs the incoming trunk through the sender to connect to the trunk link connector (connection 8), which in turn cuts through to the marker the test leads associated with the trunk links that serve the switch on which the incoming trunk is terminated.

3.08 When the pair of office link frames is seized, the marker also starts testing for an idle outgoing trunk as mentioned in 3.07. At this point, the marker signals the sender to release the marker connector which in turn releases the marker. This completes the first or decoding stage of the marker operation. The marker connector is now free to serve other calls. The marker may also serve another call but only up to the point where the outpulsing instructions are passed to the sender. For the call in progress, the marker maintains a

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path to the sender via the trunk link connector, the incoming trunk, and the sender link (connections 7, 8, and 3).

3.09 As soon as the outgoing trunk is seized and made busy, the trunk selection relay in the marker tells it whether the trunk is located on the even or odd office link frame. The marker then tells the trunk link frame to cut through the test leads associated with the junctors to that office link frame.

3.10 The office link frame cuts through to the marker the test leads associated with the office links serving the selected outgoing trunk.

3.11 The marker now has access to the test leads for the trunk links, junctors, and office links, and it proceeds to set up the connection from the incoming trunk to the outgoing trunk. It makes the channel test by testing groups of three leads simultaneously, selects one group, and then closes the crosspoints to establish the selected channel (connection 9). The marker tells the sender that the path has been established and then releases from the trunk link and office link frames.

3.12 The sender then sends a seizure signal forward and outpulses as it had been directed by the marker. After outpulsing is completed, the talking path is cut through. The sender and sender link then release and the call is under control of the incoming trunk.

3.13 When the incoming trunk receives a release signal from the calling end, it releases the switches through the office.

Call Requiring 6-Digit Translation

3.14 A call requiring 6-digit translation follows the same method of operation as described above for a call requiring 3-digit translation up to the point of marker seizure. The sender classifies the call as being area or nonarea before calling in a marker.

3.15 When the sender has registered all digits from the distant office, it connects to a marker and passes the first 6 digits (area and office code) to the marker. Translation of the area code by the marker results in grounding a code point which operates the area relay corresponding to the area called. The operation of this area relay

causes the associated translator to be called in (connection 5A).

3.16 The marker passes the fourth, fifth, and sixth digits (office code) and area indication to the translator which translates them to one of 60 route indications. The marker uses indications to determine the routing information and the call is completed as described above.

Remote Control Zone Registration

3.17 The calls described above involved no charging functions at the crossbar tandem. All charging was handled at the originating offices. Crossbar tandem can also handle calls where the message registers at the local office are controlled by signals from the crossbar tandem equipment. This is known as remote control zone registration.

3.18 Calls using remote control zone registration are handled by revertive pulsing trunks and senders. The trunks have options for various initial and overtime intervals and for various numbers of registrations for the initial and overtime periods. A trunk may be arranged for one or two rates. To indicate more than two rates, separate trunk groups to tandem must be used. Where a trunk is arranged for two rates, the marker examines the called code and determines which rate is to be applied.

Coin Zone Dialing with Operator Assistance

3.19 Crossbar tandem handles coin zone calls with the assistance of a traffic service position (TSP/S) operator. This type of call is dialed by a customer at a coin station and is routed to crossbar tandem by the local office. A TSP/S operator is called in to request and monitor the initial deposit and to time the overtime on calls which exceed the initial charge period.

Centralized Automatic Message Accounting (CAMA) Features of the Crossbar Tandem

3.20 Figure 15 shows, in block diagram form, the equipment involved on a CAMA call. The trunk link frame, office link frame, outgoing trunks, sender link and controller, sender, marker connector and marker are used to set up the connection in exactly the same way as described previously for a non-CAMA call.

3.21 The position link and controller, CAMA switchboard, call identity indexer, transverter, billing indexer, recorder, perforator, master timer, and associated connectors are involved on all CAMA calls. Their overall function is to provide the billing information for the calls. In some offices the CAMA billing function is provided using a commercial computer arrangement known as CAMA-C.

3.22 The CAMA trunk circuit appears on the trunk link frame and sender link frame, the same as a non-CAMA trunk. It also appears on a call identity indexer whose function is to provide the trunk identification data (call identity index) for the billing tape.

3.23 CAMA trunks from step-by-step offices are also terminated on an incoming register link frame whose function is to attach an incoming register to the trunk. Register link frames, registers and sender-register connectors (or data transfer circuit) are required only for these step-by-step CAMA trunks.

3.24 Since all digits on a CAMA call from a step-by-step office are sent directly to the crossbar tandem, a rapid means of connecting the CAMA trunk to a digit storage unit is required. Since the sender link frame may require several seconds to connect a sender, it might not be attached soon enough to receive all of the digits being dialed.

3.25 Therefore, a 3-digit (or 10-digit) incoming register is provided to temporarily store the first 3 (or all) digits immediately following the directing code (1). The trunk is connected to the incoming register through the fast operating incoming register link frame (connections 1a and 1b). While the 3-digit incoming register is recording the first 3 digits, the sender link frame and controller are attaching the sender. The 10-digit register, however, does not seek a sender until all digits are registered.

3.26 When the A, B, and C digits have been received by the 3-digit incoming register, and a DP sender is attached to the trunk, the sender-register connector connects the register to the sender (connections 1e and 1f). When the connection is completed, the register transfers the A, B, and C digits simultaneously into the A, B, and C registers of the sender. The register link frame, register and sender-register connector are then released to handle other calls, and the remaining digits are dialed directly into the sender as on a

non-CAMA call. The above equipment is not required on trunks from a No. 5 crossbar office. The senders in No. 5 offices are arranged to wait for a start-dial signal from the crossbar tandem office sender before outpulsing any digits.

3.27 Ten-digit incoming registers do not use sender-register connectors. They receive all of the digits dialed, and when registration is complete, the digits are passed to a *multifrequency (MF) sender* through a data transfer circuit. However, for purposes of illustration this data transfer circuit and the sender-register connector can be considered as performing the same function, ie, providing a channel for the incoming register to transmit the digits it has received to a sender.

3.28 When the sender has received three digits, it signals its marker connector to seize an idle marker (connections 2a and 2b). The sender, assuming DP outpulsing is required, then gives the marker the information necessary to select an outgoing trunk and establish a transmission path through the office. The marker selects an idle outgoing trunk (connection 3) and an idle channel (connections 3 and 4) and sets up a connection between the incoming trunk and the outgoing trunk. The marker gives the sender outpulsing instructions and releases leaving the sender in control of the transmission path. As explained later, two marker seizures are required if outpulsing is on an MF basis.

3.29 After the called number is registered on operator number identification (ONI) calls, the sender calls in the position link frame (connection 5a) which in turn seizes an idle CAMA position (connection 5b) and connects it to the sender. The position link and controller frame which is described more fully later, is similar to the sender link and controller frame.

3.30 A CAMA position is automatically selected, and connected to the trunk and the operator receives a tone and lamp signal, indicating that there is a call. The operator requests the number of the telephone from which the subscriber is calling. The operator then keys this number into the sender.

3.31 On automatic number identification (ANI) calls, the sender signals the local central office equipment to furnish the calling number when the calling number has been registered. The

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CAMA position and position link are not required for these calls.

3.32 Both the called and the calling telephone numbers have now been stored in the sender, and by this time the marker has completed its work and has been released. The channel has been established, connecting the incoming trunk to the outgoing trunk, and the sender has received its outpulsing instructions. The sender proceeds with its outpulsing as on a non-CAMA call except that on a CAMA call the sender cannot outpulse the last digit until the initial entry has been made on the tape. This insures that the answer entry does not precede the initial entry, since the called subscriber cannot be connected until the last digit is outpulsed. Where the dial pulse sender is required to outpulse on an MF basis a slightly different method of operation is required. On the first, the marker identifies the trunk to the sender, but it does not set up the channel through the office. When the operator keys the first digit of the calling number into the sender, the marker is called in a second time, the trunk is seized, and a connect signal is sent to the distant office. In either case, the transverter, billing indexer, recorder-perforator, and call identity indexer are now brought into play to make the initial entry on the tape.

3.33 The transverter is connected to the sender by a transverter connector (connections 6a and 6b) after the sender has registered the called and calling numbers. The transverter receives from the sender the necessary items of information such as the recorder number, called and calling office codes, etc. After checking that this information is complete, the transverter transmits this information to the billing indexer (connection 7) by the billing indexer connector (which is a part of the transverter frame). The billing indexer, through its cross-connections, determines the other information needed by the transverter for the initial entry. The information which the billing indexer furnishes the transverter is the message (billing) index number, office index and type of initial entry. When the transverter has received all of the necessary information on an operator number identification (ONI) call, it signals the sender to release the CAMA position since the position would not normally be required again for this call.

3.34 The transverter now has all of the information necessary for the initial entry of the call.

This information is transmitted via the recorder-connector (connections 8a and 8b) to the recorder and associated perforator for perforation of the initial entry or for computer storage in the case of CAMA-C. During perforation the call identity indexer is called in (connections 9 and 10) to identify the CAMA trunk. When the initial entry is completed, the transverter signals the recorder that the initial entry is complete. This signal is relayed to the incoming CAMA trunk (connections 9 and 10) from the recorder and tells the trunk that the call should be charged for if answered, ie, answer entry should be made. The recorder also sends a release signal back to the sender, and the sender then outpulses the last digit to complete the call. Normal crossbar tandem operation follows, passing control of the channel back to the CAMA trunk when the sender releases.

3.35 When the answer is recognized by the trunk the call identity indexer is seized again (connection 9), registering the trunk number (call identity index). The recorder (connection 10) associated with this call identity indexer perforates the answer entry, which includes the time and the CAMA trunk number.

3.36 The normal disconnect entry will be perforated in a similar manner to that of the answer entry and includes the same information. If for some reason the calling party does not hang up, the trunk starts timing, and if the calling customer has not disconnected by the end of the timing period, the outgoing trunk is released and a "timed release entry" is made on the tape. An adjustment for the time required for the trunk time-out is made on the call.

4. FUNCTIONS OF PRINCIPAL EQUIPMENT ELEMENTS

4.01 In Part 3, the equipment elements were named and a description was given of the part each element played in switching a call. Each element will now be described more fully with emphasis being placed on the how and why of the functions.

Switching Frames and Their Connectors

4.02 The incoming trunk appearances, used in the talking connection, are on the trunk link frames and the outgoing trunk appearances on the office link frames. The trunk termination

capacities of these frames were discussed in Part 2.

4.03 As described in Part 2, the primary and secondary switches of both the trunk link and office link frames are connected by links, and the trunk link and office link frames are connected by junctors.

4.04 The marker gains access to the trunk links and junctors for testing purposes through a connector mounted on the trunk link frame. It gains access to the office links through a connector on the office link frame.

4.05 There is one connector on each trunk link frame. Simultaneous connection to two or more markers is prevented by the use of a marker preference circuit. Each connector contains two preference circuits, a regular and an emergency circuit. Either of these may be used to control the connection in normal operation. When trouble occurs, an automatic throw-over transfers control to the other circuit which remains in control until action is taken by the maintenance force.

4.06 A marker must connect to a pair of office link frames in order to test for idle outgoing trunks. Each frame has one connector and one marker preference circuit. The preference circuit of either frame may be used to control the connection to a pair of frames. When trouble occurs, an automatic throw-over transfers control to the other circuit which remains in control until action is taken by the maintenance force.

4.07 As mentioned previously, the outgoing trunks appear on the office link frames. Since the marker can test up to 40 trunks at a time, the outgoing trunk groups are divided into subgroups of 40 or less trunks. Each subgroup of outgoing trunks is assigned to a pair of office link frames. In this way, the marker can gain access to all of the trunks in a test group by connecting to a pair of office link frames through one connector.

4.08 When there are 40 trunks in a subgroup, these trunks are assigned to two horizontals on each of the 20 switches on a pair of frames. When a connector is seized by a marker, the marker furnishes it with a number corresponding to the two horizontals on which the test group is terminated. The connector then cuts through 40

test leads to the marker corresponding to the trunks on these levels.

4.09 When there are less than 40 trunks in a subgroup, the connector still cuts through 40 leads to the marker, but the marker tests only those associated with the trunks in the subgroup.

4.10 The trunk group busy circuit, by means of detecting relays, recognizes the condition that all trunks in a group are busy. This allows reduced marker holding time by allowing the markers to route calls directly to overflow without waiting for a time-out. As long as this condition exists, a group busy signal is sent to the marker circuits and an associated no circuit (NC) lamp is lighted on the traffic supervisory cabinet. When this circuit is associated with a 2-way trunk group arranged for directional reservation, the trunk group busy signal may be initiated by the directional reservation circuit. When associated with the dynamic overload control circuit, the trunk group busy signal may be initiated by the dynamic overload control circuit. Each group busy circuit serves a marker testing group of trunks which may contain up to 80 trunks.

Sender Link Frames

4.11 At the sender link frame, senders are attached to incoming or 2-way trunks. Each frame has terminations for 100 trunks and 40 senders of each of two types.

4.12 Each sender link frame consists of two units, designated A and B, which operate independently using separate controllers. Each unit contains four 200-point, 5-wire crossbar switches, two primary and two secondary, as shown in Fig. 16. Each trunk has two appearances on a frame, one on each unit. This prevents loss of service in case of failure of a controller.

4.13 The trunks appear on the horizontals of the primary switches and the senders 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 of the proper type on the sender link frame.

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Trunk Appearance on Primary Switches

4.14 As mentioned above, the trunks appear on the horizontals of the primary switches, with each trunk having an A and B appearance. The trunks are connected to like-numbered horizontals on the A and B switches.

4.15 The two switches in each unit are arranged to accommodate 100 trunks. In each unit, the 100 trunks require 200 horizontal terminations because each trunk has ten leads and 5-wire switches are used. In order to get the 200 horizontal terminations, each switch is split after every second vertical (Fig. 17). This split divides the two switches of a unit into 20 pairs of verticals, each being associated with ten horizontals. By this process, each decade of trunks has access to four sender links; the A switches provide two of these links and the B switches provide the other two.

4.16 A maximum of 40 senders of one type or 40 senders of each of two types have appearances on the horizontals of the secondary switches. When 40 senders of one type appear on a frame, the secondary switches are split in half to provide 20 horizontals on each switch. Each of the four switches terminates ten senders. (Two horizontals are required for each sender to extend the ten leads from each link and in turn from each trunk to the sender.)

4.17 When two types of senders appear on a frame, the secondary switches require a further split to provide additional horizontal terminations. For example, referring to Fig. 17, if the 40 trunks comprising trunk decades (0) through (3) were DP trunks and the 60 trunks comprising trunk decades (4) through (9) were MF trunks, the horizontal strapping of each secondary half switch would be split between verticals 3 and 4. The horizontals associated with verticals 0 through 3 would terminate DP senders and the horizontals associated with verticals 4 through 9 would terminate MF senders.

Sender Links

4.18 Each decade of trunks has access to four sender links; two on the A switches and two on the B switches. The sender links associated with trunk decade (3) are shown in Fig. 17. The two links from the A switch terminate one each on the two A secondary switches, and similarly

the two links from the B switch terminate one each on the two B secondary switches. In this way, each trunk has access to 40 senders.

Controller

4.19 When an incoming trunk signals for a sender, a link controller is called in to close the crosspoints on the sender link frame between the trunk on the primary switch and a sender on a secondary switch.

4.20 Each frame has two controllers; an A controller which sets up connections on the A switches and a B controller which sets up connections on the B switches. Since each trunk has an A and a B appearance, each request for a sender may be handled by either controller. However, half of the trunks prefer the A controller and half prefer the B controller.

4.21 Test leads associated with the incoming trunks, sender links, and senders are closed through to the controller which then tests for and selects an idle sender and link and connects the trunk to the sender. The controller then releases itself and is free to serve another call.

Multiplying of Senders to Sender Link Frames

4.22 Each sender link frame provides 100 trunks with access to 40 senders. However, these senders are available to trunks on other frames and in many installations are part of a larger number of senders. In order to insure that all senders serve about the same number of trunks, the senders in an office are divided into subgroups of five senders which are assigned to the frames in a progressive diagonal order. When there are less than eight subgroups in the office, some subgroups will appear more than once on a given frame. This is to insure that all links on a frame are used. When there are eight subgroups, each subgroup serves every frame. When there are more than eight subgroups, each subgroup may serve only some of the frames.

4.23 The multiplying arrangement of the sender subgroups can best be understood from an example. Table B shows the distribution of 11 sender subgroups (55 senders) over nine sender link frames.

Decade Arrangement of Trunks

4.24 As mentioned previously, the incoming trunks are divided into groups of ten. This arrangement not only affords an easy system of terminating the trunks on a sender link frame, it also permits that frame to transmit to the sender information common to the ten trunks in a group. This information consists of the number of the trunk link frame and the class of service as well as several other items of information used for CAMA.

Senders

4.25 The main functions of a crossbar tandem sender are as follows:

- (a) To receive digital information from the operator, customer, or preceding sender
- (b) To receive trunk class information from the sender link
- (c) To transmit the called area code and/or office code and the trunk class information to the marker
- (d) To output digital information as directed by the marker.

4.26 There are several kinds of crossbar tandem senders which differ from each other mainly in digit capacities and types of inpulsing and outputting. Each of the senders receives the type of inpulsing designated by its name. They can be used to complete calls to operators without pulsing.

4.27 Crossbar tandem senders can output (except with battery and ground pulsing) to a link-type or common control office through an intermediate step-by-step office and are arranged to expect a stop signal until the link-type or common control office is ready as signified by the return of a go signal.

MF, DP, PCI, and RP Senders

4.28 The panel call indicator (PCI) sender can register and output a maximum of 8 digits, while the MF and DP senders can register and output a maximum of 11 digits. Each sender can output the called number as received, code convert, or delete the code, as instructed by the

marker. Four types of outputting are available: DP, MF, PCI, or revertive pulsing (RP). The DP, MF, or PCI senders can be arranged for non-AMA operation or combined AMA and non-AMA operation.

4.29 The DP and MF senders can handle operator dialed or customer dialed traffic and can complete these calls either by outputting or on a straightforward basis. They can:

- (a) Complete to either 2-digit TX operators (11XX) or to 3-digit TX operators (11XXX).
- (b) Output the digits as received.
- (c) Skip 1 to 6 digits on 10- or 11-digit calls or 1, 2, or 3 digits on 7- or 8-digit calls.
- (d) Code convert the first 3 digits to 1, 2, or 3 arbitrary digits.
- (e) On 10- or 11-digit calls, skip the first 3 digits and code convert the next 3 digits to 1, 2, or 3 arbitrary digits.
- (f) Prefix 1, 2, or 3 arbitrary digits to 7 or 8 digits received when outputting MF or DP.
- (g) Operate with 6-digit translation.
- (h) On a PCI basis they can output 5 digits to call indicator position.
- (i) On a revertive basis they can output the equivalent of 4 digits to local offices.

4.30 The MF and DP senders are arranged to complete customer dialed calls such as time of day on a straightforward basis, suppressing the last four digits. The PCI sender completes these calls by PCI outputting into an inert digit absorber called the "run down" circuit.

4.31 *Revertive Pulsing (RP) Sender:* The revertive pulsing sender is used for traffic incoming from panel or No. 1 crossbar offices or from keypulsing switchboards in panel or crossbar offices. It can receive two offices selections representing one-out-of-100 office codes which may or may not be followed by four digits. It can output a maximum of six digits on a DP basis or the equivalent of four digits on a revertive basis. When it receives only the office selections, it sets up an outgoing connection thus permitting the

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originating office to complete the call to an operator without pulsing or by PCI pulsing through the tandem sender. In the latter case, the tandem sender releases upon receipt of a final heavy positive pulse which indicates that pulsing is completed.

Intersender Timing

4.32 The intersender timing feature is provided to prevent a shortage of senders in an office ahead from being reflected as a shortage of senders in the crossbar tandem office. When all subgroups of the same type of sender on any sender link frame become busy, the intersender timing is reduced from 20 to 40 seconds to 3, 5, or 8 seconds. Upon time-out, the sender requests an announcement trunk. This timing may be held over for 10, 20, or 30 seconds after some senders become idle.

Marker Connector

4.33 A marker connector connects senders to markers so that information can be exchanged between these circuits. There are two types of connectors; one for use with the DP and MF CAMA senders and one for use with the remaining senders. All connectors have access to the full marker group which consists of a maximum of eight markers. Each connector can serve a maximum of five senders, and each sender appears in only one connector.

4.34 Within any one connector, only one connection can be made at a time. However, as many simultaneous connections as there are markers can be made through different connectors.

4.35 In case of simultaneous demands on a connector by two or more senders, the senders take their turn as determined by their position in a sender preference circuit.

4.36 Each connector prefers markers in a fixed order which differs in the various connectors for the purpose of distributing calls as evenly as possible over a group of markers. To accomplish this, the connectors are divided into as many groups as there are markers in the office and each marker is assigned as first choice marker in one of the connector groups. Second, third, etc, choice markers are assigned similarly in rotation.

4.37 To give each connector approximately equal access to markers during periods of heavy

traffic, a connector, after serving a call, cannot serve another call until all other connectors waiting for markers have each handled one call.

4.38 The marker connector frame has a capacity of three connectors serving a maximum of 15 senders. A maximum of 13 such frames may be provided.

Marker

4.39 The marker is one of the major equipment elements in the crossbar tandem system. It has the following functions:

- (a) Receives the trunk link frame number, class of service, and code digits from the sender.
- (b) Uses this information to determine routing information necessary for routing the call. On calls requiring 6-digit translation, the marker calls in a translator to translate the first three digits following the office code for PBX dialing and office code for foreign area calls before operating a route relay.
- (c) Gives outpulsing instructions to the sender.
- (d) Locates and seizes an idle outgoing trunk.
- (e) Marks an idle path from the incoming trunk to the selected outgoing trunk.
- (f) Closes the crosspoints to establish this channel. This path or channel consists of a trunk link, a junctor, and an office link.

4.40 One of the features of the marker is that it uses 2-stage operation. This arrangement permits the marker to accept a second call before completion of the first. During the first stage of its operation, the marker is connected to the sender via the marker connector. The marker performs functions (a), (b), and (d) above and establishes a second connection to the sender via the trunk link frame, the incoming trunk, and the sender link. When this is completed, the marker connector is released but the second connection to the sender is maintained for the second stage of marker operation during which time the marker performs functions (e) and (f). As soon as the marker connector is released, the marker can receive another call through the same or another marker connector. This second call can advance to the completion of

function (c) of stage one while the first call is still in stage 2.

4.41 Under certain conditions, calls may be completed by a marker on a second trial basis. A second trial may be initiated by a marker or a sender. The marker requests a second trial if it encounters trouble or if it finds all channels busy. It sends a release signal to the sender which attempts to seize another marker and requests completion on a second trial basis. The sender will initiate a request for a second trial if it finds the outgoing trunk open or with polarity reversed, or on flashing received during outpulsing.

Information from Sender to Marker

4.42 The marker receives three types of information from the sender.

- (a) The code digits as dialed or RP digit information.
- (b) Information from the sender link decade arrangement.
- (c) Miscellaneous information.

4.43 Depending upon the type of sender used, the marker can receive the following types of code information:

- (a) Office brush and office group selections—300 codes (This requires three trunk groups.)
- (b) Three-digit office or area codes—1000 codes
- (c) Three-digit area code followed by three-digit office code—maximum of 20 foreign and/or PBX codes
- (d) Two-digit TX codes (11XX)—90 codes
- (e) Three-digit TX codes (11XXX)—300 codes
- (f) Service codes and arbitrary toll codes (OXX and 1XX less 1XX)—190 codes.

4.44 The sender passes to the marker the following information derived from the sender link decade arrangement.

- (a) Trunk link frame number—one out of 20.

- (b) Class of service—one out of a maximum of 21.

4.45 The marker also receives other miscellaneous information from the sender such as:

- (a) First, second, or reorder trial.
- (b) The type of sender initiating the call.
- (c) Whether the call is a test call.

Routing Information

4.46 Routing information is obtained from two wires threaded through inductors in an inductor field. The inductor field consists of nine rows or inductors each row containing from three to seven inductors.

4.47 The routing information consists of the following:

- (a) Outpulsing instructions to the sender
- (b) Location of outgoing trunk group
- (c) Charge information to incoming trunk
- (d) Route advance address to use for the next routing in case all trunks in the outgoing trunk group test busy
- (e) Peg count.

Information from Marker to Sender

4.48 The marker passes the following decoded information, where required, to the sender:

- (a) Type of outpulsing
- (b) Number of digits to outpulse
- (c) Prefixed or code converted digits
- (d) Compensating resistance
- (e) Miscellaneous information such as 2-way outgoing trunk, cancel code conversion, cancel CAMA charge and cancel trunk guard test on straightforward class.

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4.49 The routing information provides the marker with the outgoing trunk group. With this information the marker seizes a pair of office link frames. When connected, a trunk level relay is operated on each office frame, each in turn connecting 20 trunk leads associated with that level or a total of 40 trunk leads for the two frames. The marker searches for an idle trunk and selects the first one it finds.

Locating Incoming Trunk

4.50 The marker has been supplied the number of the trunk link frame when the sender seized the marker. Following the seizure of the office frames the marker seizes the proper trunk link frame. A signal then is sent through the marker connector, sender, and sender link to tell the trunk to indicate the primary crossbar switch in the trunk link frame with which the incoming trunk is associated. The incoming trunk is also told to indicate the select magnets on that crossbar switch with which it is associated.

Seizing an Idle Channel

4.51 The marker now has access to the appearances of test leads for 20 trunk links, 20 junctors, and 20 office links that can be used in combinations as 20 channels to switch this call.

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

- (a) An idle trunk (A link) going to a trunk link secondary switch which has
- (b) An idle junctor (B link) to an office link primary switch which has in turn
- (c) An idle office link (C link) to an office link secondary switch with the seized outgoing trunk.

The marker, when an idle channel is found, operates the select and hold magnets associated with this channel. This establishes the transmission path between the incoming and outgoing trunks.

Junctor Subgroups

4.53 The marker is arranged to test 20 junctors at one time. When a junctor group has more than 20 junctors, it is divided into subgroups of 20 or less junctors.

4.54 For example, in an office with 25 junctors in a group, each group is divided into two subgroups, one of 20 junctors and one of five junctors. When the marker is making channel tests, it first tests the larger subgroup for an idle junctor that matches the trunk and office links. If none is found, the marker "advances" to the other subgroup and repeats the test.

Junctor Pattern Feature

4.55 When testing for an idle channel, the trunk link connector extends up to 20 junctor test leads to the marker. When there are less than 20 junctors in a test group, there is a junctor pattern feature in the marker which automatically simulates a busy for those junctors which are not available for switching the call.

4.56 As an example of this junctor pattern feature, we can again use the case of the office with 25 junctors in a group. The marker tests the first subgroup which consists of 20 junctors. If these are all busy, the trunk link connector extends an additional group of 20 junctor test leads to the marker. Only five of the leads are made available for test. The other 15 are made to test busy by the pattern relays in the marker.

Translator

4.57 The translator is used in conjunction with the marker to select the route by which the tandem office can reach a foreign numbering plan area or private branch exchange (PBX) office. The translator has a capacity of 60 routes to each of 10 different foreign areas of PBX office codes. When 11 or more foreign areas or PBX code translations are required, areas 0 and 10, 1 and 11, etc, respectively, share the 60 routes.

4.58 There are three types of translations.

- (a) Foreign area translation (10- or 11-digit call), used to complete calls to a foreign area by translation of the area code and office code.

- (b) Foreign area translation (7- or 8-digit call), is used to complete calls from a foreign area to the same foreign area by translation of the office code.
- (c) Private branch exchange (PBX) translation (7-digit call) is used to complete calls directed to a PBX extension by translation of the PBX office code and the thousands, hundreds, and tens digit of a 7-digit customer's number.

The translator is always arranged for paired operation with another translator frame. A maximum of four paired frames or a total of eight frames are required to provide 6-digit translation for 20 NXX codes.

Incoming Register and Register Link Frames

4.59 There are two types of incoming registers available for crossbar tandems. The 3-digit register which associates with a DP sender through a sender-register connector, and the 10-digit register which associates with an MF sender through a data transfer circuit.

4.60 The 3-digit incoming register and register link frame is a two-bay frame equipped with two 200-point crossbar switches and three 3-digit registers which may be expanded in increments of one switch or one register to a capacity of ten switches and ten registers (see Fig. 18).

4.61 The incoming CAMA trunks are connected to the verticals of the register link switches, one 200-point crossbar switch being provided for each 20 trunks. The registers are connected to the switch levels (horizontal), and corresponding levels on all of the ten switches of a frame are multiplied together.

4.62 When an incoming CAMA trunk from a step-by-step office is seized it gives simultaneous start signals to the incoming register link circuit and to the sender link and controller circuit, thereby requesting connection to an incoming register and a dial pulse sender. Upon seizure by the incoming CAMA trunk the register link selects a register and returns a register attached signal to the trunk. It does this using by-link operation, which is merely a temporary connection through two preference chain relays, and at this point pulsing may begin even though no crosspoint has been closed to the sender. When the crosspoint

is closed it parallels the chain relay contacts and the chain relays are released. The crosspoint is then held under control of the register.

4.63 The incoming register receives the first three digits from the incoming trunk. When it receives a sender attached signal via the sender-register connector and the incoming trunk, the three digits are passed to the sender-register connector. If a sender is not available by the time the third digit is registered, the register instructs the trunk to return a reorder signal (120 IPM tone) to the customer.

4.64 The 10-digit incoming register link frame consists of ten 200-point crossbar switches. The number of registers provided may vary from a minimum of ten to a maximum of 20, depending on traffic requirements. The 20 trunks on each switch have access to ten registers, and each register is available to trunks on several switches. The access of trunks to registers will vary depending upon the number of registers provided. Therefore, if incoming registers are made busy to control traffic, this must be taken into consideration if more than ten registers are provided in a group. (This applies only to 10-digit incoming registers.)

4.65 In operation, the 10-digit incoming register link frame is similar to the 3-digit. The major differences which should be noted are that it receives and stores all digits dialed and requests an MF sender after all digits have been received.

Sender-Register Connector

4.66 The sender-register connector connects dial pulse senders to 3-digit incoming registers. Each office has four connectors and all connectors have access to the full register group, a maximum of 130 registers. Each connector can serve a possible total of 50 senders.

4.67 When the 3-digit incoming register has received and registered the A, B, and C digits it signals the sender, which was attached by the sender link. The sender then seizes the sender-register connector associated with it, signals the register by the trunk and gives it the identity of the connector. The connector then connects the incoming register to the sender. When the connection between the register and the sender is complete the three digits recorded (A, B, and C) in the register are simultaneously transmitted by

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the connector to the sender. The connector then signals the register to disconnect.

4.68 Within any one connector only one connection can be made at a time. However, all four connectors can be used simultaneously. In the case of simultaneous demands on a connector by two or more senders, the senders take their turn, as determined by a lock-out preference chain.

4.69 As was noted earlier, 10-digit incoming registers do not use sender-register connectors, but require a data transfer circuit to pass information to an MF sender.

Position Link and Controller Frame

4.70 The position link and controller frame is provided to connect the sender to the CAMA position on operator number identification (ONI) calls. It provides a path for the calling number information which will be registered in the sender as keypulsed by the CAMA operator.

4.71 When the local central office has automatic number identification (ANI) equipment, the position link and CAMA position are not required to identify one- and two-party subscriber numbers. These numbers are transmitted automatically upon receipt of a signal from the crossbar tandem sender. The CAMA operator is called in, however, to identify all four- and eight-party lines or when the ANI equipment is not able to identify the calling number on one- and two-party lines because of an equipment malfunction.

4.72 The position link provides access for a maximum of 40 senders through a primary-secondary link arrangement to a maximum of 100 positions. Traffic is distributed on a call distribution basis by two controllers per frame, each of which can simultaneously set up one call at a time. Each position link frame serves a different group of 40 senders, but all link frames have access to all positions.

4.73 The position link frame is a two-bay frame equipped with sixteen 200-point crossbar switches and two controllers. Each bay consists of one controller and eight crossbar switches. Four crossbar switches terminate 40 senders and four crossbar switches terminate a maximum of 50 positions. The senders appear on horizontals of the four lower crossbar switches in the left-hand

bay and are multipled to the four lower crossbar switches in the right-hand bay. The positions appear on horizontals of the four upper crossbar switches in each bay.

4.74 The controller function, generally speaking, is similar to the sender link controller. That is, there are definite preferences for the groups of senders and individual senders much the same as preferences for the groups of trunks and the individual trunks in the sender link controller. To insure equitable distribution of the traffic over the switchboard, the positions are divided into groups and adjacent positions are assigned to different groups. With this arrangement, a controller, in distributing calls over a group, distributes them over separate positions along the switchboard. In some cases, call distributors and preference control circuits are used to distribute calls to idle positions.

4.75 When the controller has selected an idle position the link connection is established, and the controller releases leaving the link under control of the sender circuit. Figure 19 shows a schematic of the position link frame.

CAMA Position

4.76 The CAMA switchboard is of the cordless type consisting of one or more line-ups of two-position sections and a cable-turning section. Figure 20 is a photograph of a switchboard section and the cable-turning section. A maximum of 100 positions may be provided. The CAMA positions may be located at the crossbar tandem switching point or at a remote location. Each position is equipped with the following:

- (1) 10-button key set
- (2) CAMA supervisory lamp (red)
- (3) Reset key
- (4) Position disconnect key
- (5) Calls waiting lamp (white)
- (6) Service assistant call key and lamp
- (7) KP key and KP lamp (green)—remote positions only.

4.77 When the position is connected to the sender by the position link frame, the CAMA supervisory lamp (red) lights and a tone is given to the operator. The operator then asks the calling subscriber for the calling number. Upon receipt of the number, the operator keys it into the sender.

4.78 The KP key is provided at remote positions only. Upon obtaining the calling number, the operator then operates the KP key. When the KP lamp lights, it is an indication that the operator can start keying the calling number.

4.79 The red supervisory lamp mentioned above is lighted at the position as long as it is connected to the sender. This same lamp flashes (120 IPM) if the number keyed by the operator is not accepted as satisfactory by the sender, transverter or billing indexer. The operator receiving the flashing supervisory lamp can press a register reset key at the position and release the sender register relays containing the calling number and key the number again. If the operator makes an error, it is possible to perform the same operation providing the final digit has not been keyed.

4.80 The position circuit is held by the sender, via the position link, until the sender receives a signal from the transverter that the output information of the billing indexer is satisfactory (transverter is ready to start the initial entry). When this signal is received by the sender, the position and position link are released.

4.81 The position disconnect key is provided at each position so the operator is able to free the position if necessary. The operation of this key signals the sender to release the position link and position, and the call is then routed to reorder (ROA).

4.82 A lamp standard that contains a service assistant call lamp and three calls waiting lamps (green, white and red) is furnished for each division of ten positions. The calls waiting lamps indicate the senders waiting for a position. The number of positions waiting is indicated by the lighting of the green, white and red lamps in that order. A multiple of the white calls waiting lamps also appears in each position.

4.83 The calls waiting lamps are under the control of two keys. A calls waiting key, which puts the circuit into operation, and a team size

key. The keys are located on the cable-turning section. The team size key has three positions (A, B, and C) and is set to the desired operating team size, depending upon the traffic conditions during the day. Assuming the calls waiting system to be adjusted so that the green lamp lights with one call waiting per occupied position, the white lamp lights when two calls are waiting per occupied position and the red lamps light when three calls are waiting per occupied position. Representative team sizes are one to four positions occupied for setting A, five to ten positions for B, and over ten positions for C. If eight positions are occupied (key setting B) and 16 calls come in simultaneously, eight calls would be handled immediately (one each position) and the waiting eight calls (total one call waiting per occupied position) will cause the green lamps to light. As soon as one of the eight calls being served is completed, one of the waiting calls is served and the green lamp is retired. This procedure follows for two and three calls waiting per occupied position, lighting the white and red lamps respectively.

4.84 During light loads it may be desirable to transfer CAMA calls to a regular switchboard position, either of the DSA or toll board type. Switchboard positions are assigned to the position links in the same manner as CAMA positions except that they are assigned as positions 99, 98, 97, etc. This is done to allow growth of the regular CAMA positions and to allow growth in the number of transfer positions as the number required increases. Each switchboard position arranged for dual operation (regular toll and CAMA) is equipped with a transfer key which, when operated, allows selection by the CAMA position link just as any of the regular CAMA positions are selected. The toll operator then handles the CAMA traffic in the same manner as a CAMA operator at a cordless position. The switchboard is provided with similar keys and lamps for this purpose.

Transverter and Transverter Connector

4.85 A transverter connector connects senders to transverters so information can be exchanged between these two items of equipment. All connectors have access to all transverters, and each connector can serve five senders. Each sender has an appearance in only one connector. Within any one connector, only one connection can be made at a time. However, as many simultaneous connections as there are transverters can be made

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through different connectors. In case of simultaneous demands on a connector by two or more senders, the senders are served by their relative position in the sender preference chain circuit.

4.86 The transverters are arranged in a definite order by a chain circuit in each connector. If the first choice transverter is busy, then the first idle transverter in the order of preference is selected. If all transverters are busy, the connectors take their turn depending upon the relative position which each connector has in the transverter preference chain.

4.87 If a transverter fails to complete its functions and times out, it gives a trouble release signal to the connector. The connector releases the transverter and makes a second trial by seizing another transverter or the same transverter if all others are busy. If this second transverter encounters trouble, the call is routed to reorder (ROA).

4.88 The transverter connector frame (Fig. 21) is a single-bay frame and has capacity for two connectors serving a maximum of ten senders.

4.89 The transverter registers, translates and converts the information received from the sender and billing indexer to a form or pattern satisfactory for recording, and transmits to the recorder all pertinent information for the initial entry. The transverter is used only in connection with the perforation of the initial entry.

4.90 The transverter upon receipt of a signal from the transverter connector that it has been selected, receives the following information from the sender:

- (1) Calling number (office code and numerals)
- (2) Called area code, if necessary
- (3) Called number (office code and numerals)
- (4) Reorder number
- (5) Class of service, if required
- (6) Trunk test, sender test, or service observing indication, if required.

The transverter uses this information in performing its functions. The calling office code and the called office code are passed to the billing indexer. The transverter also determines the terminating area when interarea traffic is served and passes the terminating area indication to the billing indexer. Although the transverter controls the recording and uses the recorder number to select the proper recorder, the recorder number is required by the billing indexer for other purposes and it is passed on by the transverter.

4.91 The billing indexer performs its functions, as described later, and passes to the transverter the calling office index and the type of initial entry to be made. After the complete information is received and is checked as satisfactory, the transverter sends a position release signal to the sender and a release signal to the billing indexer. The recorder is then called in and the initial entry information is perforated on the tape.

4.92 The transverter bids for a particular recorder, as determined by the recorder number registered. The transverter takes its turn in a preference arrangement in the recorder group with other transverters, call identity indexers, and master timing equipment. The preference arrangement is such that the master timer has first preference, the transverter second, and the call identity indexer third. When the recorder is available and the transverter has preference the recorder is seized, the recorder connector closes perforator and other control leads between the transverter and recorder. Recording of the initial entry cannot be started until the output of the billing indexer has been checked. At about the time the recorder is seized, the transverter signals the call identity indexer to identify the incoming trunk. As the initial entry is being perforated, the call identity indexer furnishes the incoming trunk number to the recorder. With the initial entry completed, the transverter signals the recorder that the initial entry has been made. This signal is relayed from the recorder to the trunk and tells the trunk the call should be charged for if answered.

4.93 As shown in Fig. 22, the transverter frame is a single-bay frame and accommodates the equipment of one transverter. It can be arranged to operate with the maximum of 20 recorders, 40 transverter connectors, and 3 billing indexers. A billing indexer connector is part of

each transverter and provides access to all three billing indexers.

Billing Indexer

4.94 One of the primary purposes of the billing indexer, as the name implies, is to provide a message billing index which determines the amount to be charged on a local call. However, some companies do not have any such local billing arrangements. All DDD calls through the tandems are billed on a toll statement basis. Therefore, a message billing index "9" (toll statement) is provided for all calls. The originating and terminating rate treatments that are used to determine the message billing index are also used to screen out "misrouted non-CAMA" (MCA) calls that have not been screened by class of service in the marker. An MCA call is a local (free-service) call which has entered the crossbar tandem equipment, and it is routed to the MCA announcement.

4.95 The billing indexer has other functions which are also required when all billing is by toll statement. It checks the calling office code, as keyed by the CAMA operator, against the recorder group number. If the office code is not one that is assigned to the group, a "wrong office code" indication is obtained and the CAMA operator receives a reorder signal. The billing indexer also compares the originating office code with the called office code, if both are in the same NPA, to determine if the customer gave the operator the called rather than the calling number. If the codes are the same, a "match check" indication is received, and the CAMA operator receives a reorder signal.

4.96 The billing indexer consists of a two-bay originting frame and a single-bay supplementary frame. The originating frame is sufficient when all the traffic terminates in one area. Figure 23 shows the two-bay billing indexer frame. The supplementary bay is provided when information for a terminating area, other than the home area, is required. Three billing indexers are required for each office.

Call Identity Indexer

4.97 The call identity indexer is activated by the transverter as soon as the recorder is seized and the call identity indexer furnishes the number

of the incoming CAMA trunk when signaled to do so by the transverter.

4.98 Each call identity indexer and recorder is associated with a particular group of 100 trunks and is cabled directly to the recorder which deals with the same group of trunks. No connector is required.

4.99 For initial entries, the call identity indexer is signaled by the transverter (through the transverter connector, sender link, and trunk) to identify the trunk to the recorder. For answer and disconnect entries, since the transverter has released, the incoming trunk calls in the recorder by closing a path between the recorder and the call identity indexer. For answer and disconnect entries, the call identity indexer has lock-out features which permit the serving of a trunk while locking out other trunks requesting the recorder for answer and disconnect entries. This feature is not necessary for initial entries, since only the transverter that has seized the associated recorder can signal the particular trunk and call identity indexer and request identification.

4.100 The call identity indexer frame for crossbar tandem is a single-bay frame with a capacity for four call identity indexer units. Figure 24 is a schematic of the call identity indexer frame.

Recorder — Perforator

4.101 Each recorder has a perforator connected directly to it. The recorder controls the perforations of the tape as directed by the transverter, call identity indexer and master timer. The recorder, in conjunction with the associated perforator, transfers the information needed for billing to the paper tape. The recorder operates in response to a transverter in making initial entries on the tape and in response to the call identity indexer in making answer and disconnect entries. Certain other entries are made under the control of the master timer. The master timer has first preference, the transverter second, and the call identity indexer third.

4.102 The perforator cabinet is a single-sided steel enclosure. Two perforators are mounted in the upper part. In the space below are the paper supply bins and the take up reels for the perforated tape. Figure 25 is a picture of the cabinet with its perforators. A maximum

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of 11 perforator cabinets, housing 20 regular and one emergency perforator, may be furnished for an office.

4.103 The recorder, upon being engaged by a transverter, call identity indexer, or the master timer, operates the perforator. The recorder registers the time in minutes and tenths of minutes past the hour, under control of the master timer, and causes a record of the time to be placed on the tape at the beginning and at the end of the conversation period as directed by the trunk and call identity indexer. At the start of each hour, the recorder places an hour entry on the tape, and at 3:00 am, an end of tape pattern. These are made under the control of the master timer.

4.104 Each recorder has the capacity of 100 CAMA trunks, all of which must be assigned to the same call identity indexer. All trunks in a decade must appear in the same recorder, and no more than 30 office designations may be assigned to the same recorder (office indexes 0 through 29). This is known as a recorder group.

4.105 The recorder frame is a single-bay frame with capacity for four recorder units, each of which operates with the full transverter group. Figure 26 shows the arrangement of the recorders on a frame.

Master Timing

4.106 The master timer is composed of an odd and an even timer. The master timer frame is a single-bay frame on which both timers are mounted (see Fig. 27). The master timer furnishes time information in the form of 6 second pulses (1/10 of a minute) from either an odd or even timer to all recorders and associated perforators. This operation can be performed by either timer, and the one selected for this function becomes the control timer. Transfer arrangements allow this and other functions to be assumed by the other timer in the event of trouble. One timer is capable of serving the entire crossbar tandem office.

4.107 Centralized automatic message accounting — computerized (CAMA-C) is a replacement method recording detailed billing information of customer dialed calls in CAMA-equipped toll switching machine installations. A detailed explanation of CAMA-C is in Dial Facilities Management Practices (DFMP), Division H, Section 12c(5).

4.108 CAMA-C utilizes a high speed minicomputer to replace the aforementioned paper tape perforators and the master timer in existing XBT/4A installations. This computer initiates a scan of all recorder leads each ten milliseconds. A call indication conditions the system to gather the initial entry data from the recorder. This information is checked for validity and stored in temporary memory until the entire call can be assembled and sent to a disc storage "sequential file" where it will remain until the file is transferred to 9-track magnetic tape. While the initial entry is in storage, the computer will scan all CAMA trunks at a 100 millisecond rate looking for a change of state from the last scan.

4.109 The trunk scanner is looking for seizure, connect, disconnect, and idle conditions. Once the initial entry is recorded the associated trunk will be constantly scanned each 100 milliseconds looking for an answer indication and a subsequent disconnect entry when the call is completed.

4.110 Periodically the computer will transfer the assembled calls from disc memory onto the 9-track magnetic tape. This dump to magnetic tape can occur at given time intervals or when the disc storage reaches a certain percent fill. As with paper tapes, the maintenance forces will forward the magnetic tapes containing billing information to the appropriate accounting location.

Trunks

4.111 Crossbar tandem has several types of trunks which serve the various types of traffic handled by an office. In the following discussion these trunks will be divided into five categories (CAMA and TSP/S trunks are not included):

- (a) Incoming trunks
- (b) Completing trunks
- (c) Intertoll trunks
- (d) Auxiliary trunks
- (e) Miscellaneous trunks.

Incoming Trunks

4.112 Incoming trunks give customers in PBXs, local offices, and operators at toll or DSA

switchboards access to crossbar tandem. There are eight trunks in this category.

- (a) A loop signaling trunk which can be arranged to receive any one of three types of inpulsing:
 - (1) Revertive pulsing from panel, No. 1 or No. 5 crossbar offices.
 - (2) Dial pulsing from step-by-step LAMA offices or from switchboards.
 - (3) Multifrequency pulsing from panel, No. 1 crossbar, No. 5 crossbar, or step-by-step modified local automatic message accounting (LAMA) offices or from switchboards.
- (b) A loop signaling trunk arranged for remote control zone registration which receives traffic from panel offices using revertive pulsing. It may be a 1- or 2-rate trunk. When it is arranged for two rates, the marker determines whether a high charge or low charge applies. To accomplish this, the marker determines the origin and destination of the call in terms of incoming and outgoing zones. It compares these zones and decides whether a high charge or low charge is required.
- (c) A loop signaling PCI trunk which can be used for traffic from No. 1 and No. 5 crossbar offices where the charge data recording is done at the local office. It can also be used for flat rate traffic from No. 1 crossbar, No. 5 crossbar, and panel offices.
- (d) A 3-wire trunk which can be used for MF pulsing from No. 1- and No. 3-type switchboards in the same building with the tandem office.
- (e) An E&M lead signaling trunk which is used from local offices beyond the loop range or where carrier facilities are employed. It is used for dial pulsing from step-by-step automatic ticketing offices or switchboards. This trunk is basically an intertoll trunk and its use as such will be discussed in that category.
- (f) An E&M lead signaling trunk to the trunk in (e) but used for MF pulsing from No. 4 or No. 5 crossbar or crossbar tandem offices or from switchboards.

(g) A non-bylink DP signaling combined MR and CAMA trunk used for outdialing from a PBX into a tandem office.

(h) DP non-CAMA bylink one-way and 2-way trunks are used with the 10-digit register, MF sender, and data transfer circuit. Trunks in this category permit handling extended area service calls from noncommon control step-by-step offices.

Completing Trunks

4.113 A completing trunk completes traffic to local offices. In most cases, these are 2-wire loop signaling trunks which require no outgoing trunk relay equipment at the tandem office.

4.114 Where the range is beyond that for loop signaling or where carrier facilities are used, an E&M lead trunk may be employed. This trunk can be used for DP or MF outpulsing and it can complete to step-by-step or No. 5 crossbar offices. This trunk is known as a signaling converter (loop to E&M). It is also used as an intertoll trunk. The single trunk make-busy circuit is used to make this trunk appear busy when the "E" lead is grounded.

Intertoll Trunks

4.115 Intertoll trunks are used to connect with distant toll centers, either dial or manual. They may be one-way incoming or one-way outgoing, or 2-way trunks. E&M lead signaling is used. Since crossbar tandem is a 2-wire switching system, separate 4-wire terminating sets or repeating coils in the tandem office are furnished to connect to intertoll facilities. There are five trunks in this category.

(a) An incoming trunk using DP pulsing from step-by-step intertoll offices or from distant toll switchboards [see 4.60(e)].

(b) An incoming trunk using MF pulsing from toll crossbar offices or from distant toll switchboards [see 4.60(f)].

(c) A signaling converter (loop to E&M) used as an outgoing trunk. It may be used with DP pulsing to step-by-step intertoll offices or

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with MF pulsing to other crossbar toll offices (see 4.62).

(d) A 2-way trunk used for MF pulsing in both directions which permits connection to a No. 4-type office or another crossbar tandem office. In addition to its incoming and outgoing appearances on the tandem switches, the trunk can also have an outgoing appearance in a No. 1- or No. 3-type switchboard with MF keysets. Seizure at any appearance makes the other appearances busy.

(e) A 2-way trunk used for MF or DP inpulsing and DP outpulsing. It can be used for connection to a step-by-step intertoll office. A delay dial feature has been added to allow connection to senderized offices, although such operation will not ordinarily be used. It can receive traffic from step-by-step switches or from operators in the building with the step-by-step office. In addition to its incoming and outgoing appearances on the tandem switches, the trunk can also have an outgoing appearance on a No. 1- or No. 3-type switchboard with DC keysets.

4.116 In addition to these five trunks, there are two other trunks (one incoming and one outgoing) that may be classified as intertoll trunks. These are 4-wire trunks with loop signaling on the phantom for connection with No. 4-type offices where, for transmission reasons, it is necessary to extend the 4-wire talking path between the two offices. The conversion between two and four wires is made by hybrid coils in the crossbar tandem trunk.

Auxiliary Trunks

4.117 The auxiliary trunks permit the tandem office to multiple to operator office and ringdown trunks. Four applique trunks are available.

(a) A trunk permitting the tandem office to complete calls to community dial offices through operator office trunks located either in the tandem building or at a nearby location. This trunk uses loop signaling.

(b) A trunk similar to the trunk in (a) using E&M lead signaling.

(c) A trunk permitting tandem to complete calls over ringdown intertoll trunks associated

with a No. 3-type switchboard in the tandem building.

(d) A trunk permitting tandem to complete calls over ringdown intertoll trunks associated with a No. 1 switchboard in the tandem building.

Miscellaneous Trunks

4.118 Reorder trunks are used to send a reorder signal, consisting of 120 interruptions per minute (IPM) in the form of tones to operators and customers. Calls are routed to reorder trunks when a blockage is encountered that is expected to be of short duration. For example, (a) all trunks busy in a group of completing trunks since these trunks are engineered with a low probability of delay. In this case, an immediate new attempt will probably be successful; (b) a shortage of links; or (c) switching troubles. When a reorder is received, the operator will usually try again.

4.119 No circuit trunks are used on toll calls to send a no circuit (NC) tone signal, to the outward operator. Tone interruptions at 120 IPM, or NC announcements are being used for the NC tone. Calls are routed to NC trunks when a blockage is encountered that is expected to be of long duration; for example, all trunks busy in a group of intertoll trunks engineered on a delay basis. In this case, the operator procedure regarding subsequent attempts may be different than when reorder is received.

4.120 TX trunks carry delayed call traffic between the crossbar tandem switching system and 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. The following trunks are available:

- 11XX—Regular TX
- 1150—Universal TX
- 1151—Conference operator
- 1152—Mobile service and marine operator
- 1153—Charge operator
- 1154—Toll Terminal operator

These trunks have no relay equipment at tandem.

4.121 Service trunks carry traffic between the crossbar tandem switching system and assistance operators and maintenance force. The following trunks are available:

- 100—Test line for noise and balance measurement
- *101—Trunk to toll testboard
- 102—1-milliwatt 1000-cycle supply
- 103—Test line circuit for supervision
- 104—Automatic intertoll trunk transmission test line circuit
- 105—ATMOS responder
- *121—Inward operator
- *131—Information operator
- *141—Route desk
- *181—Toll station operator
- *191—Transfer to CLR operator
- *958—Trunk to chief switchman or wire chief.

*These trunks have no relay equipment at tandem.

4.122 Recorded announcement trunks are used for connecting any one or more of eight announcement trunk groups to any one of six recorded announcement channels of the standard 5A announcement machine for the crossbar tandem system. The flexibility is obtained by eight manually operated control switches at the traffic supervisory cabinet. The eight announcement trunk groups are as follows:

- (1) EMG—Emergency
- (2) FRA—Final reorder announcement
- (3) MCA—Misrouted non-CAMA announcement
- (4) NCA—No circuit announcement
- (5) ROA—Reorder announcement
- (6) SOA—Sender overload announcement

- (7) UCA—Unauthorized code announcement
- (8) VCA—Vacant code announcement.

5. TRAFFIC SUPERVISORY CABINET AND TRAFFIC CONTROL CONSOLE

5.01 The traffic supervisory cabinet establishes a unified control point for traffic regulating functions for the crossbar tandem system. This cabinet has a sloping front control panel providing convenient access and display of all facilities.

5.02 Following is a description of the most prominent features associated with the traffic supervisory cabinet. A detailed explanation of the supervisory cabinet is to be issued in DFMP format at a later date.

- (a) Directional reservation for 2-way intertoll trunks in final groups to assist in the control of overloads. When directional reservation is effective (the preset busy status is reached) on a final intertoll group to a high ranking office, the equipment reserves all of the 2-way trunks in the group for the higher ranking office.
- (b) Alternate route traffic control permits a network administrator to deny, to selected traffic, access to an alternate route when the distant office, or an office beyond, is temporarily not capable of handling the alternate routed traffic.
- (c) Transfer to recorded announcements provides the ability to transfer traffic from a final route to either a no-circuit announcement (NCA) or emergency announcement (EMG) trunk instead of NC tone trunks.
- (d) Flexible control of recorded announcements for toll-type crossbar tandem offices provides for connecting any one or more of eight announcement trunk groups to any one of six recorded announcement channels of the standard 5A announcement machine.
- (e) Control for the sender attachment delay recorder circuit.

5.03 The traffic control console (TCC) is a network management tool which enables the XBT network administrator to alleviate machine congestion and to control traffic entering the machine from

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its subtending offices or from other XBTs in a metropolitan network. The sloping control panel at the top contains the keys and lamps which indicate the status of the control equipment and subtending office traffic. A pen strip chart recorder may also be provided to give a continuous record of the office sender load. The TCC provides both dynamic (automatic) and manual controls.

5.04 Following is a description of some of the features associated with the traffic control console. A detailed explanation of the control console is in DFMP, Division H, Section 12d(6).

- (a) Accommodates control facilities for a maximum of 60 subtending offices or can originate 60 cancellation signals.
- (b) Cancel or prevent initiation of short sender timing. This is an action taken within the machine which applies direct relief when a marker queue detector senses congestion in the tandem (indicated by all markers busy).
- (c) Cancel traffic from subtending offices when delay in serving incoming traffic reaches certain predetermined levels. When there is an exchange of signals with the subtending offices, up to 40 controls may be put at a low level of delay (sender queue low) and 20 more at a high level of delay (sender queue high).

6. MAINTENANCE FEATURES

A. General

6.01 The basic provisions for maintenance of crossbar tandem offices consist of:

- (a) Testing equipment for the various circuits and associated apparatus.
- (b) Arrangements for providing notice of and information about failures occurring on service and test calls.
- (c) Means for removing equipment from service.
- (d) Access arrangements for setting up to particular circuits, or for selecting circuits in sequence.

In addition, testing equipment is provided for testing trunks originating or terminating in other buildings.

B. Trouble Recorder and Marker Test

6.02 The marker test circuit is mounted on the trouble recorder frame and for this section the two circuits will be considered as a unit and referred to simply as the trouble recorder.

6.03 The trouble recorder frame is used for maintenance and testing purposes. Its primary function is to facilitate the location of troubles in and to check operations of the markers and associated switching equipment, as well as the transverter and associated CAMA and TSP/S equipment. This is accomplished with punched cards by:

- (a) Taking a record of the information set up in a marker when it fails to complete its function in the allowed time or detects a fault by other means, or when a sender requests the marker for a trouble recorder.
- (b) Setting up test calls in the marker, allowing it to perform its functions, and then taking a record of the resulting translations and progress of such calls.

6.04 The recording of stuck sender (SS), trunk guard failure (TGF), or unexpected stop (UXS), and trunk identity (TI) has been provided for maintenance improvement. The recording is controlled by the RSS key located in the maintenance center. When a sender encounters an SS, TGF, or UXS trouble, and the RSS key is operated, this information is registered along with the trunk identification. When registration is complete, the information is transferred to the trouble recorder to punch a trouble card. Following the trouble recording, the call is routed to a recorder trunk on the overflow trial basis.

6.05 Vacant code and reorder "trap" circuits provide a means for reducing vacant code and reorder occurrences for the crossbar tandem system. These traps are under control of a key located at the maintenance center and are arranged to furnish a trouble record card or to light a lamp on trouble indicators. With this information corrective action can be taken.

6.06 The trouble recorder is summoned by a marker under the following conditions:

- (a) The marker times out because of a trouble condition.
- (b) One of the trouble detecting relays in the marker is operated.
- (c) The sender requests a trouble record via the marker.

6.07 When the trouble recorder is seized by a marker, a connection is also set up from the trouble recorder to the marker connector, and to the trunk link and connector. From these circuits it can obtain some or all of the following information depending upon the progress of the call:

- (a) The identification of the marker, the marker connector, the trunk link frame, the office link frame, the sender, and the incoming trunk location on the trunk link frame.
- (b) The class of service, the type of sender, and the code received by the marker.
- (c) The identification of the chosen outgoing trunk and channel.
- (d) The information returned to the sender.
- (e) The progress made by the marker before the trouble occurred.

After the record is made, the marker sends a trouble release signal to the sender and returns to normal. The trouble recorder also returns to normal and is free to serve other markers.

6.08 In the event of simultaneous attempts by two markers to seize the trouble recorder, the preferred marker will be served and the other marker will send a trouble release signal to the sender and then return to normal. The trouble recorder indicates the numbers of the markers that request it while it is busy.

6.09 As described in 3.08, the marker uses 2-stage operation. If trouble is encountered during the first or decoding stage and there is no call in the second or marking stage, a trouble recorder will be called in immediately. If, however, there

is a call in the marking stage, the marker must wait for completion of this call before it can call in a trouble recorder for a trouble encountered by the call in the decoding stage.

6.10 If a trouble is encountered during the marking stage, the trouble recorder will be called in immediately whether there are one or two calls being handled by the marker at the time. When the call advances to the marking stage, the connection between the marker and sender via the marker connector is released. Therefore, when the trouble recorder is summoned after the marker has advanced to its second stage, the record taken will not show the code and class-of-call information or the identity of the sender or marker connector that served the call. If, however, a call has entered the decoding stage while a call is in trouble in the marker stage, this information will be recorded for the call in the decoding stage.

Test Calls

6.11 The trouble recorder, in addition to taking records of service calls when summoned by a marker, is provided with means for originating test calls and indicating the progress of these calls through the marker and foreign area translator.

6.12 The trouble recorder has a switch to permit selection of a particular marker for test. It can also choose between a pair of translators. When a test call is set up, the trouble simulates some of the sequences and operations of a sender. A set of keys is provided so that the following information can be sent to the marker:

- (a) Called code (three or six digits)
- (b) Type of call
- (c) Class of service
- (d) Incoming zone
- (e) Trunk link frame number.

6.13 The marker handles a test call as it does a service call. However, the outpulsing information is sent to and stored in the trouble recorder as if it were a sender. The marker completes its functions with the trouble recorder simulating the part of the incoming trunk necessary for completion of the call. However, no connection

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is established through the office. By operation of a key, a trouble recorder may be arranged to drop a card on each call, to drop a card only if a trouble is encountered, or not to drop any card.

C. Trouble Indicator

6.14 The trouble indicator is no longer standard. It is used in older offices in place of the trouble recorder and marker test circuits.

6.15 The functions of the trouble indicator are the same as those of the trouble recorder; however, they differ in the method of indicating troubles. The trouble indicator uses a lamp display rather than a punched card. This lamp display, however, remains until it is cleared by the maintenance force.

6.16 When the trouble indicator is taking or holding a record from one marker, it makes itself busy to all other markers. All markers that summon it during this time will send a trouble release signal to the sender and then return to normal. The trouble indicator records the numbers of the markers that request it while it is busy.

D. Sender Test Frame

6.17 The sender test frames provide a means for routine testing of tandem senders and transverters on an automatic progression basis. There are two sender test frames. One of them tests the PCI, DP, and MF CAMA-type senders and the revertive sender. The other tests the older senders including the revertive sender.

6.18 The testing of a sender includes seizure of the sender, priming, and selection information, and checks on the various operations of the sender. When the test of a sender has been satisfactorily completed, the next sender is seized and tested. The test frame will continue in this manner until all senders of one type have been tested or until a trouble is encountered which will stop the test and bring in an alarm. On some types of troubles, the sender will request the marker to call in a trouble recorder or trouble indicator which will receive an indication that the failure occurred on a test call. The senders that are busy at the time of attempted seizure may be automatically passed by.

6.19 In addition to making a single test on each sender, the testing circuit is arranged so that two successive tests may be made on each sender until all of the senders have been tested twice. At all times, the sender under test can be identified by means of lamps at the test frame. Lamps are also provided to indicate the progress of various tests and to indicate the failure of the sender under specific tests.

6.20 When desired, a particular sender may be seized and tested either on a single or repeat basis. The repeat test feature is useful in locating an intermittent trouble condition by testing the particular sender until the trouble is encountered, or the feature may be used to indicate the satisfactory operation of a sender before returning it to service.

6.21 The sender test frame also applies pulses to the sender under marginal conditions which are at least as severe as those under which pulses in a service call are received. Manual means are also provided to check the quality of pulses that the sender outputs.

6.22 The test circuit is connected to the senders by means of crossbar switches. One 200-point crossbar switch is necessary for each 100 or less senders. Each switch may be connected to 20 sender subgroups with each subgroup having a maximum of five senders. Each horizontal row on the crossbar switch accommodates two subgroups of senders. A multicontact relay cuts through the leads common to a subgroup of senders from the sender link circuit to the test circuit. Two such relays are associated with a horizontal row of the crossbar switch to which are connected the senders of two subgroups.

6.23 A major alarm is given when the test circuit is blocked on a time-out while testing common equipment for five senders. A minor alarm is given when the test circuit is blocked while testing individual senders.

E. Sender Make-Busy Frame

6.24 There is a make-busy jack on this frame for each sender in the office. These jacks are used to remove senders from service. Associated with each make-busy jack are a stuck sender lamp, a cancel priming key, and a lamp to indicate stuck senders involved in delayed assignments of PCI calls.

6.25 When the cancel priming key is operated, it cancels the timed release features in the associated sender and causes it to stick after it times out on a trouble. This, in turn, causes an individual stuck sender lamp to light and brings in an audible and visual alarm. A peg count register records the number of stuck senders.

6.26 There is a sender subgroup busy jack for each five senders which permits a subgroup of senders to be made busy. When a plug is inserted in one of these jacks, an associated sender subgroup busy lamp lights.

6.27 A sender load register lamp and a reduce sender timing jack are provided per group of senders. The load register lamp lights when a predetermined number of PCI, DP, MF, or RP senders are busy. The reduce sender timing jack is used to reduce the timing in senders when delays are being encountered on PCI outpulsed calls due to slow operator answers.

6.28 A telephone circuit with associated keys and lamps provides talking facilities between the sender make-busy frame and points in the same or distant offices.

6.29 An intersender timing control unit is provided on the sender make-busy frame for each group of senders that are arranged for intersender timing.

F. Test Equipment for Zone Registration Tandem Trunks

6.30 An automatic test frame is provided for testing the zone registration-type trunks. The test frame is connected to the trunks by means of crossbar switches. The test frame places calls through the trunk to a return test line reached through the trunk link and office link frames and terminating in the test frame. The calls are routed in the same manner as service calls except that the test frame performs the functions of sending the code information (office brush and office group selections) into the sender. One of the regular office code combinations must be assigned for use in the test frame. A zone registration trunk test frame is provided for approximately 300 zone registration trunks.

6.31 Since the test frame is located in the tandem office, there is no economical way of

automatically making the trunks busy at the originating office while the tests are in progress. Therefore, the circuits are arranged so that whenever a trunk circuit is being tested, the associated trunk conductors are transferred to a reserve trunk circuit.

6.32 When a call is completed over a reserve trunk, that trunk continued in use until the call is disconnected. To prevent seriously delaying the progress of the test frame, five reserve trunks are provided. The reserve trunk may be substituted for regular trunks having various rates and it must, therefore be capable of simulating any of these trunks.

6.33 The test circuit can be arranged to test 1-rate trunks or both 1- and 2-rate trunks.

6.34 Either of two types of tests can be made.

(a) A rapid test of the miscellaneous features and the initial message registration. The message register pulses are counted and measured for their minimum length.

(b) A complete time and message register test of the initial and one overtime period. The long holding time on such tests is the reason the capacity is limited to about 300 trunks.

6.35 When testing on an automatic progression basis, the test circuit can be arranged to pass busy trunks by the operation of a key. When this key is operated, a trunk will also be passed when its reserve trunk is busy.

6.36 The test circuit can also be used manually to test any desired trunk, either once or repeatedly.

G. Test Set for Nonzone Trunks

6.37 The nonzone tandem trunks are tested by a T-wagon-type set which is arranged to route calls to a test line appearing on an office link frame or to a distant test line. The test set can be used for testing the following types of trunks.

(a) **Revertive Pulsing:** The office brush and office group selections are originated in the test set.

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- (b) **Dial Pulsing:** The test set is provided with a dial for this purpose.
- (c) **Multifrequency Pulsing:** The test set is provided with a keyset to make the selection with the pulses being generated by the test current supply control circuit.
- (d) **Panel Call Indicator Pulsing:** The number is de-keypulsed into the PCI pulse generator and from there it is PCI pulsed through the trunk into a sender.

6.38 As described later, test line circuits are provided for terminating test calls from originating offices. In order to use only one office code for two testing purposes, the test lines for this test set, and the test lines for terminating calls from originating offices, are located in the same trunk group. Normally, the trunk appearances for the test set will be busy. By means of a patch, the test set transfers the busy condition from its test lines to the other test line terminals. Under this arrangement, there is, of course, a possibility of interference between test calls from the test set and those from originating offices, but the amount of such interference is not large enough to be controlling. Of course, if there are available code combinations, the test set lines could be located in a separate group as desired. The test set is arranged to make adequate tests of the various features of the trunk circuits and is also arranged so that it can be used for setting up connections for transmission tests of the trunk circuits.

H. Terminating Test Line

6.39 This test line consists of three parts.

- (a) A test line for terminating tests originating in the test set for nonzone tandem trunks.
- (b) A test line for terminating calls from a distant outgoing trunk test facility.
- (c) Synchronous type test line for testing incoming trunk supervisory relays.

Each circuit appears on an office link frame in the same trunk group. The first test line normally appears busy thus permitting a test call from a distant office to choose the desired test line. In addition to its appearance on the office link frame,

the first test line also has a jack appearance on the incoming trunk frame where it may be patched to the test set. When it is so patched, the busy condition is removed from the first test line, the second is made busy, and the nonzone tandem test set can reach proper test line through the switches.

I. Test Trunk Circuit for Testing Incoming Trunk Circuits Arranged for Rering

6.40 This circuit is used for completing test calls incoming to the tandem office on trunks arranged for rering. It returns the signals expected by the automatic test circuit in the originating office and in the process makes current flow tests on the polar supervisory relay of the incoming trunk.

J. Automatic Incoming Trunk Test Circuit

6.41 The automatic incoming trunk test circuit tests the incoming trunks in the distant offices by testing each appearance on the crossbar tandem office link frames in succession. It can be used by a crossbar tandem office and a panel or No. 1 crossbar office or by two crossbar tandem offices in the same building and has, therefore, been arranged to test 8000 trunks.

6.42 When making routine tests, the test circuit can pass busy trunks or wait for them to release. In the latter case, sufficient time is allowed for the trunk to return to normal. It can test panel incomings or step-by-step selectors twice to see that they release properly.

6.43 The trunks are tested as follows:

- (a) When a test line in the next office can be reached by pulsing three, four, or five digits on a dial, revertive, or multifrequency basis, the supervisory and signaling features of the outgoing trunk are tested.
- (b) A polarity and continuity test of the tip and ring leads made of the following trunks:
 - (1) Trunks over which an operator must be reached for completion of the call.
 - (2) Trunks which cannot reach a test line using the limited code facilities of this circuit.

(3) Miscellaneous trunks having battery on the tip lead and ground on the ring lead when normal.

(c) Miscellaneous trunks, not having battery on tip and ground on ring when normal, are automatically passed by. Vacant office link frame terminals are also passed by.

(d) For 2-way trunks arranged for delay dial through which a test line may be reached, the following tests are made:

- (1) The ability of the trunk to pass outgoing calls.
- (2) The ring forward features.
- (3) The ability of the trunk to lock in initial off-hook signals.

6.44 Automatic transmission test and control features have been added to give this circuit the ability to make transmission measurements and noise checks on local and toll completing trunks.

6.45 This test circuit can also be used to test any individual trunk on a manual basis.

K. Manual Outgoing Trunk Test Frame

6.46 As indicated by the title, this frame provides a manual means of testing outgoing trunks. To test a particular trunk, the test circuit is patched to a trunk test jack that is multiplied to the office secondary switch multiple. One jack per trunk appears on the test frame for one-way trunks

and two jacks per trunk for 2-way trunks. A call may then be directed to a test line in a distant office by using straightforward operation or by revertive, panel call indicator, multifrequency, or dial pulsing. In conjunction with the test line, this circuit tests that the trunk is capable of reaching a particular destination and that the ringing and signaling as well as the supervision is functioning properly. Transmission tests are also made. When outgoing trunk relay equipment is provided, this is also tested.

L. CAMA Trunk Test Frame

6.47 The CAMA trunk test frame (AMATT) tests trunks for talk path, supervision and billing functions. It is capable of conducting tests on up to 2000 trunks.

7. PLANT AND TRAFFIC REGISTERS

7.01 There are numerous plant and traffic registers provided. DFMP, Division H, Section 12e(2) describes the various types of crossbar tandem registers in detail. It also covers their method of operation and recommends the basis for their provision.

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

7.03 Plant registers are used by the maintenance personnel as an aid in trouble analysis.

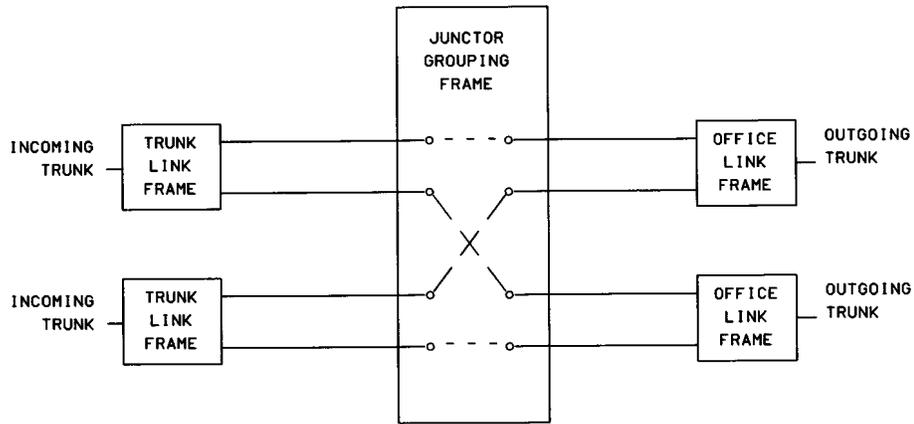


Fig. 1—Relationship of Trunk Link, Office Link and Junctor Grouping Frames (2.02)

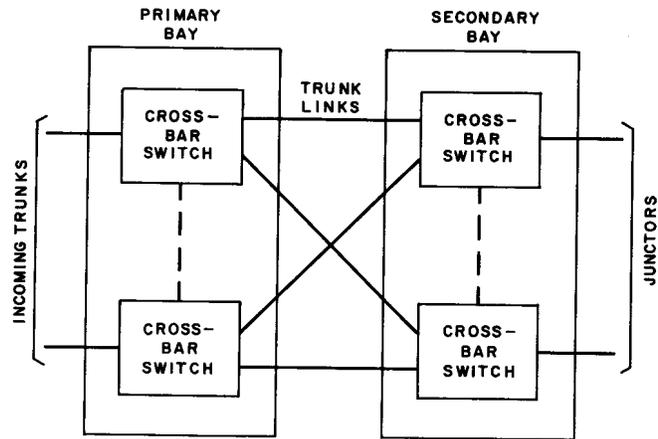


Fig. 2A—Trunk Link Frame—Primary and Secondary Bays Connected by Trunk Links (2.03)

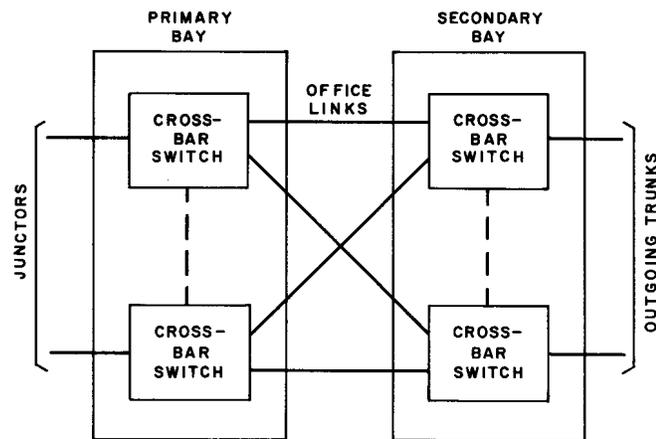


Fig. 2B—Office Link Frame—Primary and Secondary Bays Connected by Office Links (2.04)

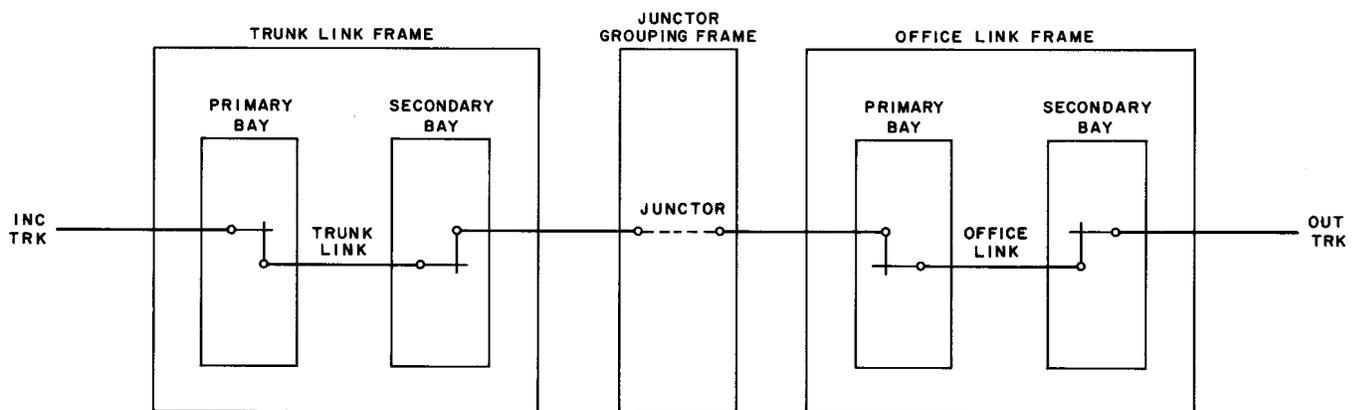


Fig. 3—Complete Channel (2.05)

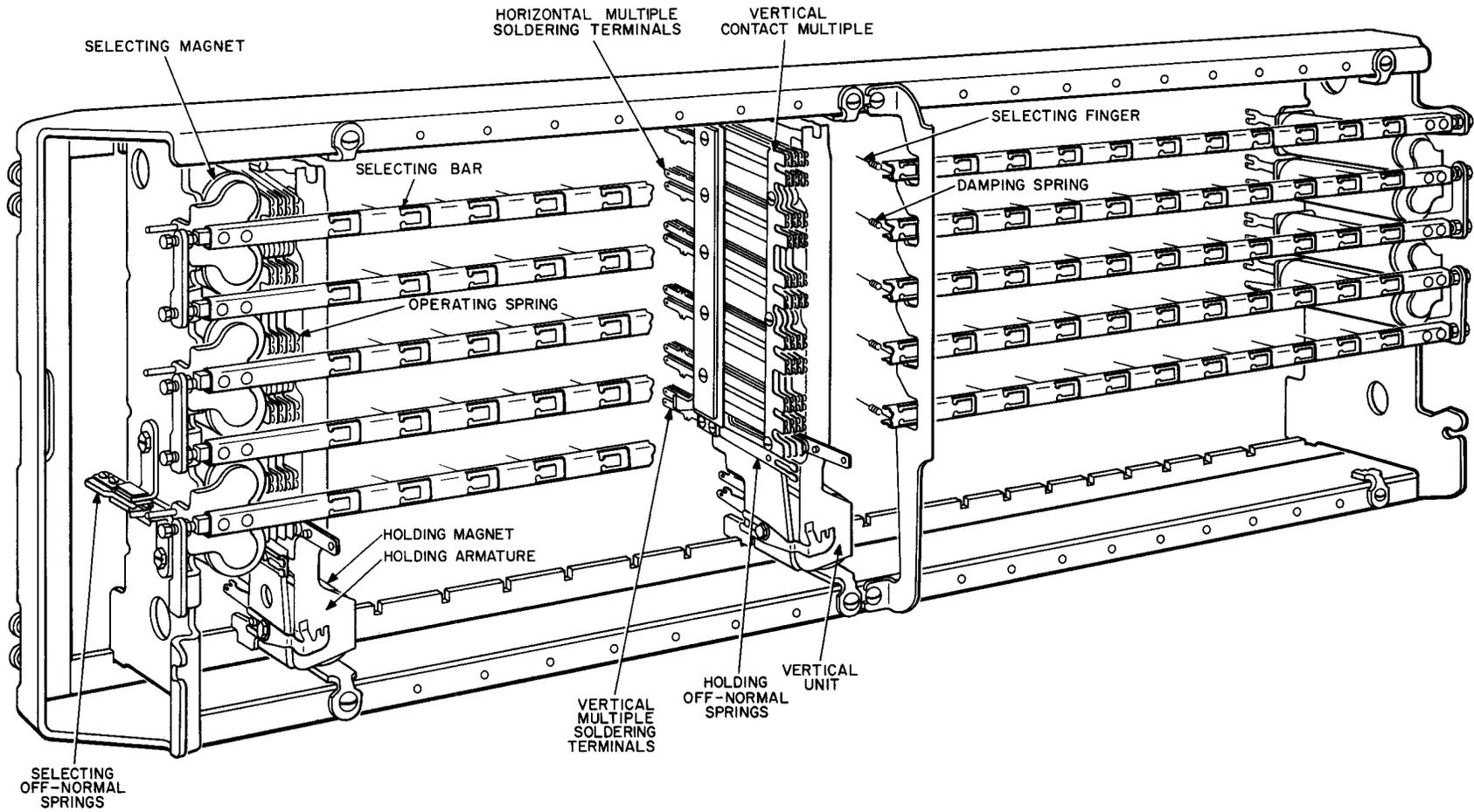


Fig. 4—Partial Perspective View of 20-Vertical Unit Crossbar Switch (200 Point) (2.06)

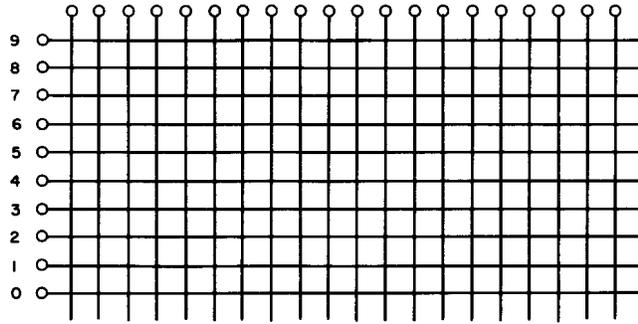


Fig. 5—Schematic of Crossbar Switch (10 Horizontal Paths) (2.13)

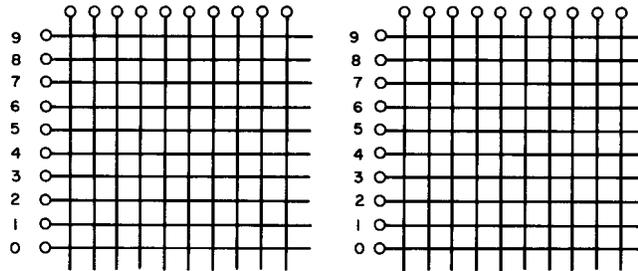


Fig. 6—Schematic of Crossbar Switch (20 Horizontal Paths) (2.14)

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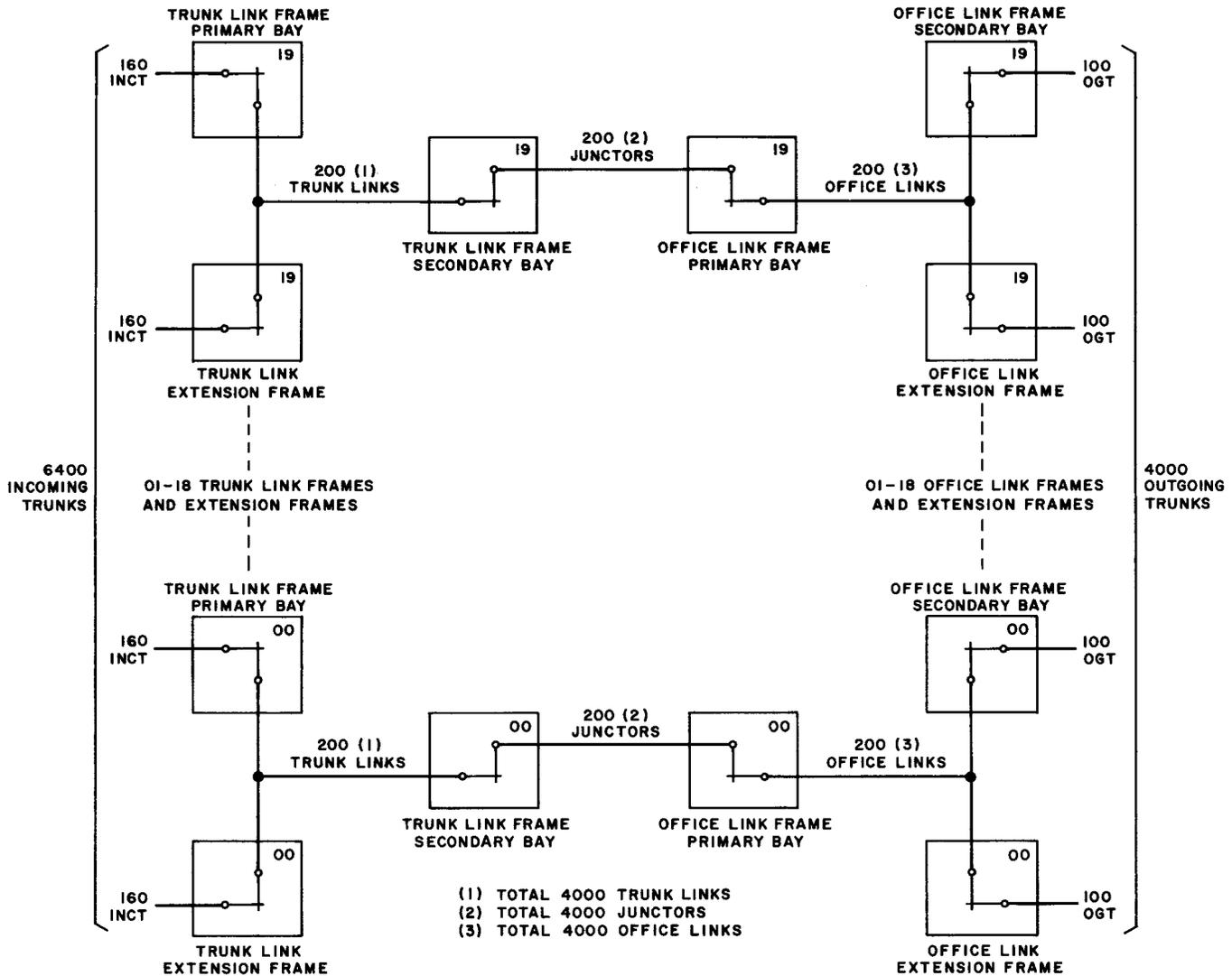


Fig. 7—Trunk Link and Office Link Extension Frames (2.17, 2.24)

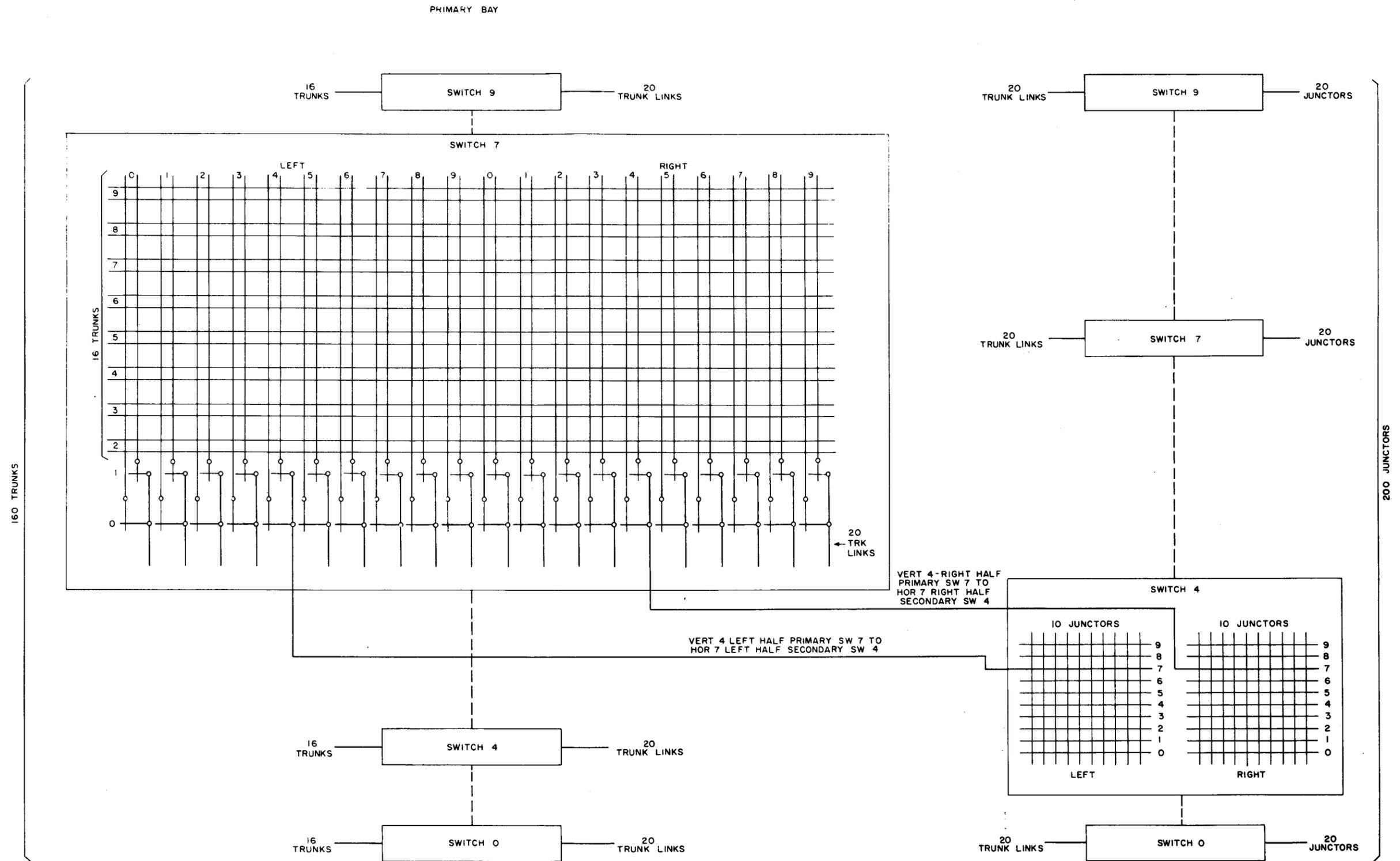


Fig. 8—Distribution of Trunk Links (2.18, 2.22)

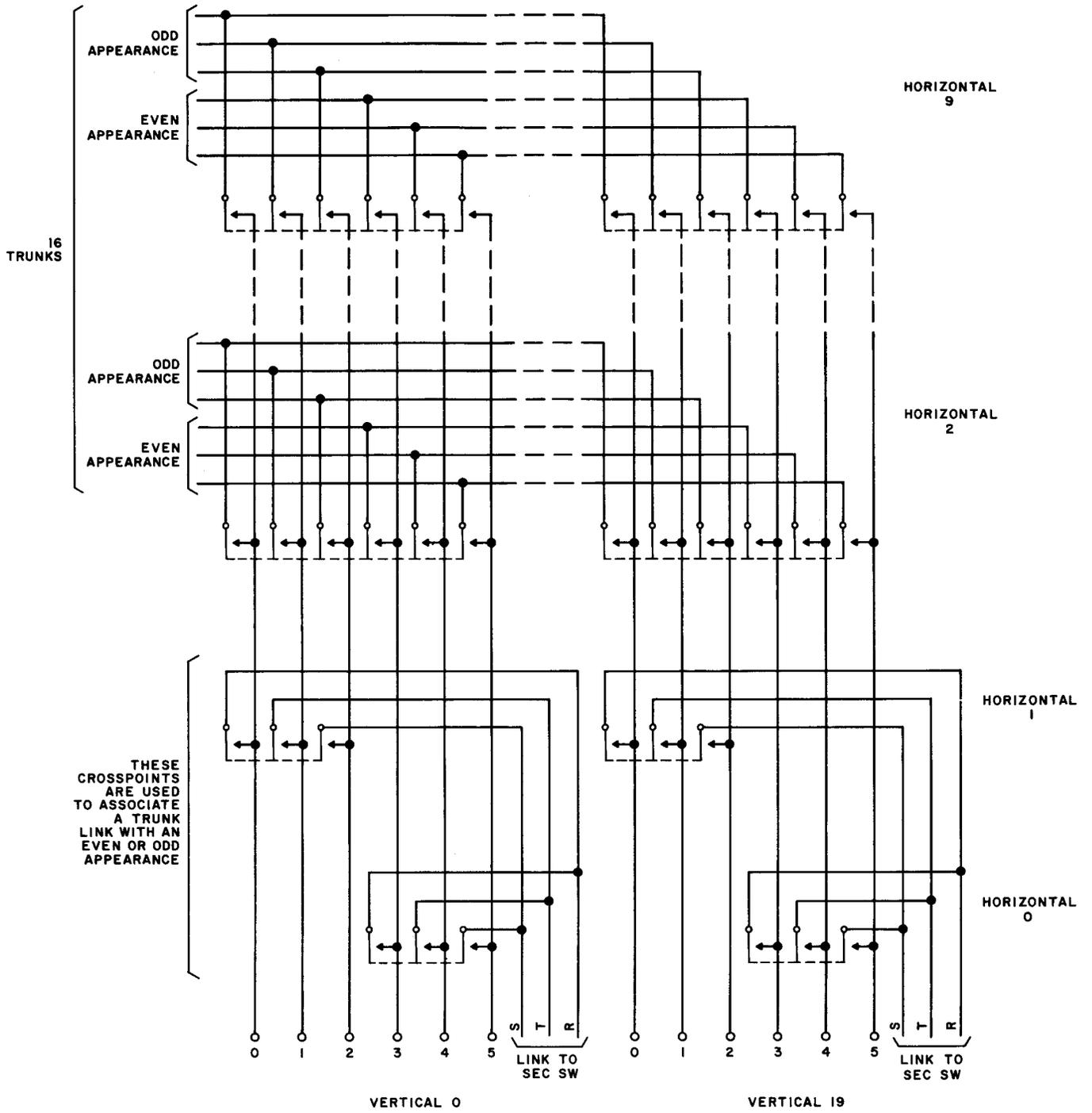


Fig. 9—Switch Arranged for 16 Trunk Appearances (2.19)

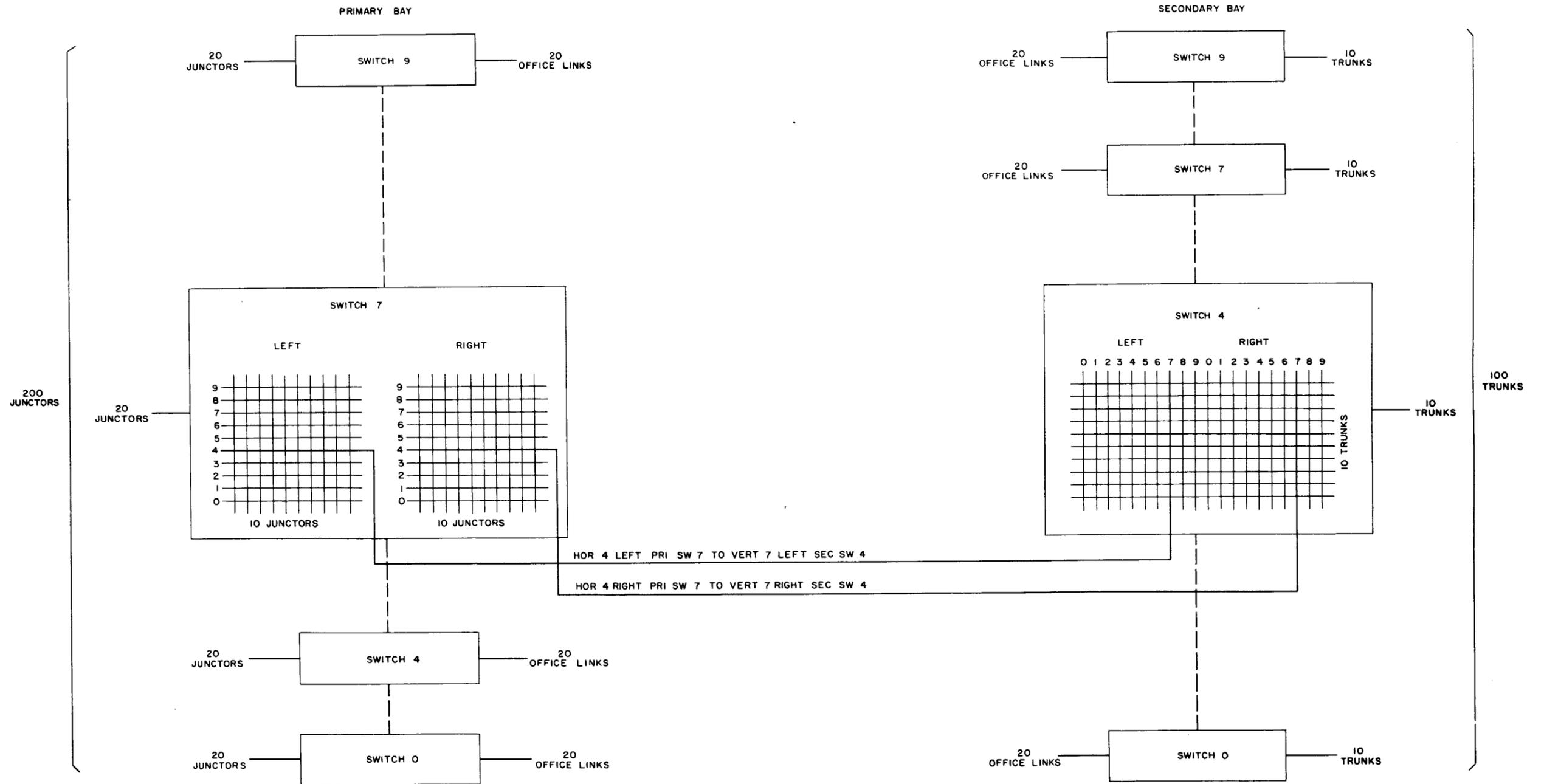


Fig. 10—Distribution of Office Links (2.27, 2.28)

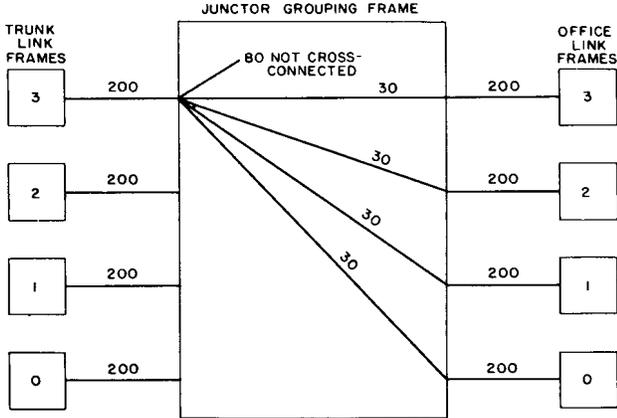


Fig. 11—Junctor Group—4-by-4 Size Office (2.34)

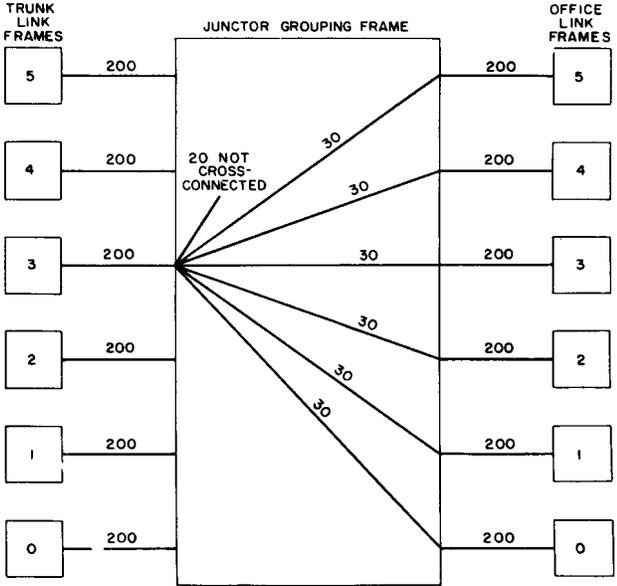


Fig. 12—Junctor Groups—6-by-6 Size Office (Initially 4-by-4 Size) (2.35)

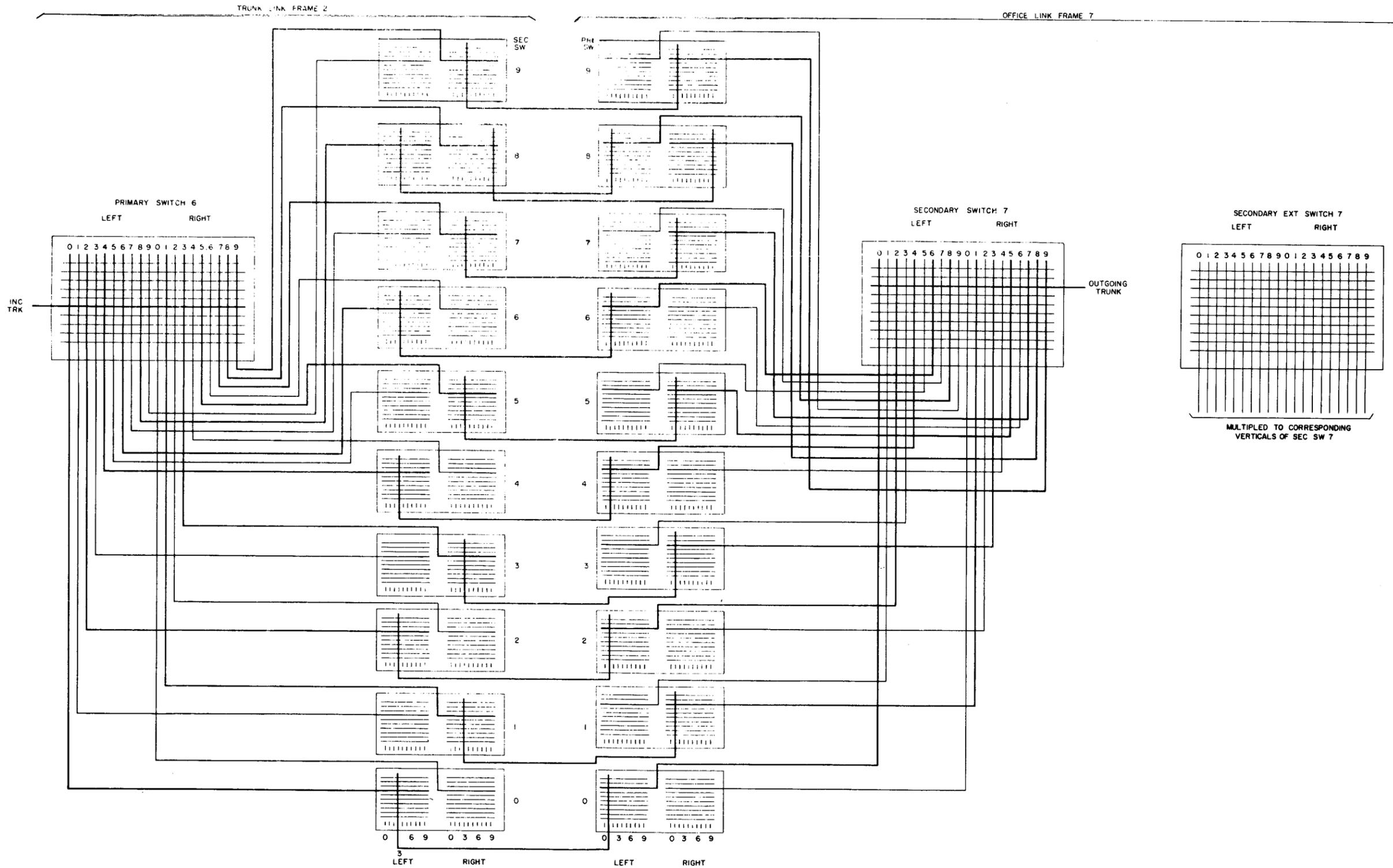


Fig. 13—Channels Between an Incoming Trunk and an Outgoing Trunk in an Office Equipped with 18 Trunk Link Frames and 18 Office Link Frames (2.40)

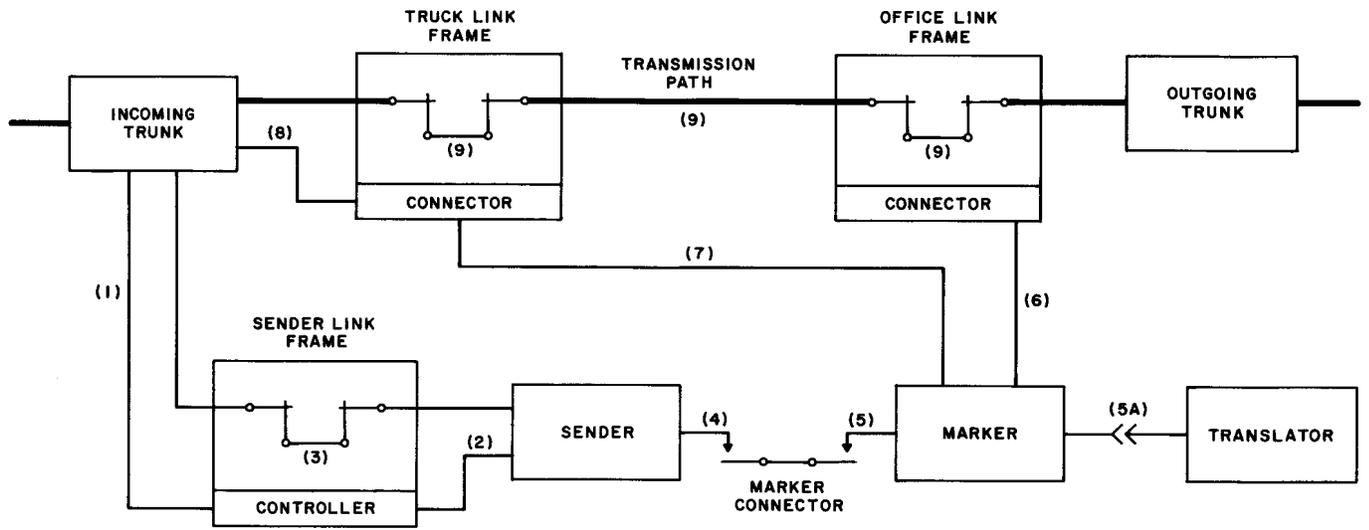


Fig. 14—Path of a Call Through a Crossbar Tandem Office (3.01, 3.02)

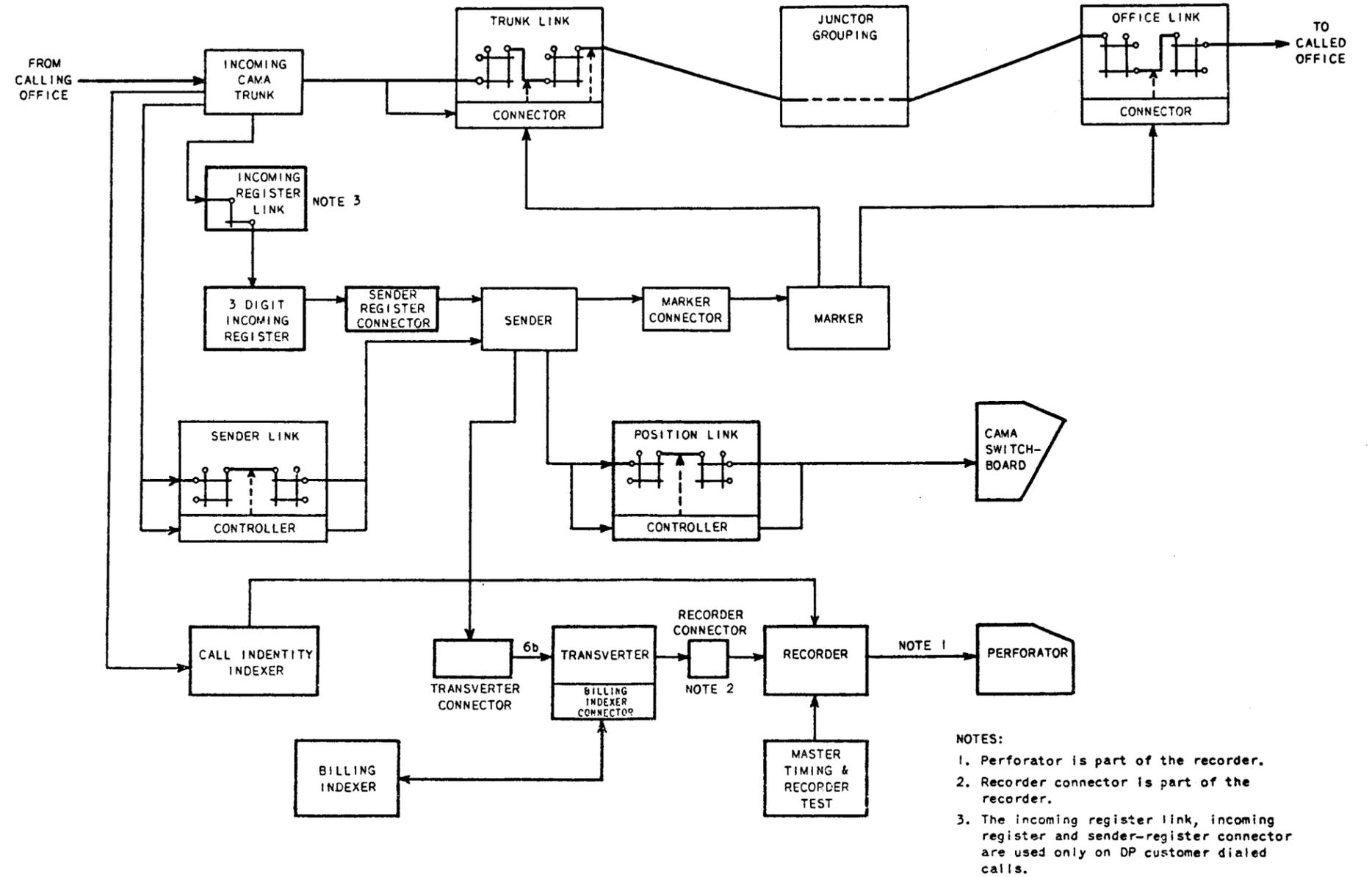


Fig. 15—CAMA Call Through a Crossbar Tandem (3.20)

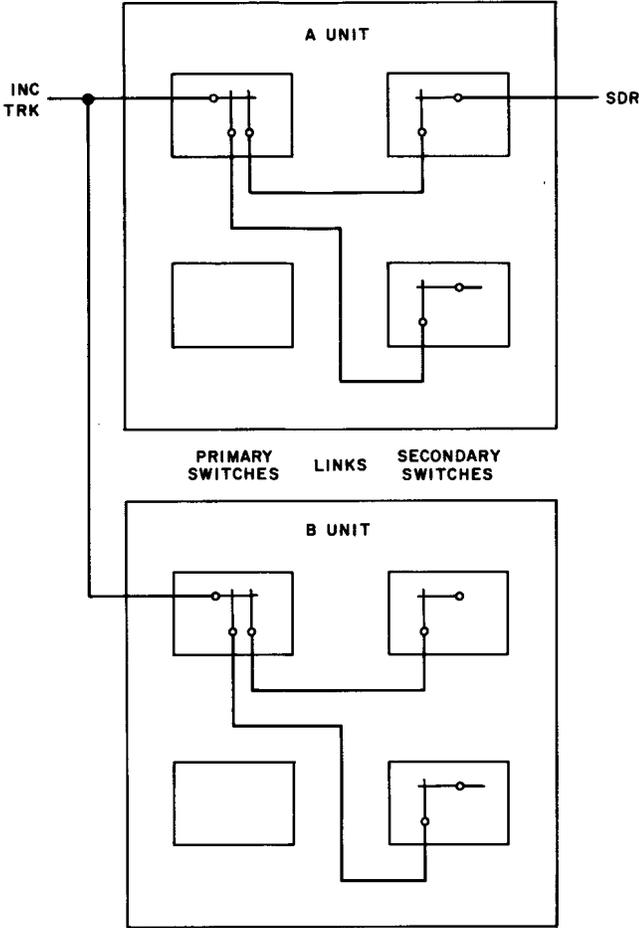


Fig. 16—Sender Link Frame—General Plan (4.12)

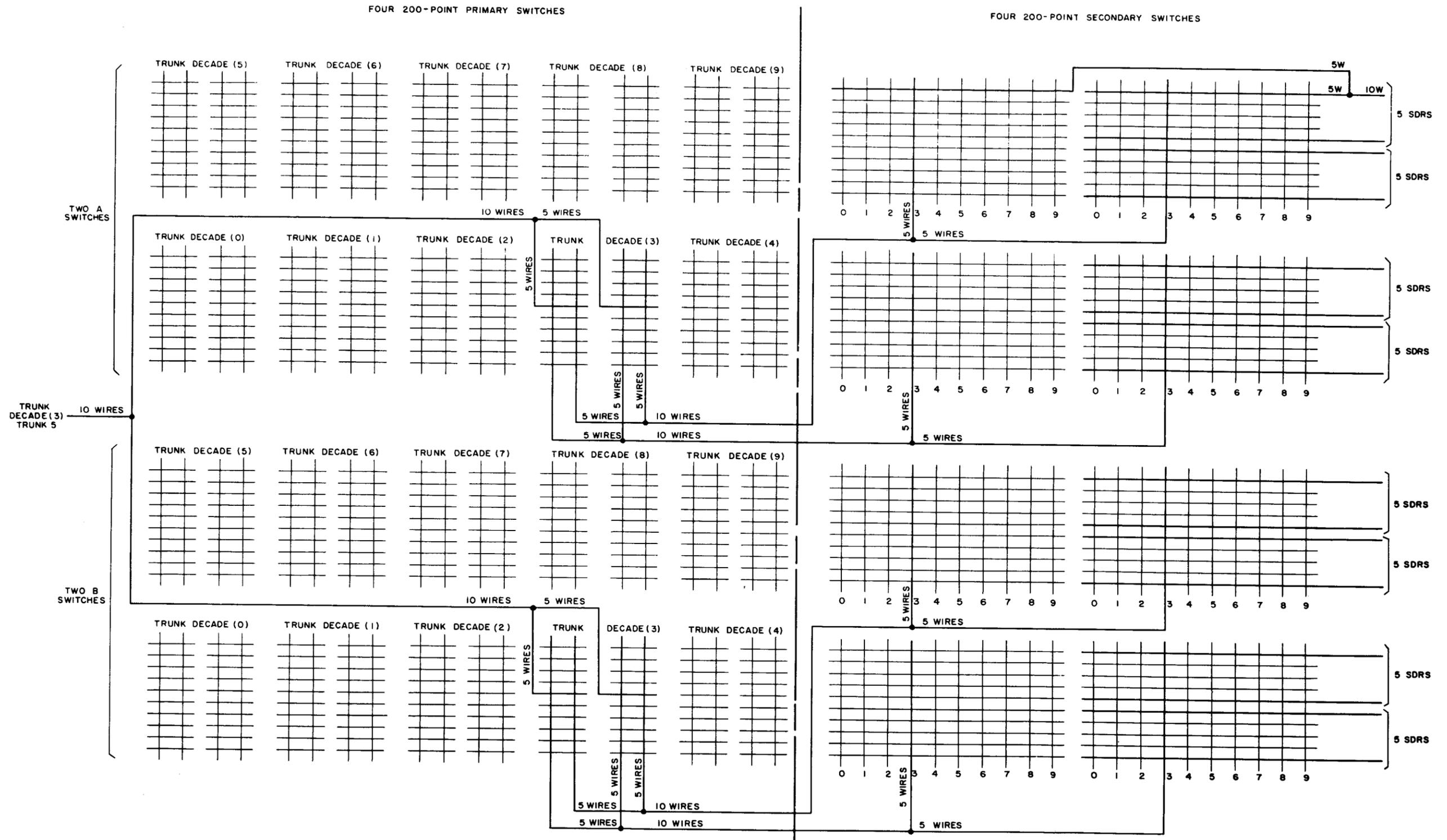


Fig. 17—Sender Link Frame—Arrangement of Switches (4.15, 4.17, 4.18)

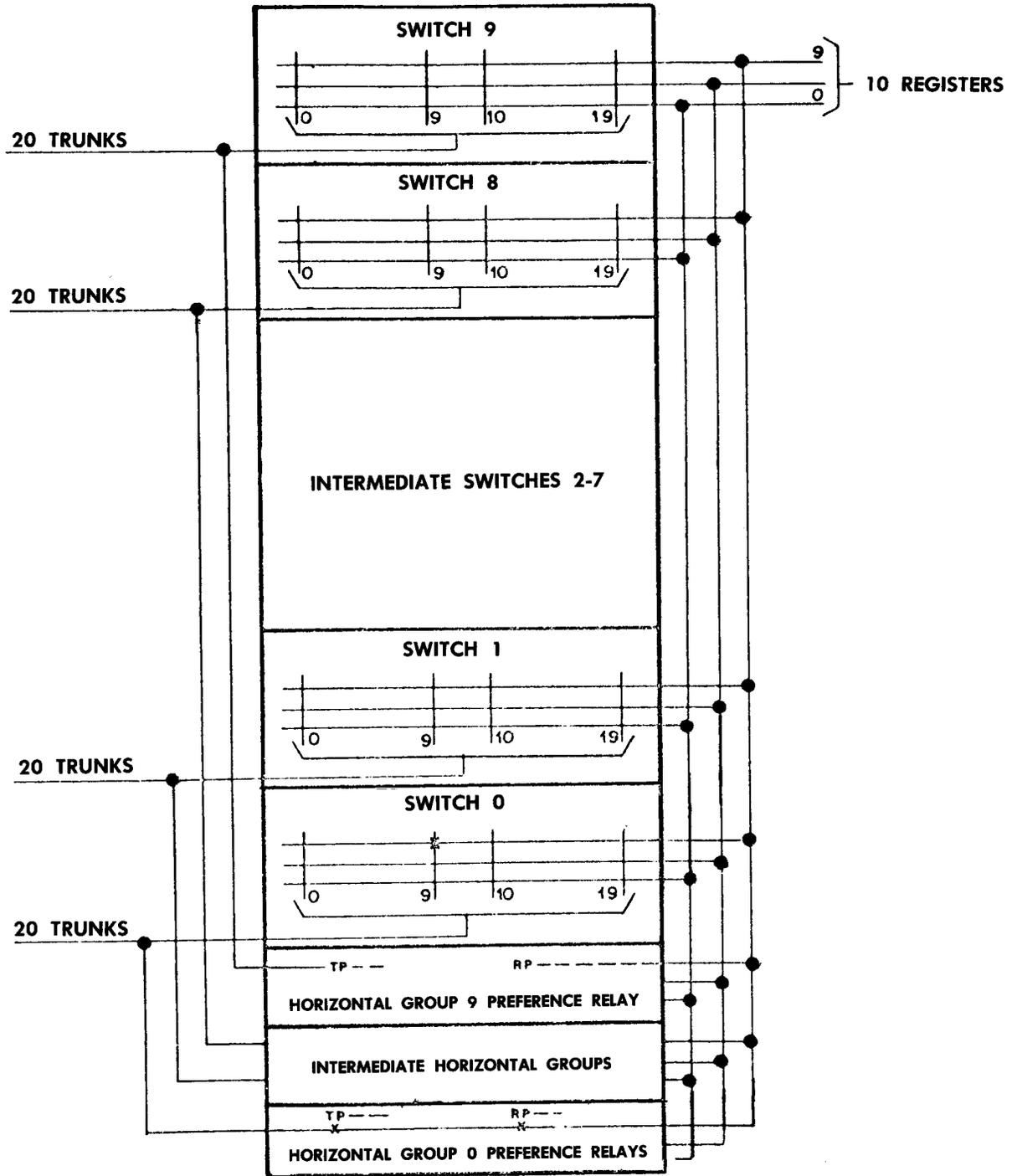


Fig. 18—Incoming Register Link Frame (4.60)

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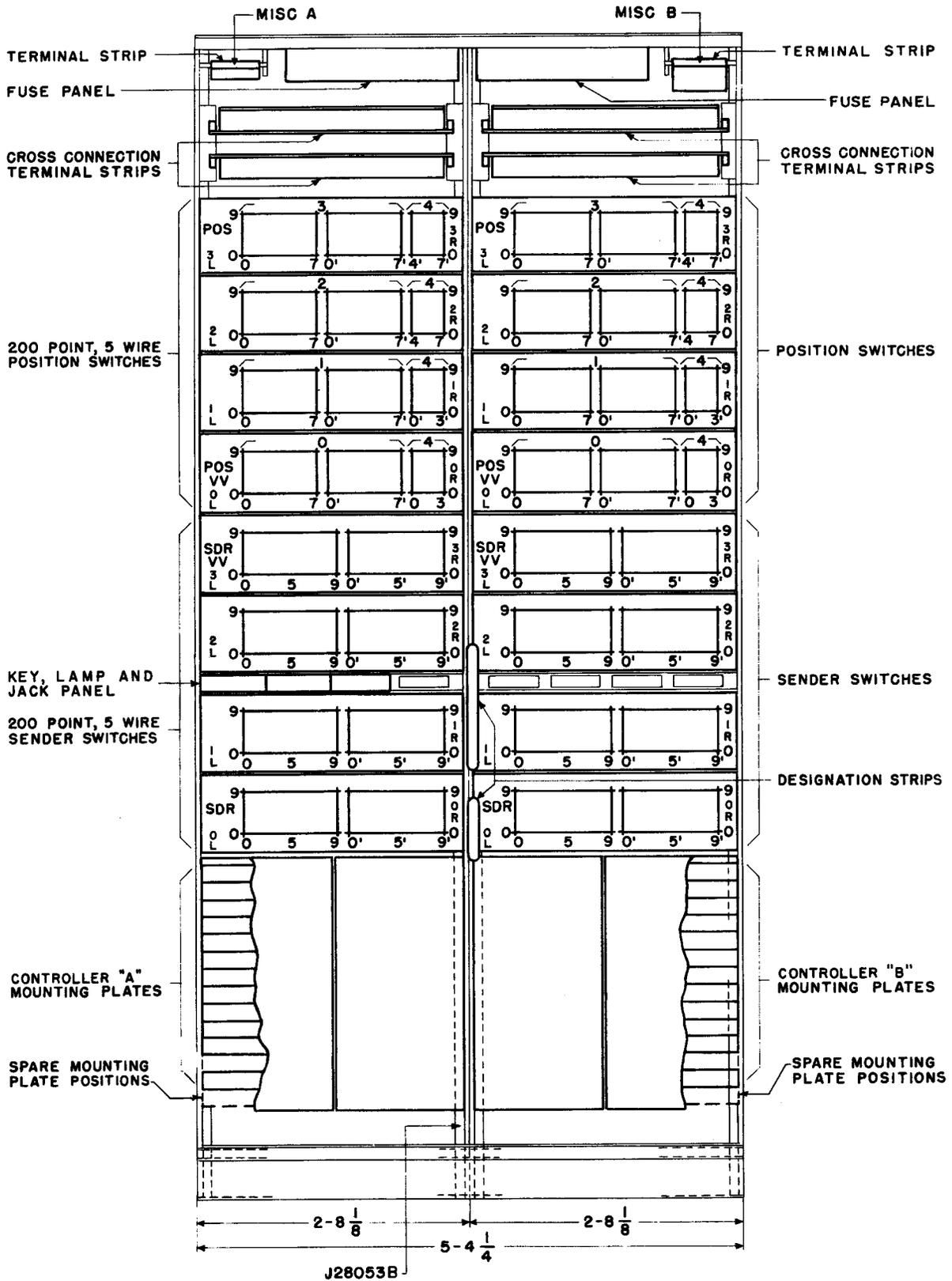


Fig. 19—Position Link Frame (4.76)

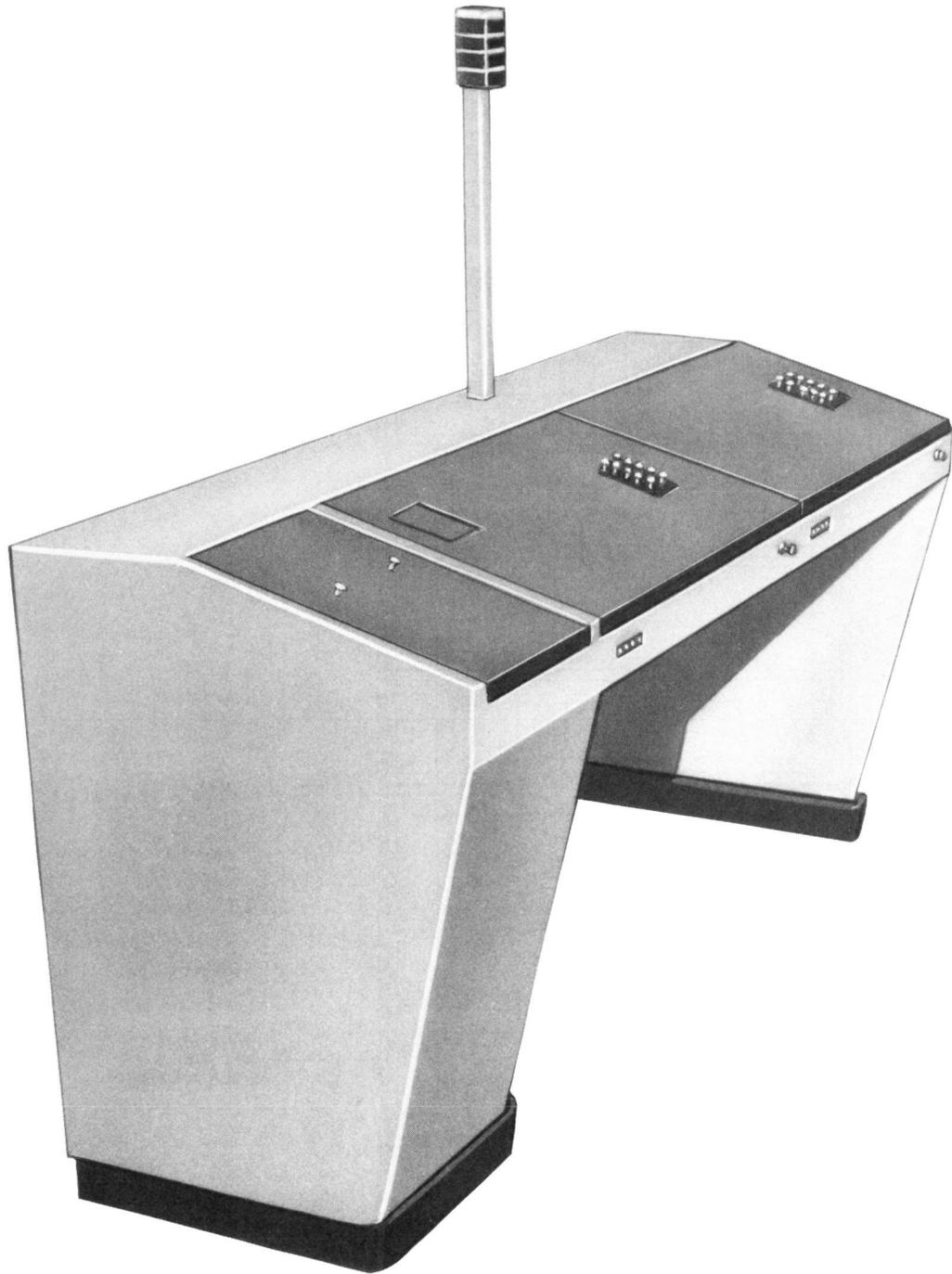


Fig. 20—CAMA Switchboard (4.76)

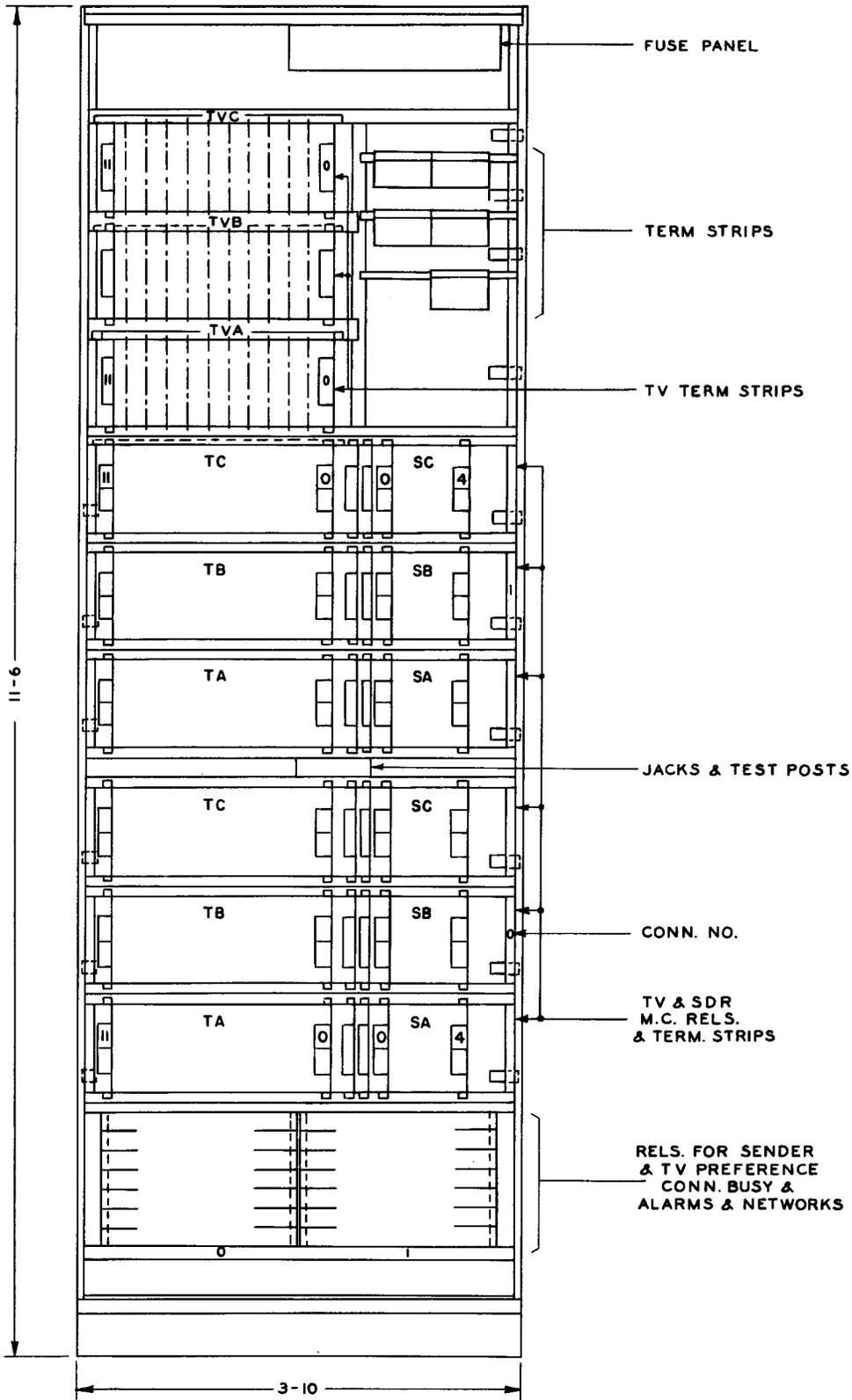


Fig. 21—Transverter Connector Frame (4.88)

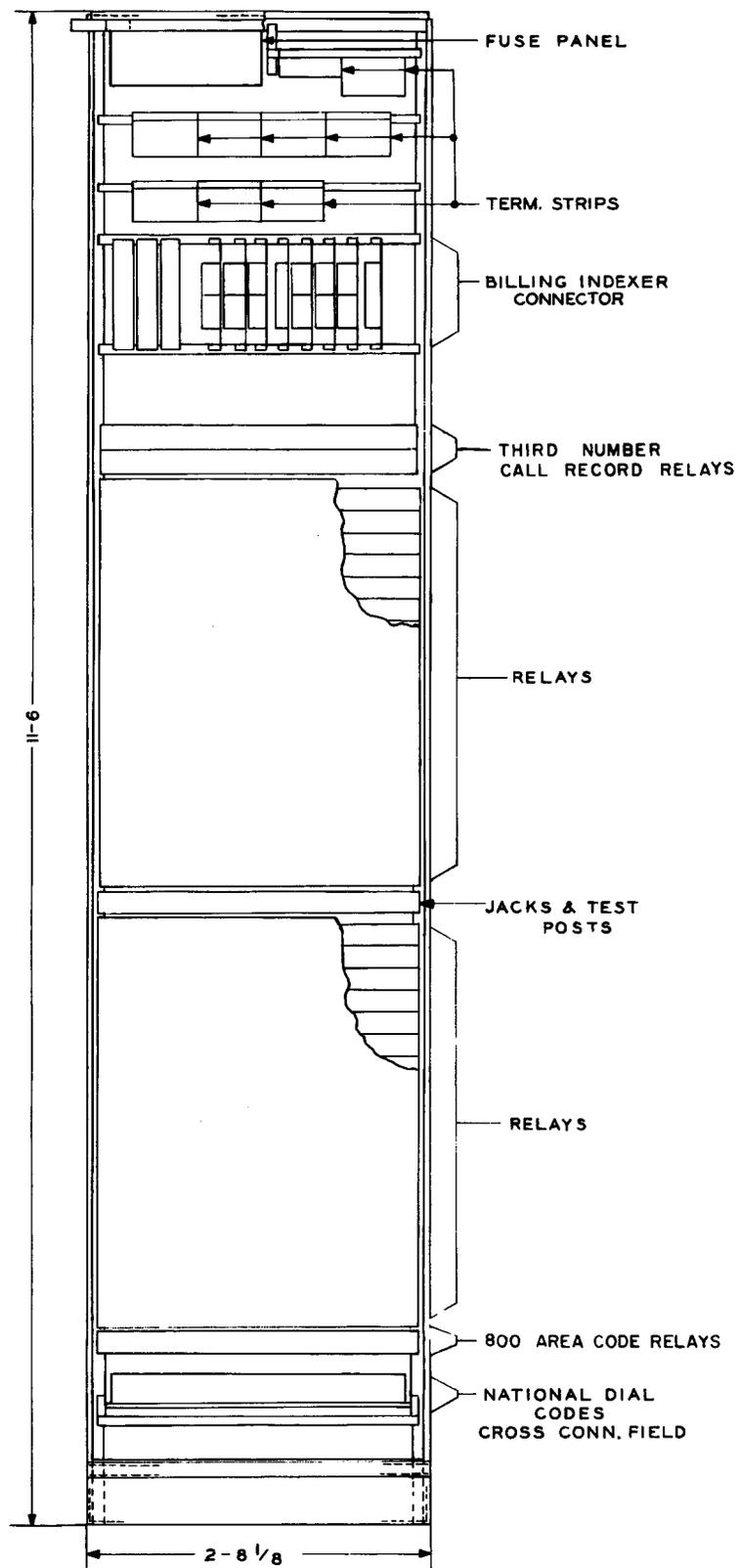


Fig. 22—Tranverter Frame (4.93)

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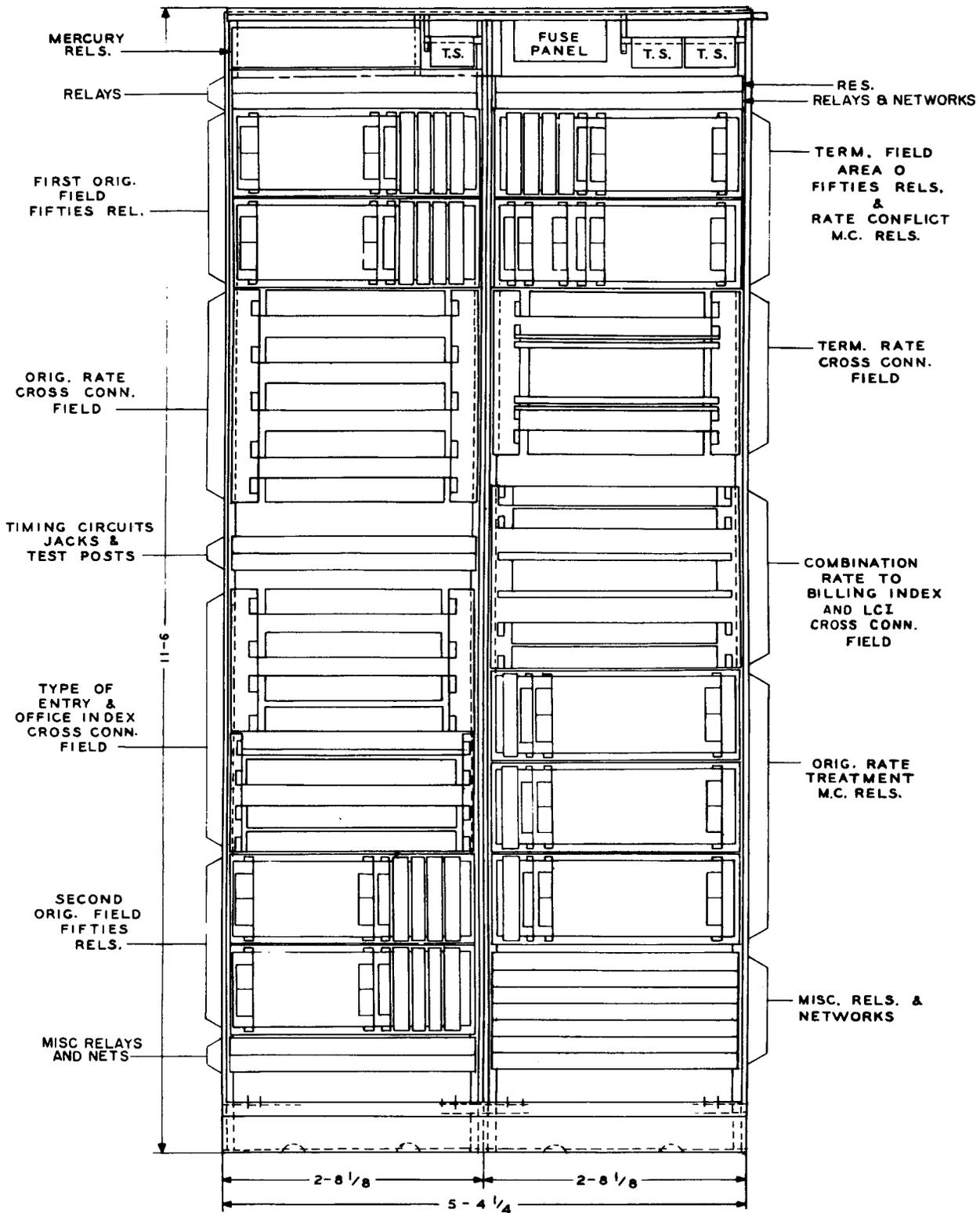


Fig. 23—Billing Indexer Frame (4.96)

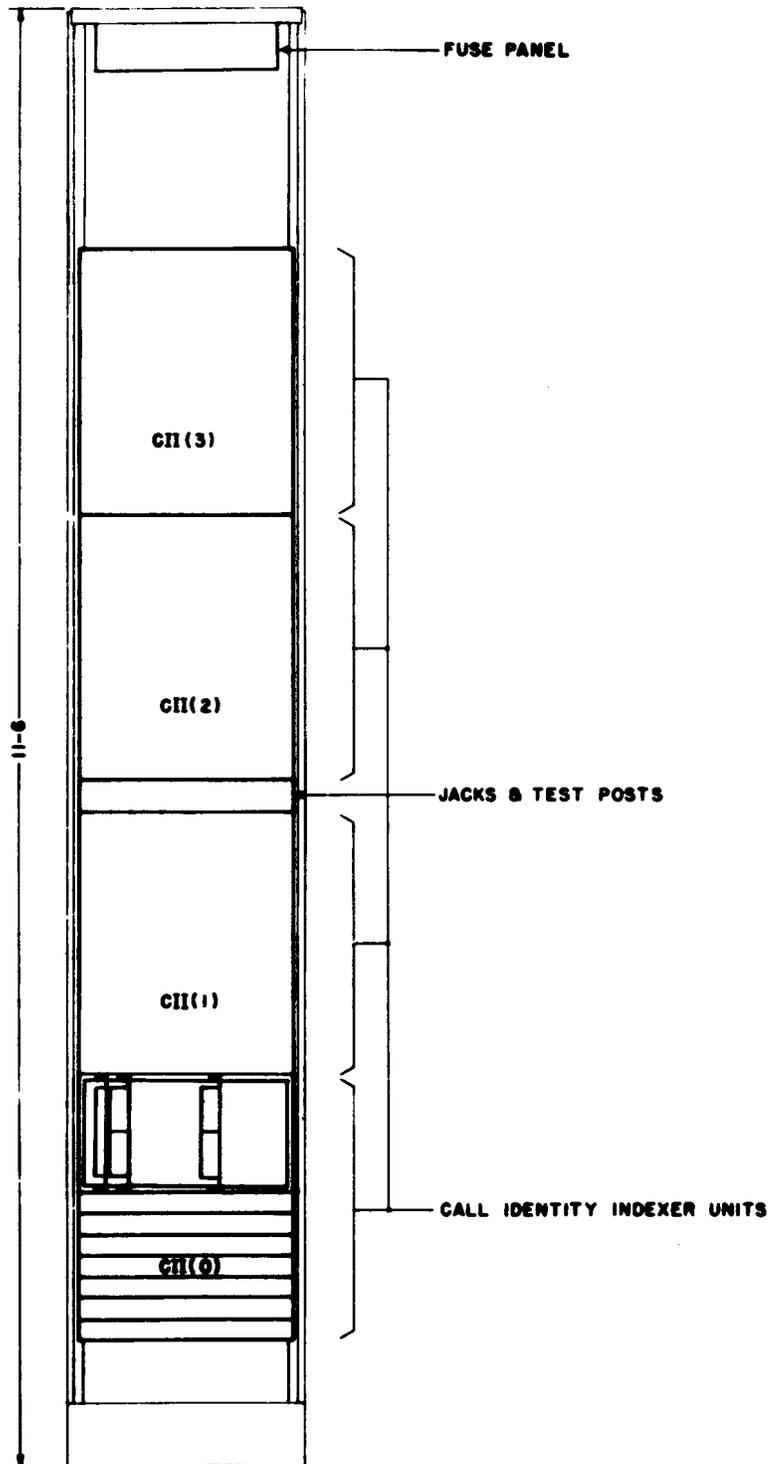


Fig. 24—Call Identity Indexer Frame (4.100)

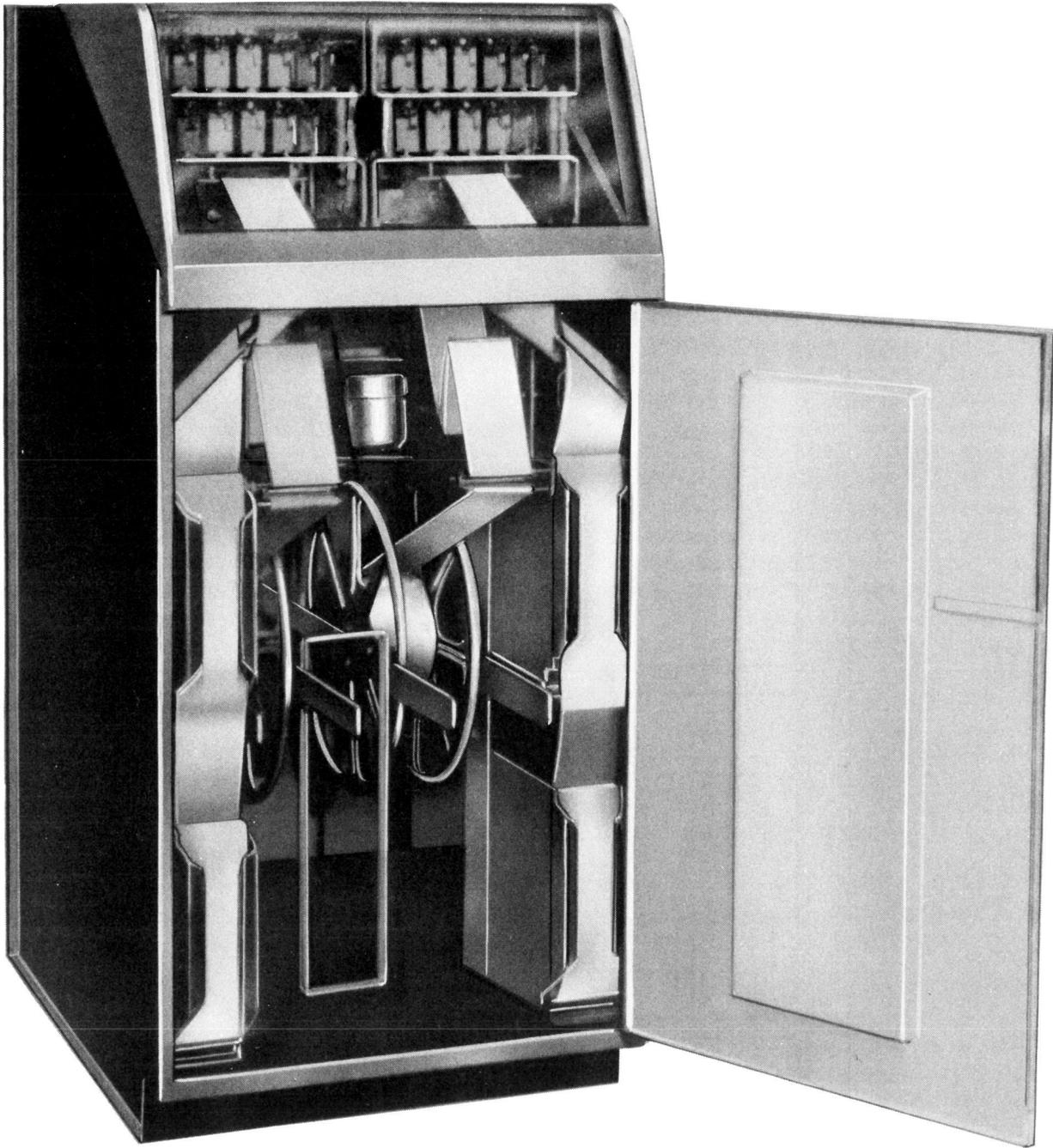


Fig. 25—Central Office Perforator Cabinet (4.102)

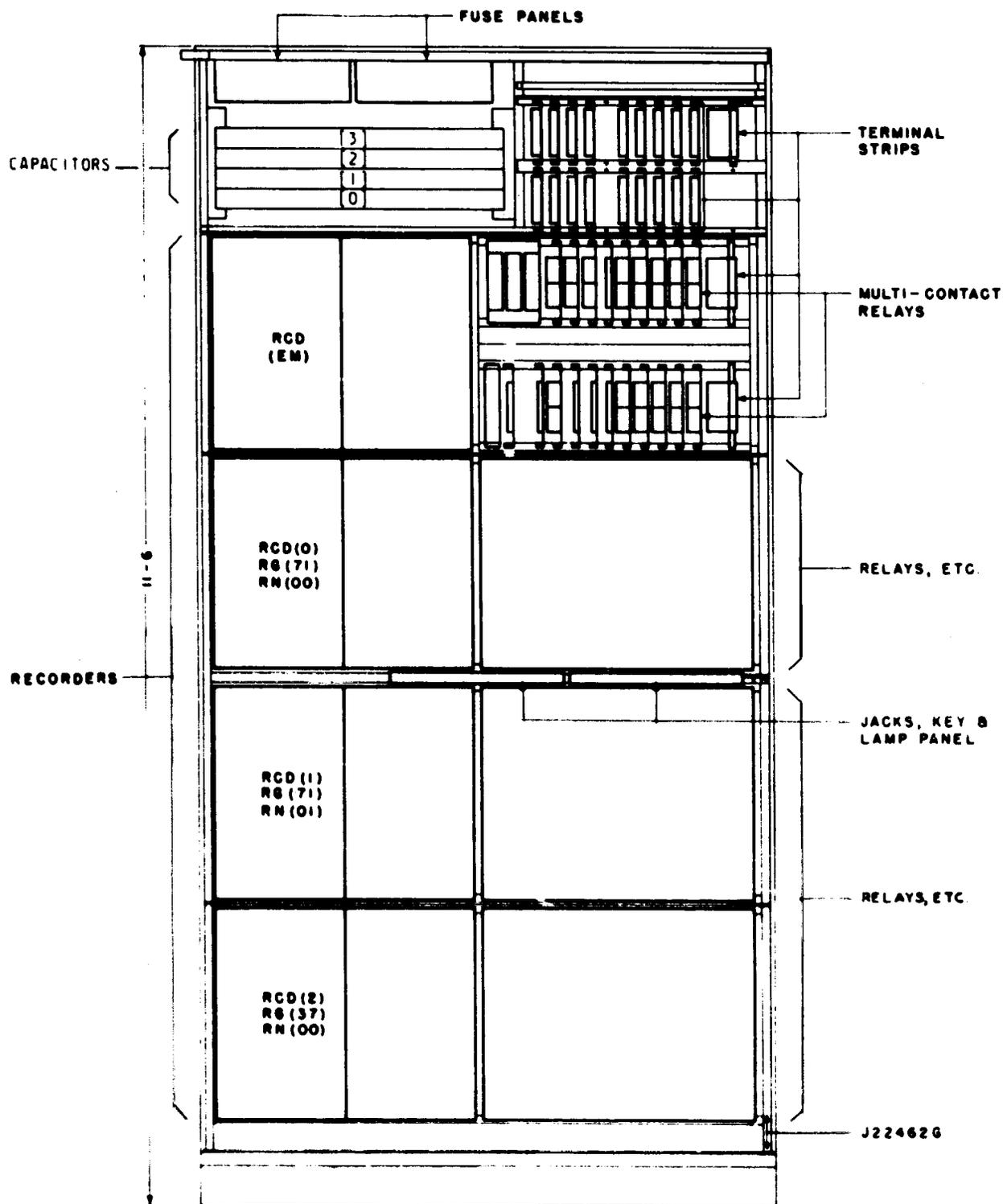


Fig. 26—Recorder Frame (4.105)

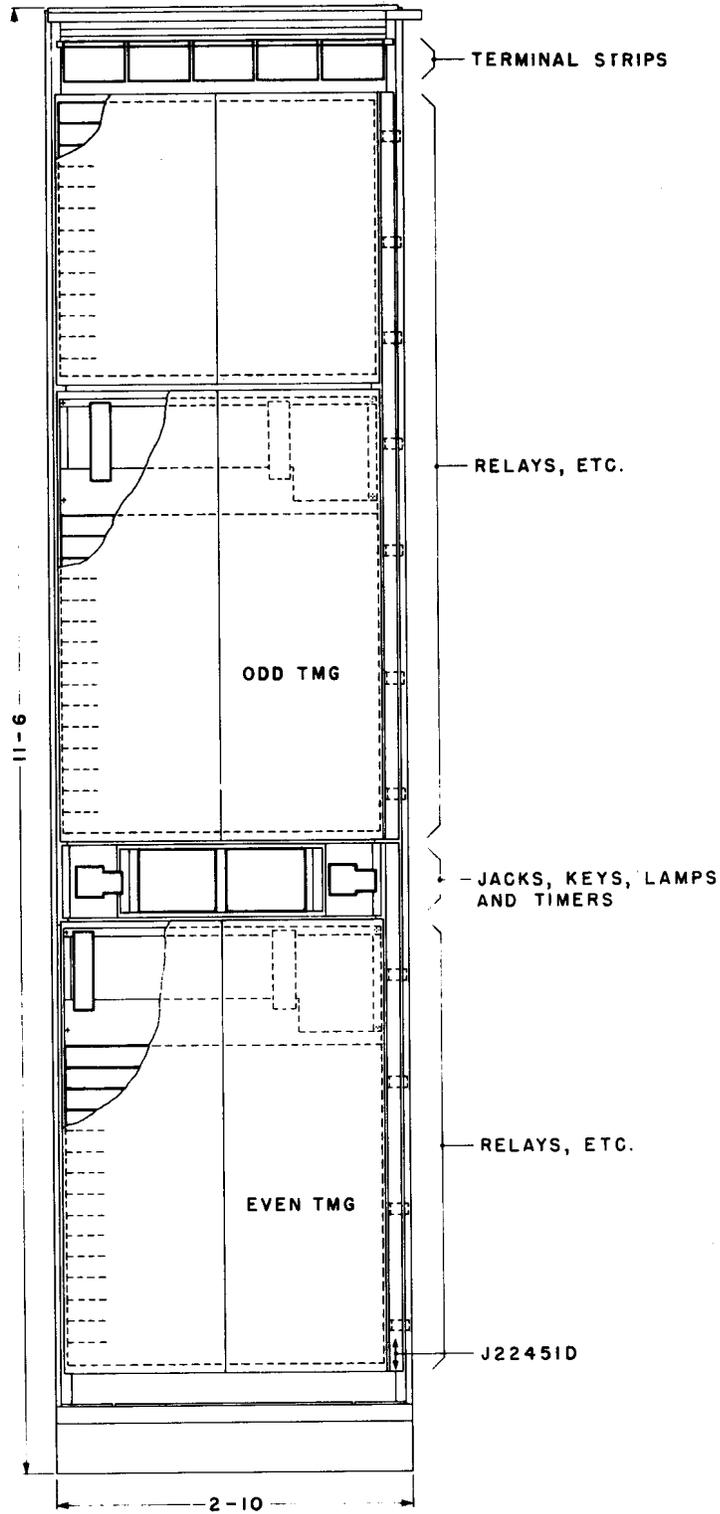


Fig. 27—Master Timing Frame (4.106)

TABLE A
CROSS-CONNECTED JUNCTORS

NO. OF TRUNK AND OFFICE LINK FRAMES	NO. OF JUNCTORS IN GROUP	
	NEW OFFICES	ADDITION
2-2	60	—
4-4	30	40
6-6	52	30
8-8	20	25
10-10	16	20
12-12	14	16
14-14	12	14
16-16	12	12
18-18	11	11
20-20	10	10

TABLE B
SENDER SUBGROUP DISTRIBUTION

LINK GROUP A OR B AND SWITCH SUBGROUP NO.	SENDER LINK FRAME NUMBER									
	0	1	2	3	4	5	6	7	8	
	SENDER SUBGROUP NUMBER									
A3	0	1	2	3	4	5	6	7	8	
A2	1	2	3	4	5	6	7	8	9	
A1	2	3	4	5	6	7	8	9	10	
A0	3	4	5	6	7	8	9	10	0	
B3	4	5	6	7	8	9	10	0	1	
B2	5	6	7	8	9	10	0	1	2	
B1	6	7	8	9	10	0	1	2	3	
B0	7	8	9	10	0	1	2	3	4	