CROSSBAR TANDEM
GENERAL DESCRIPTIVE INFORMATION

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FIGURES

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1. INTRODUCTION

A. 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. This section does not cover the application of centralized automatic message accounting (CAMA) to crossbar tandem, which is described in Section 960-310-100.

1.02 This section is reissued to include some of the newer features that have been added to crossbar tandem, such as foreign area translation, the MF toll sender, the trouble recorder, digit prefixing, intersender timing, and coin zone dialing. Since this reissue covers a general revision, the arrows ordinarily used to indicate changes have been omitted.

1.03 Crossbar tandem equipment is arranged to provide for the switching of calls between central offices situated within dial 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.

1.04 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 record automatically billing information for multiunit and toll calls. This permits customer dialing of these calls from step-by-step or panel offices where no AMA facilities are available for the local offices, as well as from No. 1 and 5 crossbar without AMA in the local offices, and for 4-party and multiparty customers in these offices for which no AMA facilities in the local offices are available.

1.05 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.

1.06 Crossbar tandem is also arranged to permit customer dialing of zone calls from prepay coin stations in panel and No. 1 crossbar areas. Operators located in the originating offices or in near-by buildings will (a) quote the initial period charges, (b) time the overtime, and (c) compute, request, and monitor the overtime charges on these calls.

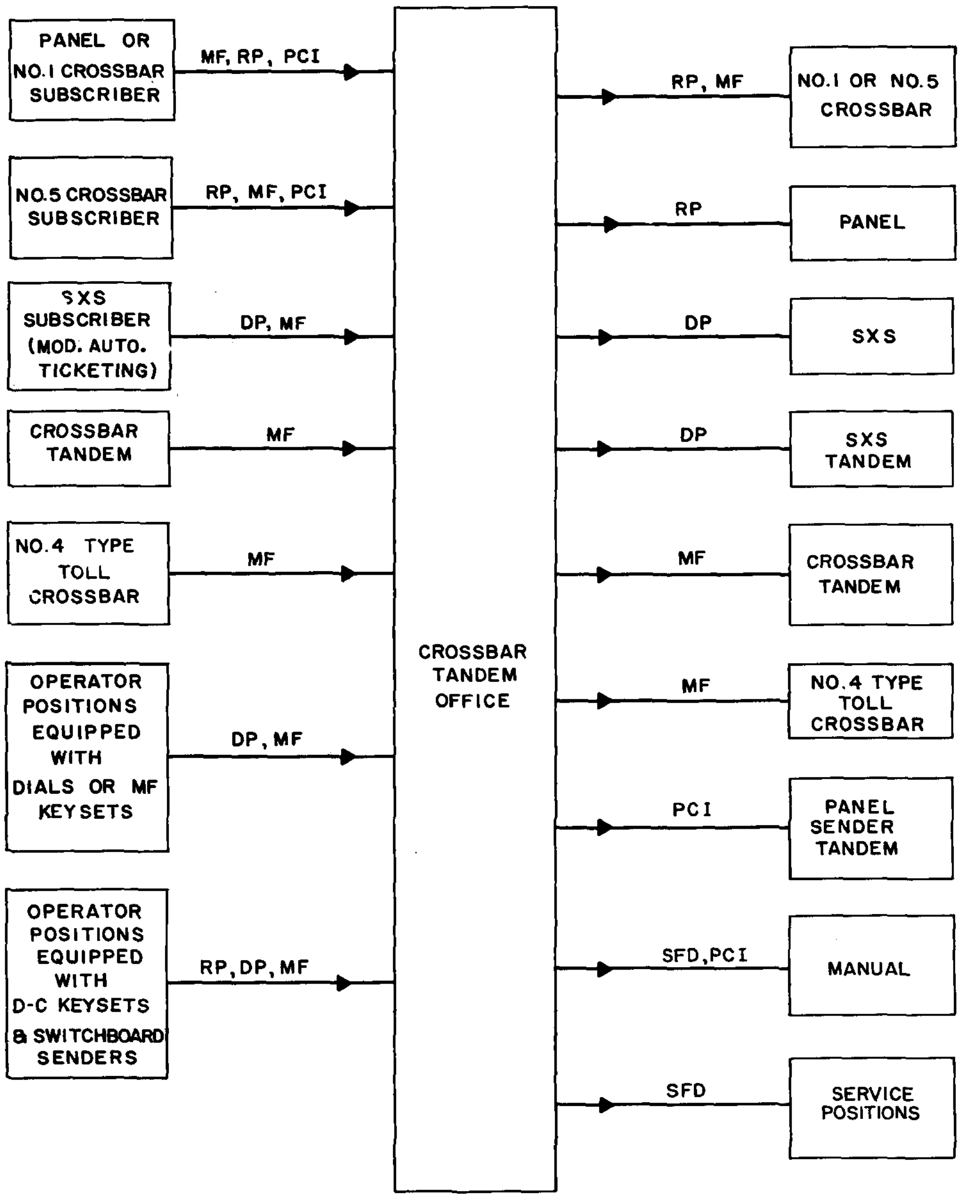
1.07 As a local switching system, crossbar tandem has three functions.

(a) It permits economical trunking by combining small volumes of traffic between local offices into larger volumes which are routed over common trunk groups with increased efficiency resulting in smaller over-all costs.

(b) With certain limitations, it can translate any type of inpulsing to any type of outpulsing to permit the handling of calls between different types of local offices which are not compatible from the standpoint of intercommunication by direct pulsing.

(c) It permits the centralization of equipment and services.

1.08 Crossbar tandem in its original version, was a replacement in panel and No. 1 crossbar areas for the office selector tandems. For this purpose, it used revertive pulsing and could accommodate 50 codes. Later, a change made 100 codes available. With split trunk groups, 300 codes could be accommodated. Calls could be completed to manual, panel, No. 1 crossbar, and step-by-step offices.



NOTE: NOT ALL SENDERS ARE EQUIPPED FOR ALL TYPES OF OUTPULSING SHOWN ABOVE.

Fig. 1 — Block Diagram of Sources and Destinations of Traffic Routed Through Crossbar Tandem Systems

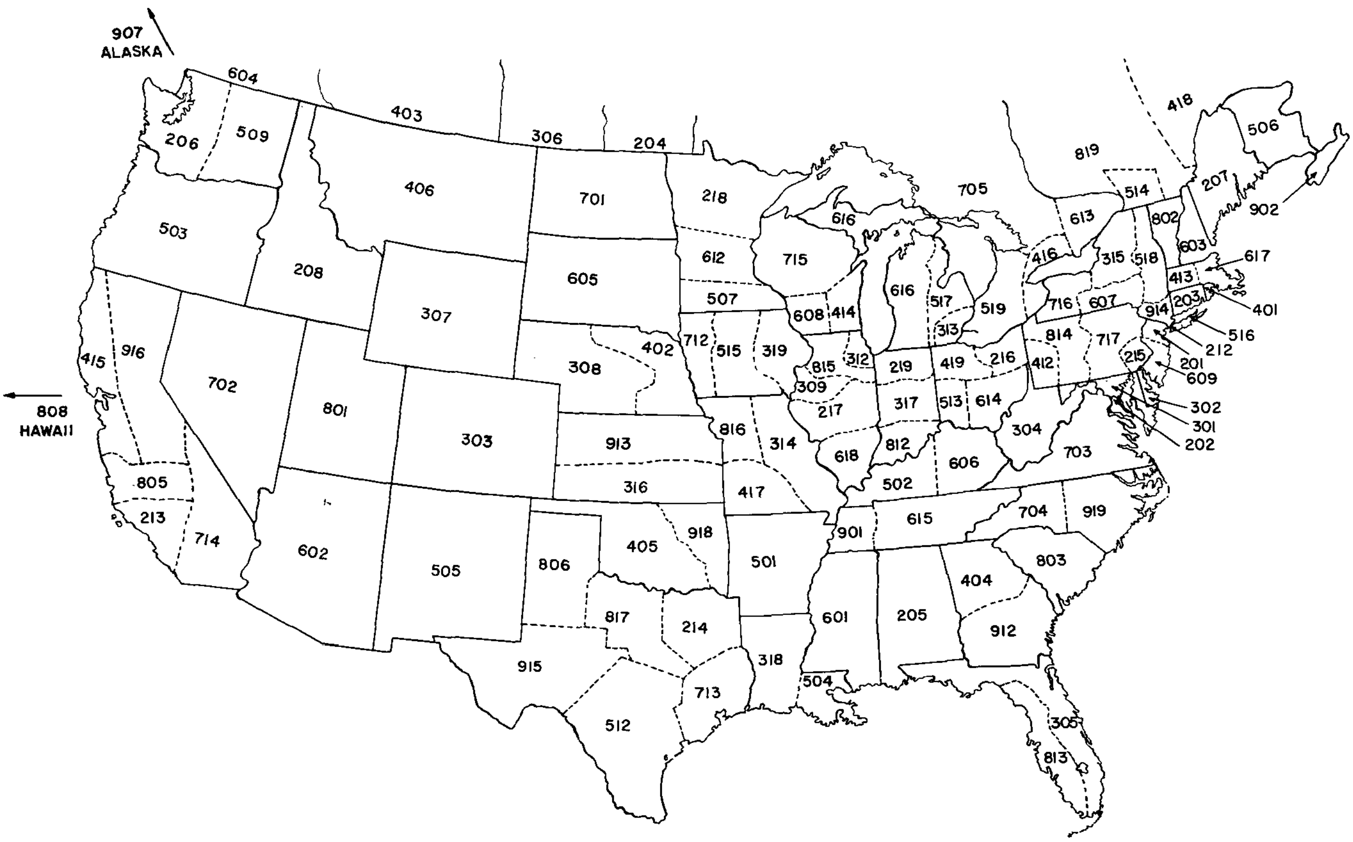


Fig. 2 — Numbering Plan Areas With Codes

1.09 Subsequently, features were added to permit receiving dial pulses from step-by-step offices and dial switchboards. The code capacity with incoming dial pulsing was 800 codes, later expanded to 1000 codes when some toll functions were added.

1.10 Where a crossbar tandem office had access to all the local offices in the area in which it was installed, it was attractive for completing short- and long-haul toll calls. To permit this type of completion, features were added including the ability to receive seven digits on a multifrequency basis.

1.11 In a later version, crossbar tandem began handling outgoing intertoll traffic. This was accomplished by the addition of multifrequency outpulsing features and the expansion of multifrequency inpulsing and outpulsing to ten digits.

1.12 Additional toll features have been developed for crossbar tandem which permit its use as a through-toll switching system. In this connection, crossbar tandem will be used in cities where the higher cost of the No. 4A toll switching system may outweigh the economies possible with its large capacity and versatility.

1.13 The introduction of crossbar tandem (a 2-wire system) as a toll switching system has been made possible by improved transmission techniques. The effect of echo paths at the through switching points, many of which will employ crossbar tandem switching systems, has been minimized by providing high average office return losses. Impedance compensators and fixed pads are used to improve terminal return losses, when necessary, in order to secure the transmission advantage of eliminating switching pads at the terminals of toll connections. Further, through the use of carrier systems, intermediate singing and echo paths that are normally present in 2-wire facilities have been eliminated.

1.14 Fig. 1 is a block diagram showing the sources and destinations of traffic which can be routed by a crossbar tandem system which is completely equipped. However, not all crossbar tandem offices are equipped for all types of inpulsing or outpulsing.

1.15 Before considering the switching features of crossbar tandem which permit its use as a through switching system, the general aspects of the nationwide dialing plan will be discussed first. This will include the numbering plan and the switching plan.

B. Numbering Plan

1.16 In order to permit nationwide dialing, a numbering plan has been set up in which each telephone in the United States and Canada has a unique telephone number. To make these numbers convenient for dialing, each will consist of ten or eleven digits (one for a party letter) arranged in an easily recognizable pattern. Each consists of three parts: an area code (three digits), a central office code (three digits), and four or five numericals.

1.17 The United States and Canada have been divided into more than 100 geographical subdivisions called Numbering Plan Areas (NPA). This is shown in Fig. 2. Some of the areas cover as much as an entire state or province while others cover parts of states or provinces with high population and telephone development. The scope of an area is limited to about 500 office codes. Each numbering plan area is assigned a 3-digit area code of the form A0X or A1D where A is any digit except 0 or 1, D is any digit except 1, and X is any digit. (These are often referred to as X0X and X1X codes.)

1.18 The central office code consists of three digits of the form AAX (often referred to as ABX). These codes followed by the numericals are referred to as 2-5 numbering or as 2L-5N. The AAX block of numbers provides 640 nonconflicting codes of which about 540 are suitable for office names. A limit of 500 codes is commonly quoted for an NPA. The nationwide numbering plan retains these codes for local calls and also uses them in the nationwide plan for toll calls.

1.19 To illustrate how this is done, consider a New York City telephone with a local listing of MAin 2-9970. Since the area code for New York City is 212, the nationwide telephone number is 212-MA2-9970. To reach this number from any point in the New York City dialing area, MA2-9970 is dialed. To reach this number by direct distance dialing from any point outside this area, 212-MA2-9970 is dialed.

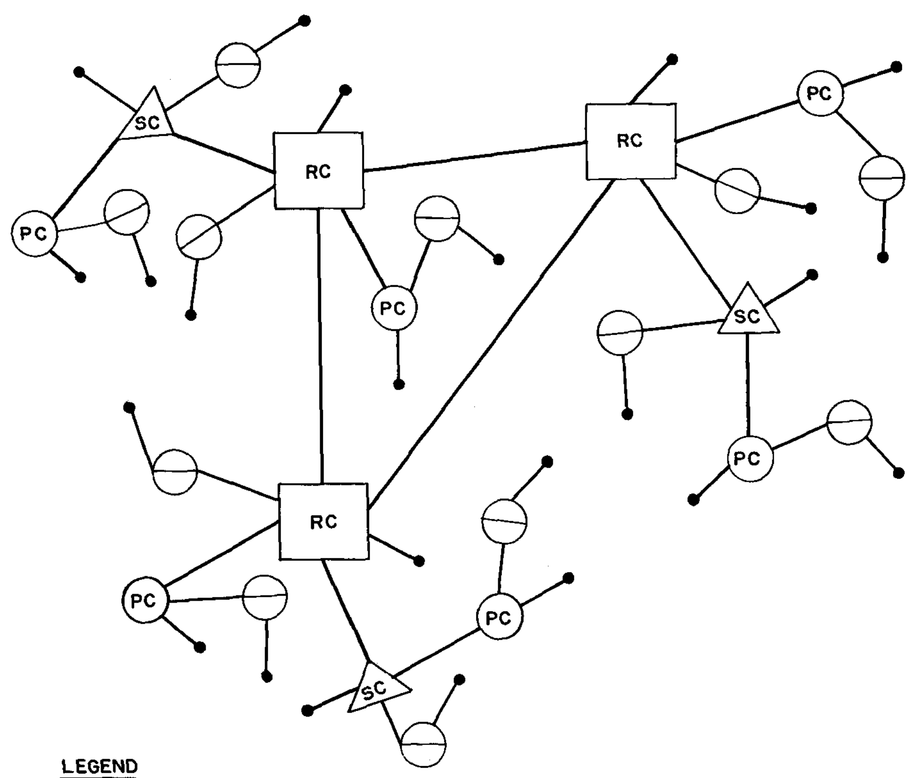
C. Switching Plan

1.20 The switching plan used in nationwide dialing employs a system of routing toll calls in which intertoll trunks are utilized at very high efficiency and yet the chance of a call being delayed due to finding all trunks busy is small. This is made possible by an alternate routing plan in which, on a given call, a preferred route and as many as six alternate routes may be tested for an idle trunk in rapid succession. (A direct route and a maximum of three alternate routes are available in crossbar tandem.) In this way, the call can be advanced toward its destination over the first trunk found idle in any of the available routes.

1.21 The intertoll trunks are used at high efficiency because most of the trunk groups are engineered to carry only a part of the traffic load offered during the busy hour. The balance is overflowed successively to other groups in a predetermined order. The calls not disposed of on these high usage trunk groups are overflowed to a final trunk group where they are quite likely to find an idle path. These final trunk groups are engineered on a low delay basis; that is, enough trunks are provided to make the probability small that any call will encounter an all-trunks-busy condition in the busy hour. The effect is to keep most of the trunks in the network busy a large proportion of the time in the busy hour, and at the same time to minimize the proportion of the calls encountering an all-trunks-busy condition.

1.22 The traffic is distributed over these high usage and final trunk groups at control switching points (CSPs). These CSPs are the more important toll centers and have a systematic classification. Each of these offices will be a No. 4A or 4M toll crossbar, crossbar tandem, No. 5 crossbar, or step-by-step installation, or any suitable dial equipment of independent manufacture.

1.23 There are three types of CSPs: regional center (RC), sectional center (SC), and primary center (PC). These are also referred to as Class 1, 2, and 3 offices, respectively, as shown in Fig. 3. Each toll center (TC) that is not a CSP has a final group of trunks to one particular CSP. This is its home CSP which may be a PC, SC, or RC. In a similar manner, there is a final group from each PC to its home



LEGEND

SYMBOL	CLASS	NAME	ABBREVIATION
□	1	REGIONAL CENTER	RC
△	2	SECTIONAL CENTER	SC
○	3	PRIMARY CENTER	PC
⊖	4	TOLL CENTER	TC
●	5	END OFFICE	EO

Fig. 3 — Homing Arrangements

SC or RC, and from each SC to its home RC. All RCs in the United States will be interconnected with final groups. These final groups of trunks comprise the backbone network of paths between any two toll centers.

1.24 In addition to this backbone network of final trunk routes, high usage trunk groups may be provided between any two points, regardless of their categories, that is, whether TC, PC, SC, or RC, where the traffic and cost ratio justify their use.

1.25 In a few cases, the volume of traffic between two CSPs other than RCs, where normally high usage groups would be established, may be so high or the back haul via the final network so long that a final group will be established and the alternate through a higher center will not be used.

1.26 The following discussion describes the possible routes which a call may take in going from a PC (A), to a TC (B). (See Fig. 4.) This figure shows seven intermediate links or six switches (-PC-SC-RC-RC-SC-PC-), which is the maximum number required to switch a call between any two toll centers in the nationwide network. Actually, very few calls will involve as many as six switches.

1.27 It will be noted from the following discussion, that a call is progressively routed in a predetermined order from one CSP to the next in the chain in its search for an idle trunk.

1.28 At the home PC (A), there are six routes, five high usage trunk groups and a final route, which can be used to get to TC (B). The high usage groups are tested in the following order: a, b, c, d, and e. If no idle trunk is found in these groups, the call is switched over the final group of trunks, f, to the home SC. At the SC, four high usage groups are possible. These are tested as follows: home SC to TC (B), and then in order to distant PC, distant SC, and distant RC. If these are all busy, the call is switched over the final group of trunks to the home RC. At this RC three high usage trunk groups are possible. At the distant RC two high usage groups are possible. At the distant SC one high usage group is possible and the call progresses in the manner described trying all available high usage trunks until it gets to the final route between the distant PC and TC (B). In a rather unlikely case, the call would be advanced to its destination, TC (B), entirely by final trunk groups.

1.29 As indicated in this example, the order of testing the trunk groups is from far to near along the final route. That is, the first route tested is direct to the distant TC serving the called local office. Testing then proceeds in order to the distant PC, SC, and RC, then to the home RC, and finally to the home SC. The whole operation of checking the available routes is performed in about a second at each office.

1.30 Fig. 4 shows the preferred route and the five alternate routes available between a PC and a TC. The six alternate routes referred to in 1.20 assume that a direct trunk group is provided from a PC to a distant end office; in which event, the first alternate route is from the PC to the TC of the end office.

D. Switching Features of Crossbar Tandem

General

1.31 This part describes the features which have been added to crossbar tandem to permit its use as a CSP. These include automatic alternate routing, the ability to store and send forward digits as required, code conversion (transmitting forward digits different from those registered), prefixing digits ahead of the called central office code, and 6-digit translation. Code conversion and prefixing cannot be used on the same call.

Alternate Routing

1.32 The switching plan, as described in 1.20 through 1.30, is based on the use of alternate routing. Crossbar tandem can test a maximum of three alternate routes in addition to the first choice route.

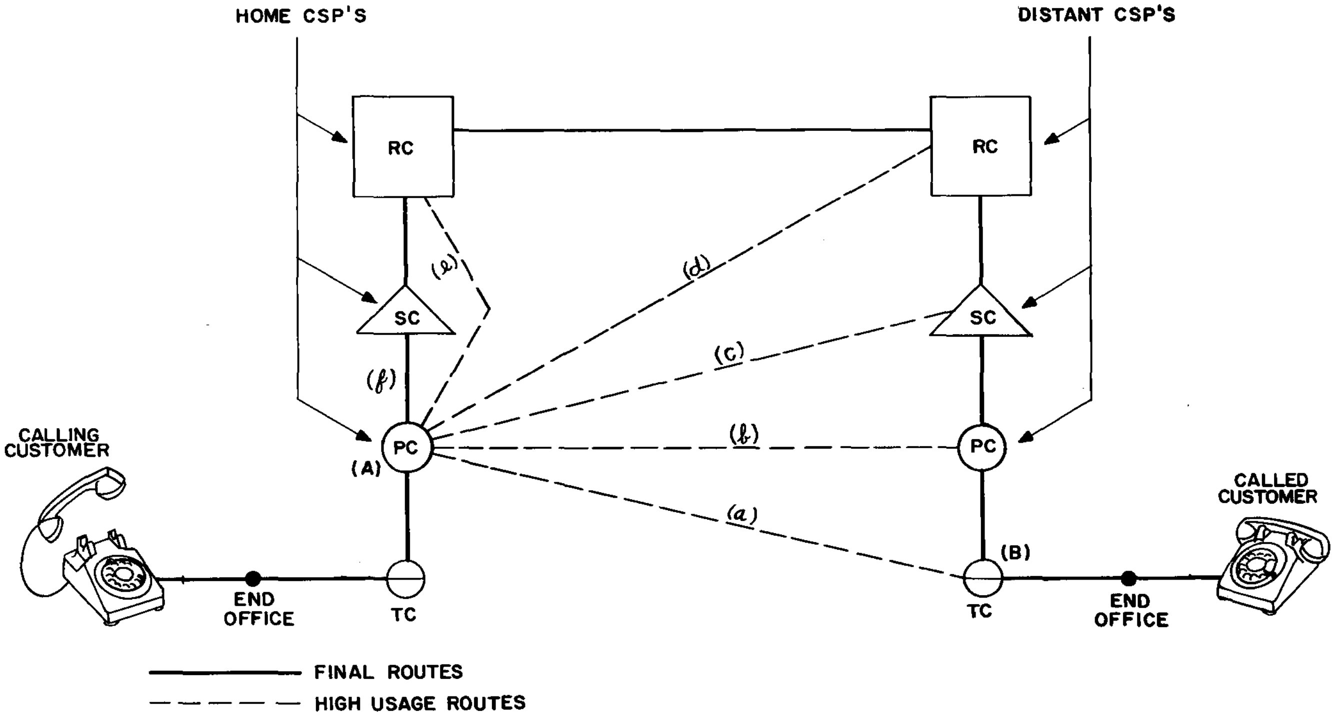


Fig. 4 — Illustrative Toll Network

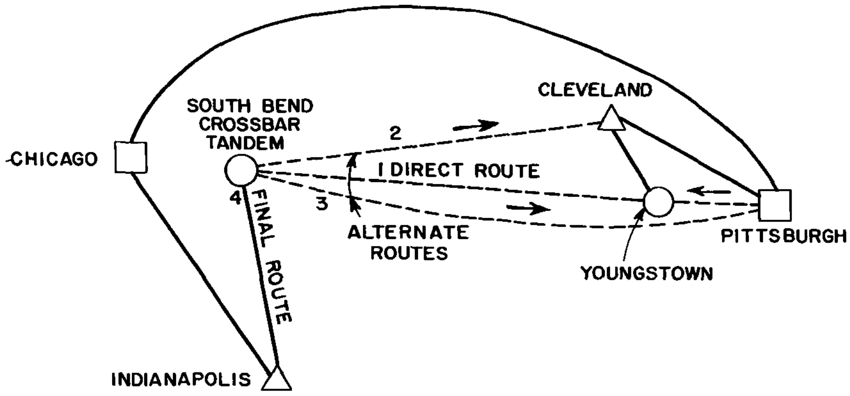


Fig. 5 — Alternate Routing

1.33 Fig. 5 shows a hypothetical example of alternate routing where a crossbar tandem office at South Bend, Indiana, receives a call destined for Youngstown, Ohio. To select an idle path using this plan, the switching equipment at South Bend first tests the direct trunks to Youngstown. If these are all busy, it tests the direct trunks to Cleveland where the call would be completed over the final group to Youngstown. If the group to Cleveland is also busy, South Bend would test the group to Pittsburgh, and on its last attempt it would test the final group to Indianapolis.

1.34 If the call were routed to Pittsburgh or Indianapolis, the switching equipment at these points would attempt by first choice and alternate routes to reach Youngstown. The final choice backbone route would be via Indianapolis, Chicago, Pittsburgh, and Cleveland, to Youngstown. Should all the trunks in any of the final groups tested be busy, no further attempt to complete the call is made by the switching system.

Storing and Sending Forward Digits as Required

1.35 The crossbar tandem equipment at control switching points must store all the digits received and send forward as many as are required to complete the call. The equipment is therefore arranged to delete up to three digits on 7-digit calls and up to six digits on 10-digit calls.

1.36 For example, suppose a call is originated by a customer in South Bend, Indiana, destined for customer NAtional 4-9970 in Washington, D. C. If it is assumed that the route to Washington is via a CSP in Pittsburgh, then the crossbar tandem equipment at South Bend pulses forward to Pittsburgh 202-NA4-9970, 202 being the area code for the District of Columbia. Pittsburgh, in turn, will delete the area code and send NA4-9970 to the District of Columbia terminating area.

1.37 As another example, suppose the crossbar tandem office at South Bend receives a call destined for a nearby step-by-step end office in Michigan. The crossbar tandem equipment receives and stores a 10-digit number comprising the area code and the seven digits for the office code and station number. Assuming that direct trunks to the step-by-step end office in Michigan are available, the area code and office code are deleted and the station number only is pulsed forward.

1.38 The previous paragraphs described the ability of crossbar tandem to register and outpulse a varying number of digits. In some cases, all digits are outpulsed, and in other cases one or more digits are skipped before outpulsing.

Code Conversion

1.39 Crossbar tandem is provided with another feature called code conversion which permits it to change the code digits received and outpulse the digits required to route a call through an intermediate step-by-step PC.

1.40 This type of operation is illustrated in Fig. 6, where an operator in Chicago desires to reach an information operator in Williston, North Dakota. To do this, she keys 701 + 390 + 131 [N. D. NPA code, plus Williston terminating toll center (TTC) code, plus toll information code] into the No. 4A switching equipment at Chicago.

1.41 The Chicago equipment seizes a trunk to Fargo, deletes the 701 area code (Fargo is in area 701), and outpulses 390 + 131 into the crossbar tandem equipment at Fargo.

1.42 If a direct high-usage trunk between Fargo and Williston is available, the Fargo equipment seizes the trunk and outpulses 131 to reach the information operator. If, however, all of these trunks are busy, the call is routed over the final route via Minot. In this case, the Fargo equipment code converts the Williston TC code 390 to 025 which is the code required to route the call through the step-by-step equipment at Minot. The 025 is used by the step-by-step switches at Minot to establish the connection and the 131 is sent through to Williston.

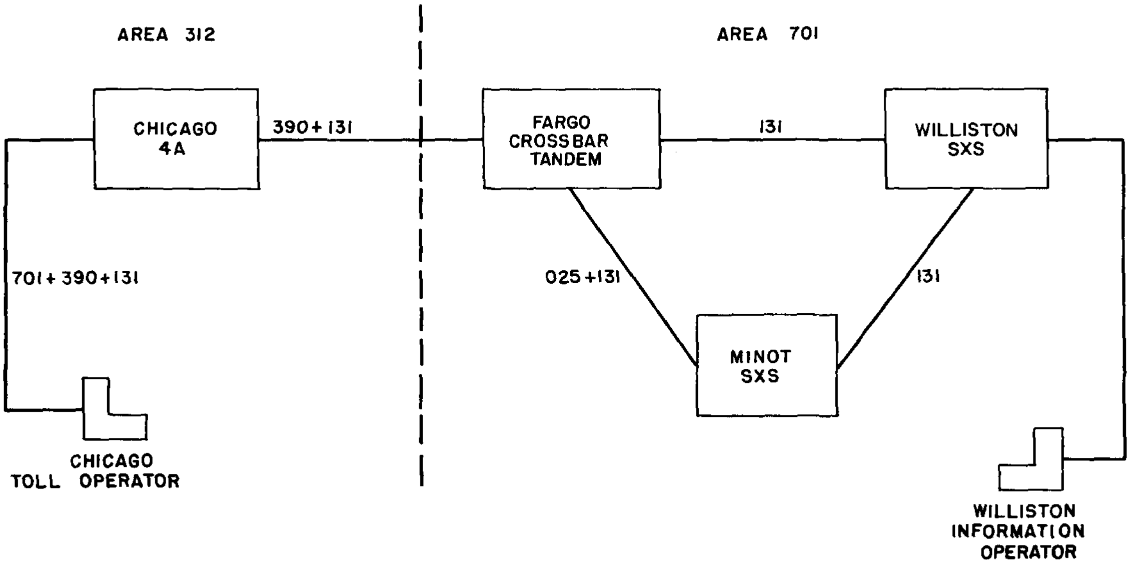


Fig. 6 — Code Conversion

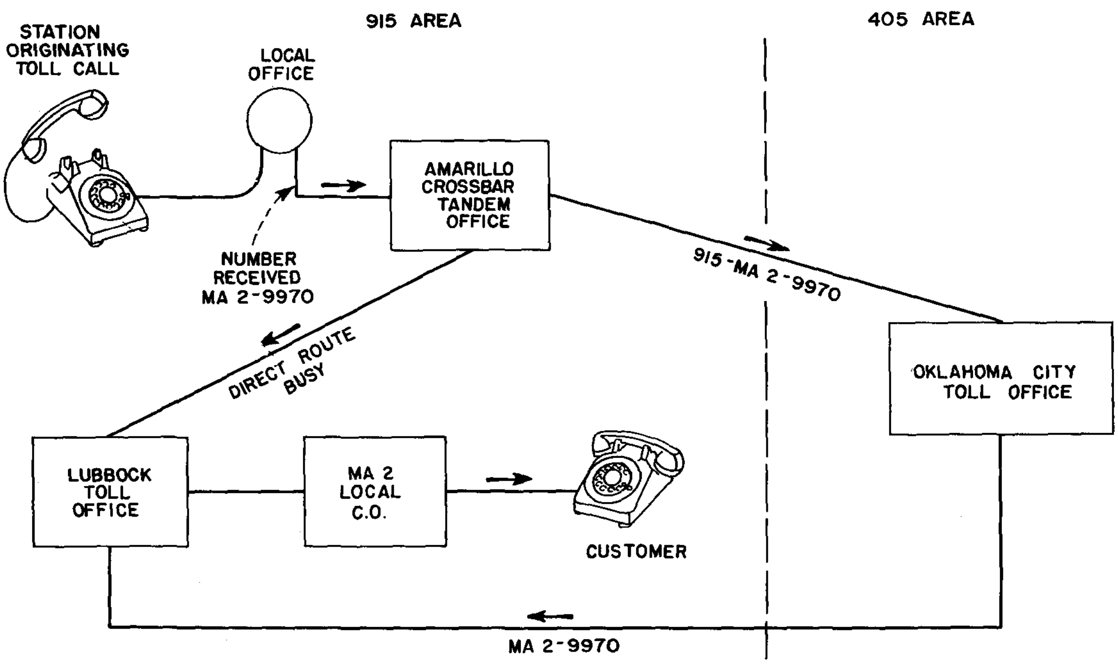


Fig. 7 — Prefixing — Routing Through a Foreign Area

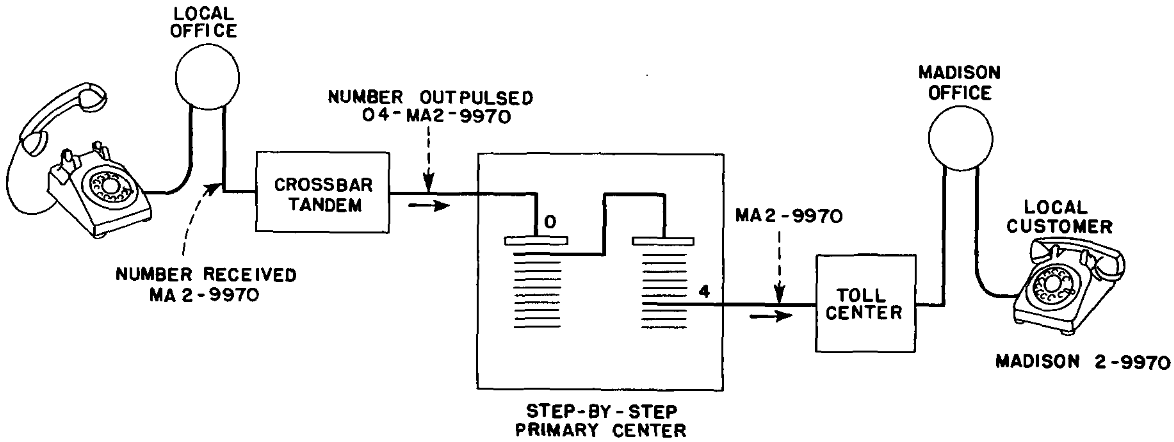


Fig. 8 — Prefixing — Routing Through a Step-by-Step Primary Center

Prefixing Digits

1.43 It may be necessary to route a call from one area to another and back to the original area for completion. Such a situation arises on a call from Amarillo to Lubbock, Texas, both in area 915, when the crossbar tandem switching equipment finds all of the direct trunks from Amarillo to Lubbock busy as illustrated in Fig. 7. The call could be routed to Lubbock via Oklahoma City which is in area 405. A 7-digit number, for example, MAin 2-9970, is received in the crossbar tandem office at Amarillo. Assuming that the call is to be switched out of the 915 area through the 405 area and back to the 915 area for completion, it is necessary for the crossbar tandem office in Amarillo to prefix 915 to the MAin 2-9970 number so that the No. 4A switching equipment in Oklahoma City will know that the call is for the 915 area and not for the 405 area.

1.44 Prefixing digits may also be needed at crossbar tandem offices to route calls through step-by-step primary centers. The crossbar tandem office in Fig. 8 receives the 7-digit number MA2-9970 for a call to a customer in the Madison office in the same area. However, since the toll center needs the full 7-digit number for completing the call, and since the step-by-step switches at the primary center use up two digits (04), the crossbar tandem equipment must prefix 04 to the 7-digit number.

6-digit Translation

1.45 6-digit translation is another feature that has been added to the crossbar tandem system. When only three digits are translated, it is necessary to direct all calls for a foreign area over a single route. The ability to translate six digits permits the establishment of two or more routes from the switching center to or towards the foreign area. This feature is provided by the use of a foreign area translator. Translation may be made for a maximum of ten foreign areas with 60 routings to each area.

1.46 An example of the use of 6-digit translation is shown in Fig. 9, which shows Oakland and Monterey, California, in area 415 and the crossbar tandem at Fresno, California, in area 916. An economical trunking plan may provide for direct circuits from Fresno to each place. If only 3-digit translation were provided in the Fresno switching equipment, the route to both places would be selected as a result of the translation of the 415 area code alone and, therefore, calls to central offices reached through Monterey, would need to be routed via Oakland. This involves not only the extra trunk mileage, but also the use of an extra switching point. With 6-digit translation, both the area code and the central office code are analyzed, making it possible to select the direct route to either city.

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 3200 incoming trunk terminations and 4000 outgoing trunk terminations. The purpose of this part is to 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. 10, these frames are connected by junctors through a junctor grouping frame.

2.03 Each 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. 11A, the incoming trunks appear on the primary switches and the junctors on the secondary switches.

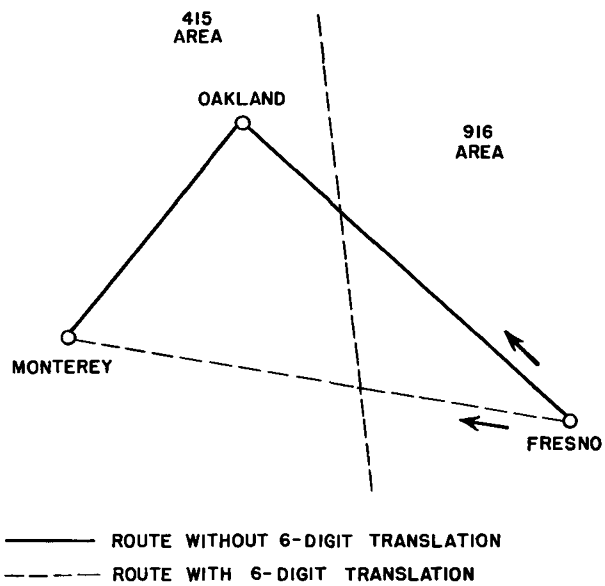


Fig. 9 — Six-digit Translation

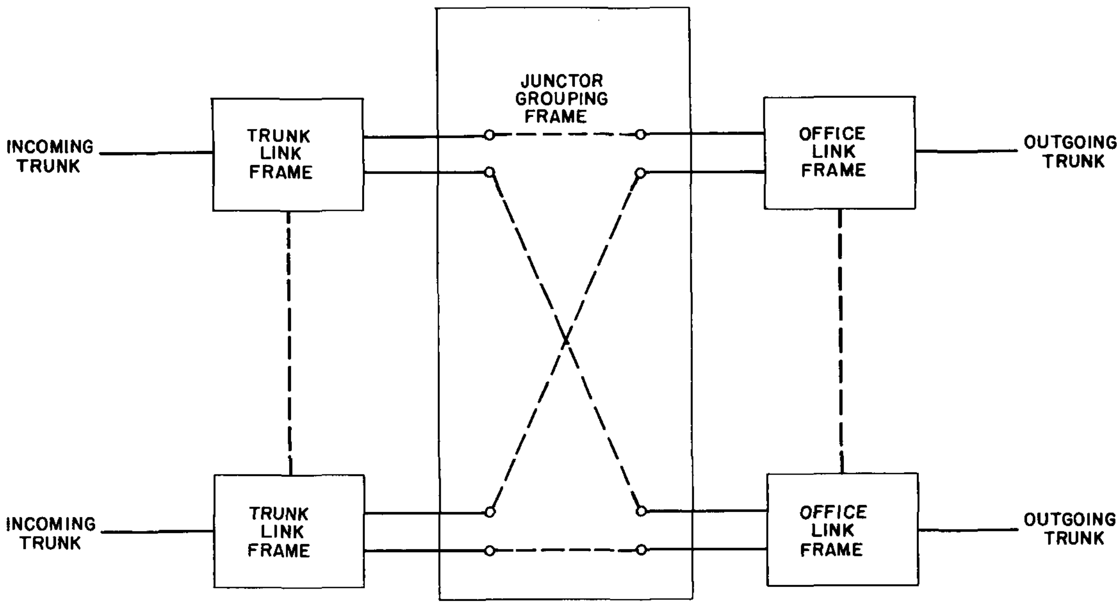


Fig. 10 — Relationship of Trunk Link, Office Link, and Junctor Grouping Frames

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. 11B, 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. 12). 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. The 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. The switch with ten vertical paths has 100 crosspoints and is called a 100-point switch; the one with 20 vertical paths has 200 crosspoints and is called a 200-point switch. Fig. 13, page 41, shows a partial perspective view of a crossbar switch.

Horizontal Paths

2.07 There are five selecting bars mounted horizontally across the face of each switch. Each selecting bar has flexible selecting fingers attached to it; one finger for each vertical path.

2.08 The selecting bars can be partially rotated either up or down, under control of select magnets, so as to deflect the selecting fingers up or down and place each one of them opposite a set of contacts for one of two horizontal paths. There are two horizontal paths per bar or a total of ten horizontal paths per switch.

Vertical Paths

2.09 Ten or 20 vertical units are mounted on the switch and each unit forms one vertical path. Each unit operates under control of

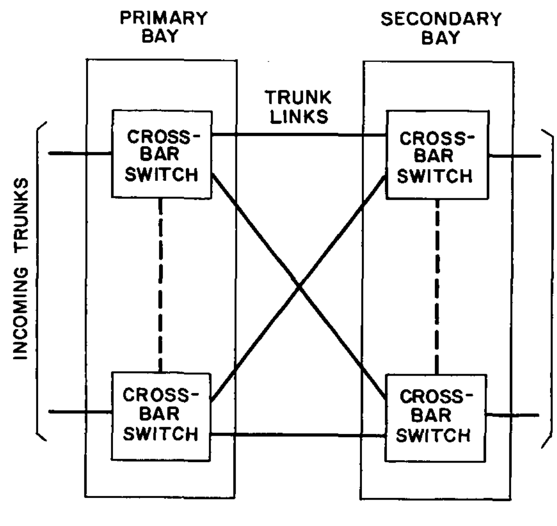


Fig. 11A — Trunk Link Frame — Primary and Secondary Bays Connected by Trunk Links

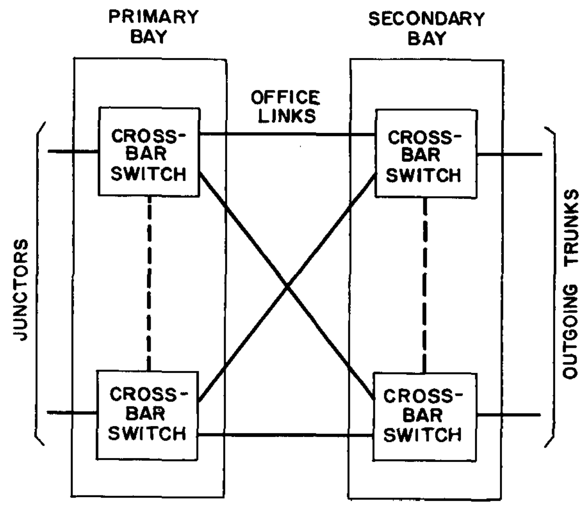


Fig. 11B — Office Link Frame — Primary and Secondary Bays Connected by Office Links

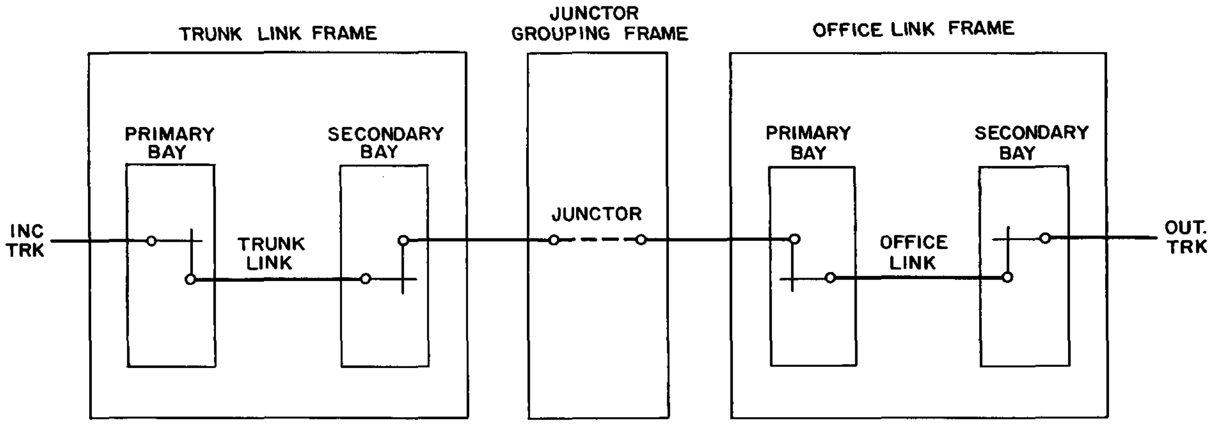


Fig. 12 — A Complete Channel

a hold magnet and has ten groups of contacts (one for each horizontal path) associated with it.

2.10 Each group of contacts may consist of three to six pairs of contact springs. A switch is classified according to the number of crosspoints and pairs of springs; for example, a 200-point, 5-wire crossbar switch.

Operation of the Crossbar Switch

2.11 The normal position of the selecting 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.

2.12 The hold magnet of the desired vertical path then operates its holding armature which causes the group of contacts beside the selecting finger to operate, thus connecting the horizontal and vertical paths. The other groups of contacts on this vertical unit do not operate since there is no selecting finger between them and the holding armature. Both the select and hold magnets must be operated in order to close a crosspoint.

2.13 After the operation of the hold magnet, the select magnet is released, returning the horizontal bar to normal. However, 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

2.14 A crossbar switch usually has each horizontal strapped on the wiring side across the vertical units, thus making ten horizontal paths, as shown in Fig. 14.

2.15 In a split switch, this horizontal strapping is cut in order to provide more than ten horizontal paths. For example, as shown in Fig. 15, a switch can be split between the tenth and

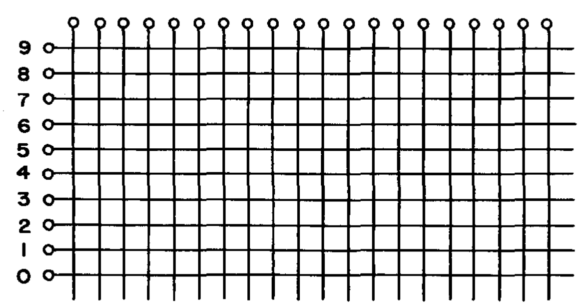


Fig. 14 — Schematic of Crossbar Switch (10 Horizontal Paths)

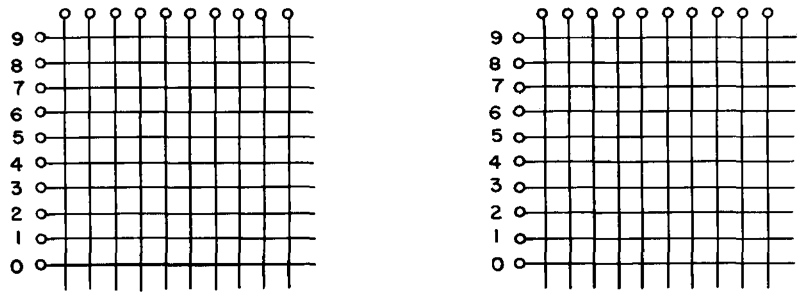


Fig. 15 — Schematic of Crossbar Switch (20 Horizontal Paths)

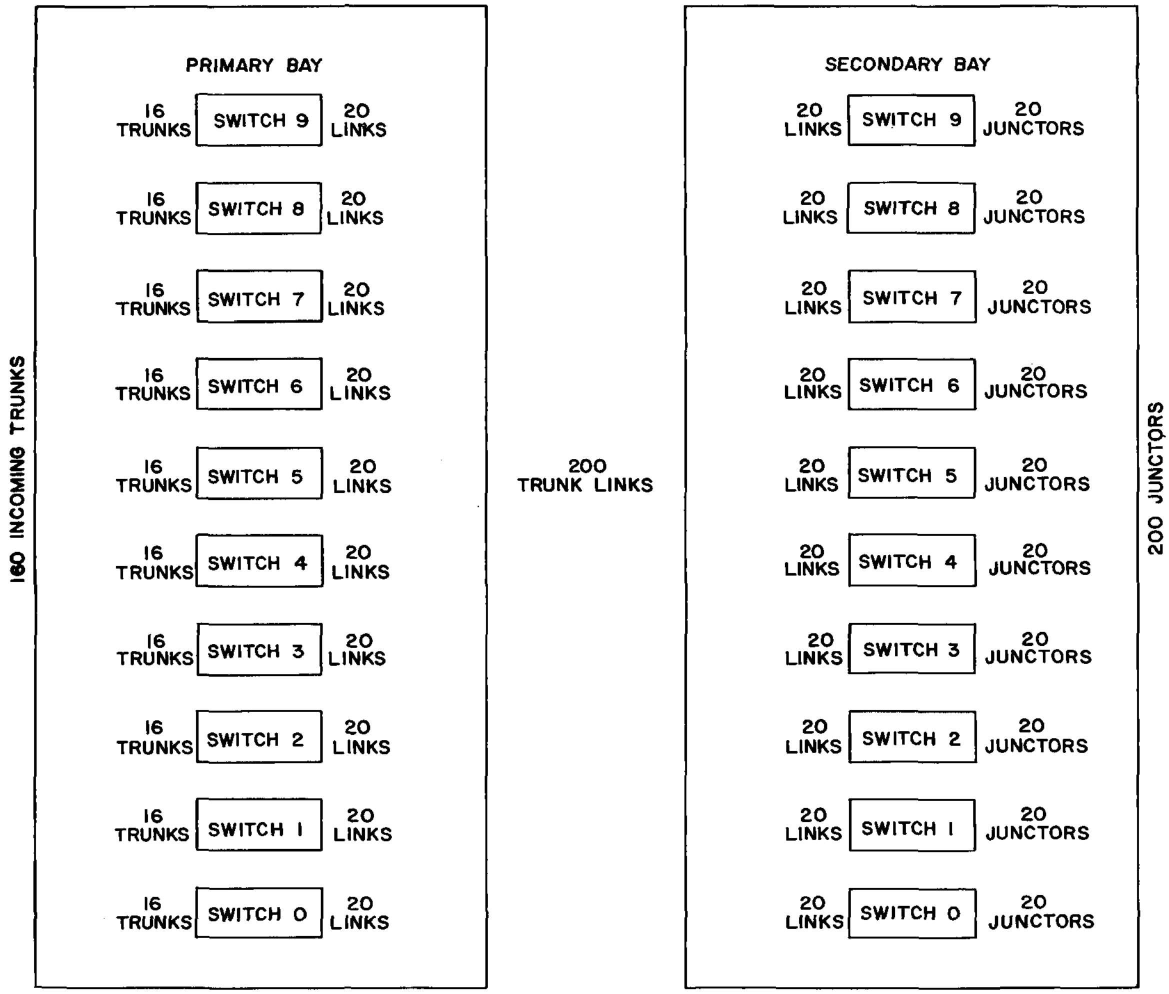


Fig. 16 — Trunk Link Frame — Capacity of Switches

eleventh verticals; this provides ten more horizontal paths on the switch.

C. Trunk Link Frame

General

2.16 A trunk link frame consists of two bays, a primary bay and a secondary bay, which are connected by trunk links. As shown in Fig. 16, each bay consists of ten crossbar switches. The 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.

Primary Bay

2.17 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 twenty verticals. Fig. 17, page 42, shows the distribution of trunk links.

2.18 As shown in Fig. 18, page 43, 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.

2.19 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.

2.20 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

2.21 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. 17, it can be seen that the secondary switches are split in half. This provides twenty horizontals on each switch for terminating twenty trunk links. Each switch also provides twenty verticals for twenty junctors.

D. Office Link Frame

General

2.22 An office link frame consists of two bays, a primary bay and a secondary bay, which are connected by office links. As shown in Fig. 19, each bay consists of ten crossbar switches. Each frame has a capacity of 100 outgoing trunk terminations and 200 junctors.

2.23 The trunk termination capacity of a frame can be increased to 200 by the addition of a secondary extension bay. The office links between the primary and secondary bay are multipled to the secondary extension bay, as shown in Fig. 20. Twenty frames, with extension bays, provide the maximum capacity of 4000 outgoing trunk terminations and 4000 junctors.

Secondary Bay

2.24 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 2.23 the trunk termination capacity can be increased to 200 by the addition of an extension bay consisting of ten additional switches.)

2.25 As shown in Fig. 21, page 44, each switch terminates one trunk on each of the ten horizontals and one office link on each of the 20 verticals. If an extension bay is provided, the verticals of each switch are multipled to the corresponding verticals of the corresponding switches on the basic frame.

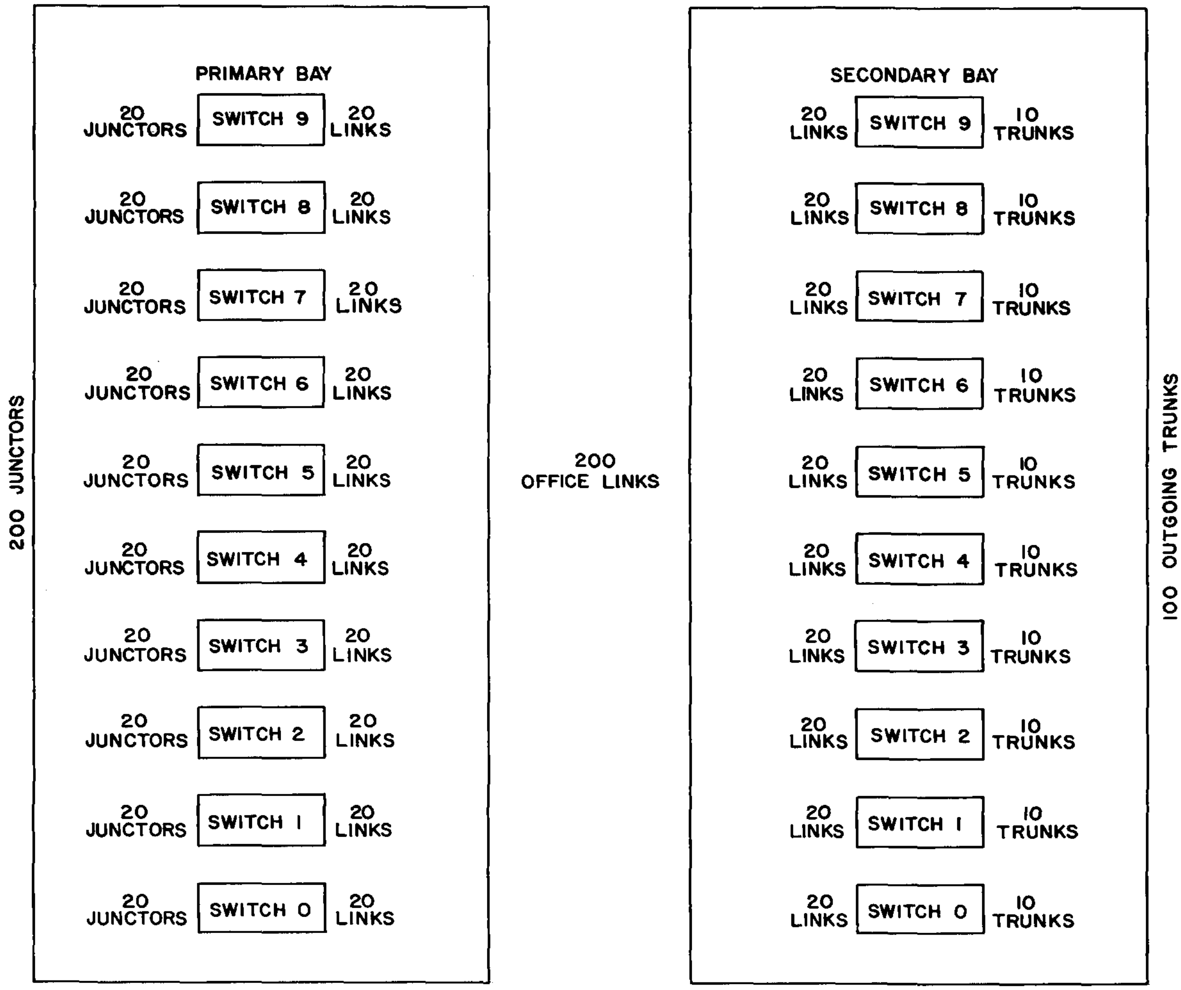


Fig. 19 — Office Link Frame — Capacity of Switches

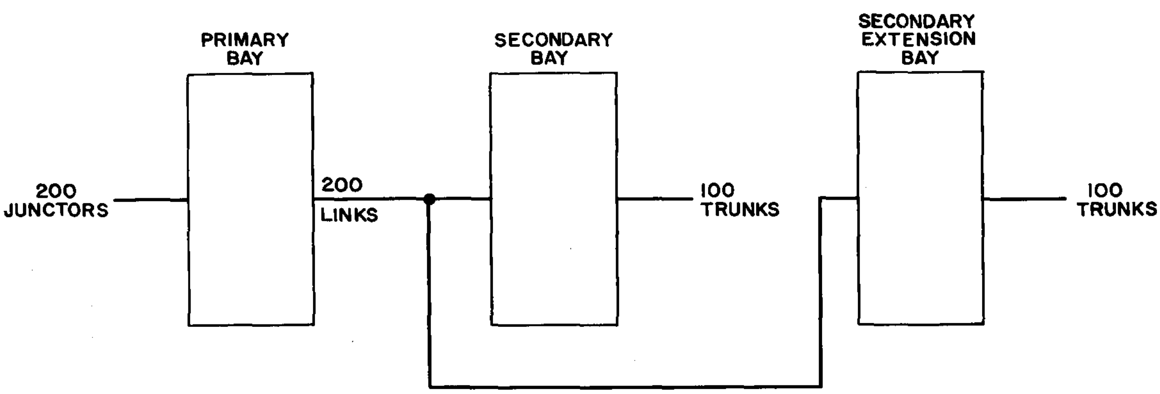


Fig. 20 — Secondary Extension Bay on Office Link Frame

Primary Bay

2.26 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. 21, 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.

E. Junctor Grouping Frame

2.27 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.

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

2.29 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.

2.30 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.

2.31 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.

2.32 This can best be understood from an example. Fig. 22 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.

2.33 The maximum number of junctors available for a group is 50 (200 ÷ 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. 23, 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.

2.34 When two more trunk link and office link frames are added, the number of junctors in a group is reduced to 25 (200 ÷ 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.

2.35 As mentioned in 2.33, 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 6-6 office, only 25 junctors in a group are used. In this case, the growth to 8-8 can be made without changing existing cross connections.

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

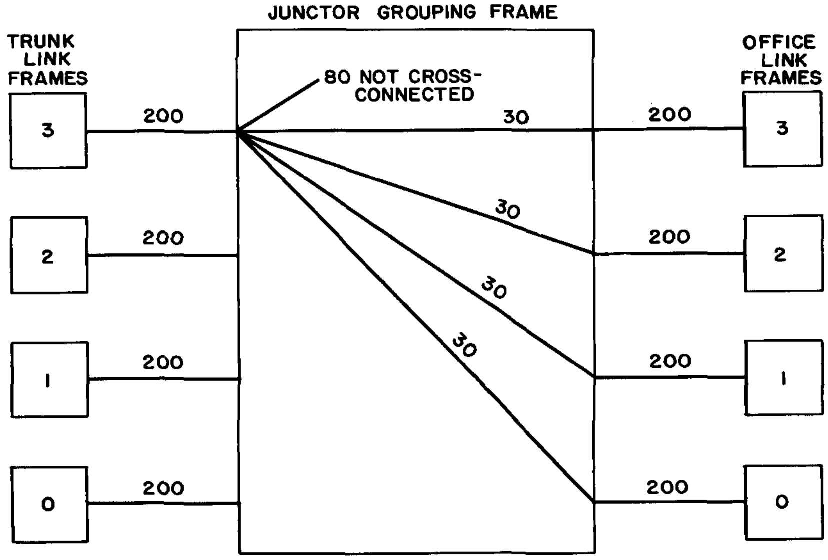


Fig. 22 — Junctor Groups — 4-4 Size Office

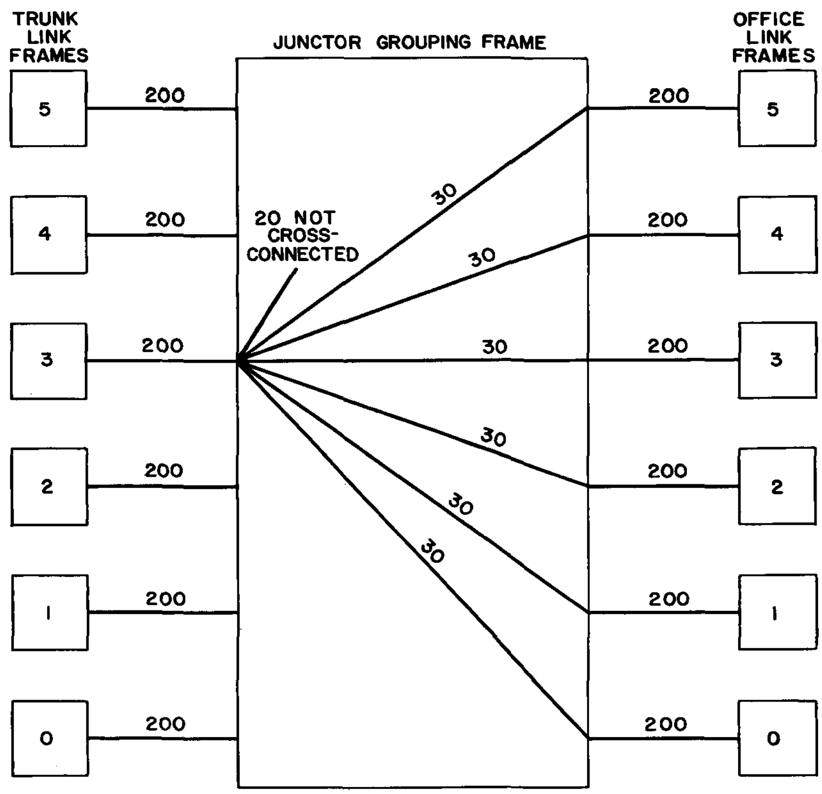


Fig. 23 — Junctor Groups — 6-6 Size Office (Initially 4-4 Size)

TABLE A

NUMBER OF TRUNK LINK AND OFFICE LINK FRAMES*	NUMBER OF JUNCTORS IN A GROUP	
	NEW OFFICES	OFFICES AFTER ADDITIONS
2-2	60	—
4-4	30	40
6-6	25	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

*The number of trunk link frames may not always equal the number of office link frames. If they are not equal, the larger number is controlling.

F. Channels

2.37 A channel consists of a trunk link, a junctor, and an office link connecting an incoming trunk to an outgoing trunk. The minimum number of channels provided for connecting a particular incoming trunk to a particular outgoing trunk is ten (20-20 size office).

2.38 Fig. 24, page 45, shows the 11 channels between a particular incoming trunk and a particular outgoing trunk in an office equipped with 18 trunk link frames and 18 office link frames.

2.39 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 of the 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 part describes the method of operation on typical calls. One call is described in detail to introduce the equipment elements and to show their interrelationship as illustrated in Fig. 25. 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 The call arrives in the tandem office over an incoming trunk and leaves over an outgoing trunk. The incoming trunk may be selected by an operator, a local office, a tandem office, or a dial toll office. (The procedure in the tandem office is the same in any case.)

3.03 As shown in Fig. 25, each incoming trunk has 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.

3.04 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.

3.05 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.

3.06 As soon as the sender is attached, it signals the originating operator or preceding office sender to begin pulsing. When three digits have been received, the sender signals the marker connector (connection 4) to seize an idle marker (connection 5).

3.07 The sender passes the first three digits (the code) to the marker along with the information derived from the decade arrangement on the sender link frame. The marker (1) decodes the information received from the sender, (2) operates one of its route relays from which it derives the information required for routing the call, and (3) passes the outpulsing instructions to the sender.

3.08 The marker then seizes the office link connector that has access to the pair of office link frames on which the 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: (1) it seizes the trunk link connector that serves the trunk link frame on which the incoming trunk is terminated (connection 7) and (2) it starts testing for an idle outgoing trunk as described in 3.09. (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.

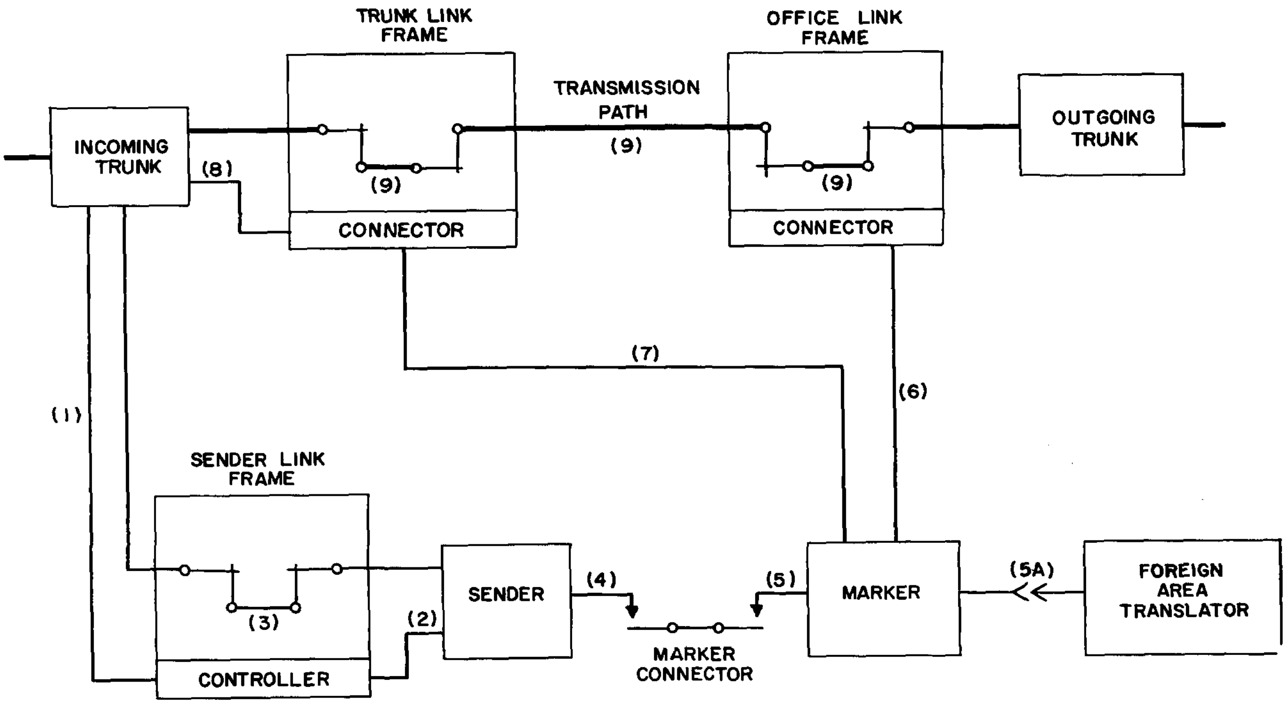


Fig. 25 — Path of a Call Through a Crossbar Tandem Office

3.09 When the pair of office link frames was seized, the marker also started testing for an idle outgoing trunk, as mentioned in 3.08. 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 path to the sender via the trunk link connector, the incoming trunk, and the sender link (connections 7, 8, and 3).

3.10 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.

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

3.12 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.

3.13 The sender then sends a signal forward and upon receipt of a go signal it 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.

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

Call Requiring 6-digit Translation

3.15 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. Since this sender is arranged for 6-digit translation and the first three digits of this call are of the form X0X/X1X, the sender waits for six digits before calling in a marker.

3.16 The marker decodes the first three digits and operates an area relay rather than a route relay. The operation of this area relay causes the associated foreign area translator to be called in (connection 5A).

3.17 The fourth, fifth, and sixth digits are sent to the foreign area translator which translates them to one of 60 route indications. The marker uses this information to operate a route relay and the call is completed as described above.

Remote Control Zone Registration

3.18 The calls described above involved no charging functions at 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.

3.19 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 Local Office Operator Assistance

3.20 Crossbar tandem can also handle coin zone calls with the assistance operators located at the local originating office or in a near-by building. This type of call is dialed by a customer at a coin station and is routed to crossbar tandem by the local office. An operator is called in to request and monitor the initial deposit and to time the overtime on calls which exceed the initial period. The operator must also compute, request, and monitor overtime charges.

3.21 This arrangement is limited to a maximum of four charges per trunk group, and only traffic originating in panel and No. 1 crossbar offices can be served.

3.22 This traffic is handled at crossbar tandem by PCI trunks and senders. The sender is arranged to delay outpulsing on these calls until it has received a go ahead signal from the operator.

4. FUNCTIONS OF PRINCIPAL EQUIPMENT ELEMENTS

A. General

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.

B. 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 the 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.

C. Sender Link Frame

4.10 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 one type or 40 senders of each of two types.

4.11 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. 26. Each trunk has two appearances on a frame, one on each unit. This prevents loss of service in case of failure of a controller.

4.12 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

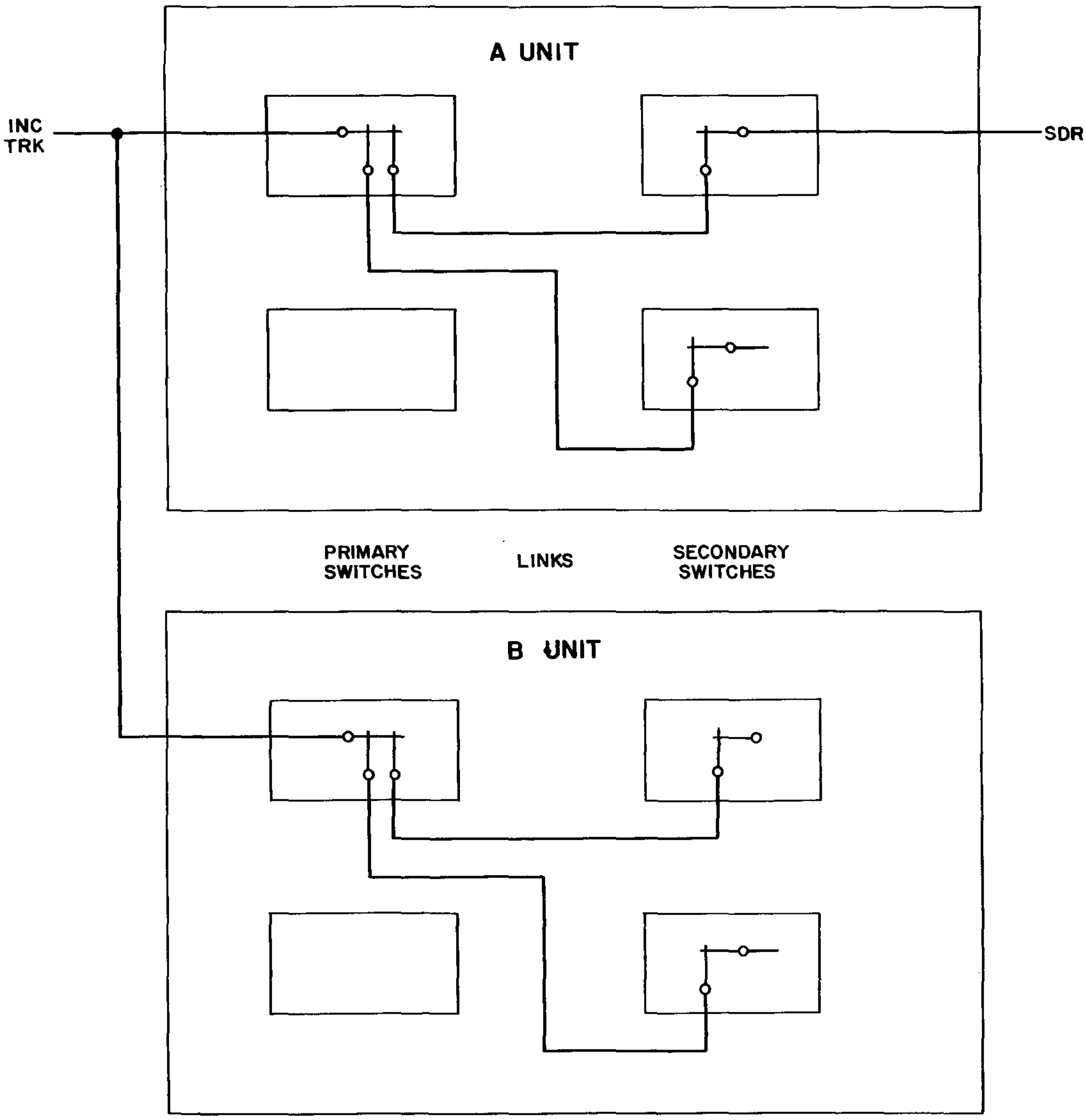


Fig. 26 — Sender Link Frame — General Plan

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.

Trunk Appearances on Primary Switches

4.13 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.

4.14 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. 27, page 46. 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.

Sender Appearances on Secondary Switches

4.15 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.)

4.16 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. 27, 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

4.17 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. 27. 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

4.18 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.

4.19 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.

4.20 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.

Multipling of Senders to Sender Link Frames

4.21 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.

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

TABLE B

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

Decade Arrangement of Trunks

4.23 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, but 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.

D. Senders

4.24 The main functions of a crossbar tandem sender are:

(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 outpulse digital information as directed by the marker.

4.25 There are several kinds of crossbar tandem senders which differ from each other mainly in digit capacities and types of inpulsing and outpulsing. Each of the senders receives the type of inpulsing designated by its name. Except for the PCI sender they can all be used to complete calls to operators without pulsing.

4.26 Crossbar tandem senders can outpulse (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.

4.27 *MF (Multifrequency) Senders:* Three MF senders have been developed for crossbar tandem. The newest of these can be used as a local or toll sender with or without CAMA. (MF CAMA features will be described in Section 960-310-100 when reissued.)

4.28 As a non-CAMA sender, it can receive calls from manual, DSA, or toll switchboards equipped for MF keypulsing or from senders arranged to transmit multifrequency pulses. It can receive from three to 11 digits.

4.29 This sender can outpulse from one to 11 digits on a DP basis or from three to 11 digits on an MF basis. It can

(a) outpulse the digits as received;

(b) skip one to six digits on 10- or 11-digit calls or one, two, or three digits on 7- or 8-digit calls;

(c) code convert the first three digits to one, two, or three arbitrary digits;

(d) on 10- or 11-digit calls, skip the first three digits and code convert the next three digits to one, two, or three arbitrary digits; or

(e) prefix one, two, or three arbitrary digits to seven or eight digits received when outpulsing MF or DP.

On a PCI basis it can outpulse five digits to call indicator positions. On a revertive basis it can outpulse the equivalent of four digits to local offices.

4.30 This sender has been arranged to operate with 6-digit translation.

4.31 This newer CAMA-type sender replaces the original 8-digit sender and the 11-digit toll sender neither of which have CAMA features. The older 11-digit sender has the same outpulsing and 6-digit translation features as described for the newer MF sender except that it cannot use prefixing when the code received is of the form 11X.

4.32 The 11-digit senders are arranged to outpulse DP to offices of independent manufacture where the incoming register accepts only a portion of the complete number. The tandem senders are arranged to accept a stop signal when the distant register is satisfied and to continue pulsing on receipt of a go signal after the distant register has set up the connection through its own office.

4.33 ***DP (Dial Pulsing) Senders:*** Three DP senders have been developed for crossbar tandem. The newest of these can be used as a local or toll sender with or without CAMA.

4.34 As a non-CAMA sender, it can receive traffic from step-by-step automatic ticketing offices or from manual, DSA, or toll switchboards.

4.35 This sender can receive from three to 11 digits and it has the same outpulsing features as the MF sender described in 4.29 and 4.32. It is also arranged to operate with 6-digit translation.

4.36 The second DP sender can receive from three to eight digits from switchboards arranged for dial pulsing, from switchboard senders, or from step-by-step offices. It can complete calls as follows:

(a) By outpulsing four, five, or six digits on a DP basis to step-by-step offices.

(b) By outpulsing five or eight digits on a PCI basis to call indicator positions.

(c) By outpulsing the equivalent of four digits on a revertive basis to panel, No. 1, or 5 crossbar offices.

(d) Directly to operator positions.

4.37 The third DP sender is a 7-digit sender which has limited use. It outpulses on a DP basis only.

4.38 ***PCI (Panel Call Indicator) Sender:*** The PCI sender can be used as a CAMA sender or as a non-CAMA sender. This sender always receives eight digits. (When only seven digits are required, the stations digit received is zero.) It can outpulse a maximum of eight digits on a DP or MF basis, the equivalent of four digits on a revertive basis, or five digits on a PCI basis.

4.39 ***RP (Revertive Pulsing) 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 office selections representing one-out-of-100 office codes which may or may not be followed by four digits. It can outpulse 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 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

4.40 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. This timing may be held over for 10, 20, or 30 seconds after some senders become idle.

E. Marker Connector

4.41 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.

4.42 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.

4.43 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.

4.44 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.

4.45 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.

4.46 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.

F. Marker

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

(a) Receives the code digits and other information from the sender.

(b) Uses this information to operate a route relay which supplies the necessary information for routing the call. On calls requiring 6-digit translation, the marker calls in a foreign area translator to translate the fourth, fifth, and sixth digits 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.

4.48 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), (c), 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 two.

4.49 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

4.50 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.

4.51 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 — 800 codes.

(c) Three-digit area code followed by 3-digit office code — maximum of 10 area codes.

(d) Two-digit TX codes (11XX) — 90 codes.

(e) Three-digit TX codes (11XXX) — 300 codes.

(f) Service codes and arbitrary toll codes (0XX and 1XX) — 190 codes.

4.52 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 ten.

4.53 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.

Operation of a Route Relay

4.54 The marker examines the first three digits and grounds one of a maximum of 1000 code points. These code points (except for a maximum of ten for which foreign area translation is provided) are cross-connected to route relays. An office may have a maximum of 360 route relays per marker. For the areas requiring 6-digit translation, the code points are cross-connected to area relays which call in corresponding foreign area translators. The marker then cuts through the fourth, fifth, and sixth digits to the foreign area translator which translates them to one of 60 routings. The marker then grounds one of 60 code points for the desired area. These code points are cross-connected to route relays. (These route relays are included in the maximum of 360 route relays mentioned above.)

4.55 The operation of a route relay directs the marker to a maximum of 40 or 80 outgoing trunks. If these trunks are all busy, the marker operates another route relay which gives it access to (a) additional trunks in the same group, (b) alternate route trunks, or (c) reorder or NC (no circuit) trunks. On a particular call, the marker can operate up to five route relays which permit it to test a maximum of 240 outgoing trunks and 40 reorder trunks.

4.56 The route relays are located and operated in a maximum of five ground supplies designated GS1 to GS5. When five ground supplies are provided, four of these, GS1 to GS4, are used to reach outgoing trunks and the fifth, GS5, to reach reorder or NC trunks.

4.57 A route relay ordinarily directs the marker to a maximum of 40 trunks, but by using a flip-flop arrangement, 80 trunks (all direct or all alternate) can be associated with one route relay. This flip-flop arrangement can be used in two ways.

(a) It can permit the marker to test the first 40 trunks and, if these are all busy, to test the second 40 trunks before advancing to the next ground supply.

(b) It can permit the marker to test only 40 of the trunks on one call and the other 40 on the next call and in both cases to advance to the next ground supply to test a common group.

4.58 This flip-flop arrangement can be used on a maximum of 58 route relays in an office. On a particular call, it can be used at most in two of the first four ground supplies.

4.59 For a particular code, the marker may be arranged to operate a route relay in any of ground supplies one to four. However, when advancing to a second ground supply, the marker always advances to a higher-numbered ground supply. On second trial, the marker does not test the trunks in ground supplies one and two. Therefore. if there are 40 or less trunks in a group and no alternate route is available, these trunks must be assigned to GS3 or GS4 in order to take advantage of the second trial feature.

4.60 In offices where no alternate routing is provided, two ground supplies will be furnished if only revertive senders are used or three ground supplies for all other cases. Where alternate routing is provided, four ground supplies will be furnished for revertive senders only, or five ground supplies for all other cases. Offices with only revertive senders use one less ground supply because reorder is returned from the RP sender and a marker does not set up to a reorder trunk on this type of call.

Information From Marker to Sender

4.61 As soon as a route relay is operated, the following decoded information, where required, is passed to the sender.

(a) Type of outpulsing.

(b) Compensating resistance.

(c) Office brush and office group selections.

(d) First, second, and/or third digits on calls with code conversion or digit prefixing.

(e) Cancel code conversion.

(f) Number of code digits to be outpulsed.

4.62 If all trunks located by this route relay are busy, this information will be canceled and the marker will send the sender new information as provided by the next route relay operated.

Connection to an Office Link Frame

4.63 The operation of a route relay gives the marker the following information to enable it to select an outgoing trunk.

(a) The pair of office frames on which the outgoing trunk group is terminated.

(b) The switch levels on which the trunk group is terminated.

(c) The group start (GS) and group end (GE) indications.

4.64 When the marker receives this information, it seizes an office link connector that has access to the desired pair of office link frames. It tells the connector to cut through 40 leads associated with the 40 trunks terminated on the desired switch levels. It then tests some or all of these trunks in accordance with the GS and GE indications.

4.65 If all of these trunks test busy, another route relay is operated and additional trunks are tested until an idle trunk is found or until the call is set up to a reorder or NC trunk.

4.66 When an outgoing trunk is chosen, the connector tells the marker whether the selected trunk is located on the even or odd frame. The marker already knows the pair of frames so that the even or odd information tells it exactly which frame is being used.

4.67 The connector then cuts through the 20 leads associated with the 20 office links serving the switch on which the outgoing trunk is located.

Connection to a Trunk Link Frame

4.68 The marker knows the number of the trunk link frame from cross connections associated with the decade arrangement on the sender link frame. This information is supplied through the sender. After the marker connects to a pair of office link frames, it connects to the proper trunk link connector. The marker then sends a signal via the sender and the trunk to the connector instructing it to cut through 20 leads corresponding to the 20 trunk links serving the switch on which the incoming trunk is located.

4.69 As soon as the marker determines the number of the office frame as described in 4.66, it tells the trunk link frame to cut through 20 test leads associated with 20 of the junctors between this trunk link frame and the chosen office link frame.

Seizing an Idle Channel

4.70 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 combination as 20 channels to switch this call.

4.71 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 link*** (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 the 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

4.72 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.

4.73 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 test, 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

4.74 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.

4.75 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.

G. Foreign Area Translator

4.76 The foreign area translator is a ring-type translator which provides translation for the fourth, fifth, and sixth digits on 10-digit X0X/X1X calls. 1000 codes can be translated into 60 route indications for each of a maximum of five foreign areas.

4.77 To provide 6-digit translation for five foreign areas, two foreign area translator frames must be furnished. Each will provide translation for the same five areas, but half of the markers will prefer one translator and the remaining markers will prefer the other translator. For ten foreign areas four translator frames must be provided.

H. Trunks

4.78 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.

(a) Incoming tandem trunks

(b) Completing trunks

(c) Intertoll trunks

(d) Auxiliary trunks

(e) Miscellaneous trunks

Incoming Tandem Trunks

4.79 Incoming tandem trunks give customers in local offices or operators at toll or DSA switchboards access to crossbar tandem. There are six 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 5 crossbar offices.

(2) Dial pulsing from step-by-step automatic ticketing offices or from switchboards.

(3) Multifrequency pulsing from panel, No. 1 crossbar, No. 5 crossbar, or step-by-step modified automatic ticketing offices or from switchboards.

This trunk can also be used within the loop range as an incoming trunk from another tandem or No. 4-type office if transmission requirements are met.

(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 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 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 similar to the trunk in (e) but used for MF pulsing from No. 4 or 5 crossbar or crossbar tandem offices or from switchboards.

Completing Trunks

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

4.81 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.

Intertoll Trunks

4.82 Intertoll trunks are used to connect with distant toll centers, either dial or manual. They may be one-way incoming, 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 4.79 (e).]

(b) An incoming trunk using MF pulsing from toll crossbar offices or from distant toll switchboards. [See 4.79 (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 with MF pulsing to other crossbar toll offices. [See 4.81.]

(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.

4.83 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

4.84 The auxiliary trunks permit the tandem office to multiple to operator office and ringdown trunks. They cannot, however, be used for outgoing calls on which an incoming PCI sender is used. 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 near-by 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

4.85 ***Reorder trunks*** are used to send a reorder signal, consisting of 120 interruptions per minute (ipm) in the form of flashes and 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 an operator receives a reorder, she will usually try again.

4.86 ***No circuit trunks*** are used on toll calls to send an NC (no circuit) signal, 30 ipm, to the outward operator. 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 operating procedure regarding subsequent attempts may be different than when reorder is received.

4.87 ***TX trunks*** carry delayed call traffic between the crossbar tandem switching system and TX (delayed outward) operators. 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.

4.88 ***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

*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.

4.89 ***Recorded announcement trunks*** are used to furnish announcements through the 5A announcement system to customers and operators. They are used on vacant code calls and on calls affected by reduced intersender timing.

5. MAINTENANCE FEATURES

A. General

5.01 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

5.02 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.

5.03 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 equipment. (CAMA features will be discussed in Section 960-310-100.) This is accomplished by punched cards by:

(a) Taking a record of the information set up in a marker when it fails to complete its functions 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.

Service Calls

5.04 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.

5.05 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.

5.06 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.

5.07 As described in 3.09, 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 also 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.

5.08 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

5.09 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.

5.10 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 recorder 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

5.11 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 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

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

5.13 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.

5.14 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

5.15 The sender test frames provide a means for routine testing of tandem senders 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.

5.16 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 the 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.

5.17 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.

5.18 When desired, a particular sender may be seized and tested either on a single or repeat test 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.

5.19 The sender test frame also applies pulses to the sender under marginal conditions which are at least as severe as those under which pulses on a service call are received. Means are also provided to check the quality of pulses that the sender outpulses.

5.20 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.

5.21 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

5.22 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.

5.23 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.

5.24 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.

5.25 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.

5.26 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.

5.27 An intersender timing control unit is provided for each group of senders that are arranged for intersender timing.

F. Testing Equipment for Zone Registration Tandem Trunks

5.28 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.

5.29 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.

5.30 When a call is completed over a reserve trunk, that trunk is 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.

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

5.32 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.

5.33 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.

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

G. Test Set for Nonzone Tandem Trunks

5.35 The nonzone incoming trunks (both tandem and intertoll) are tested by a tea wagon-type test 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.

(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 selections with the pulses being generated by the test current supply control circuit.

(d) ***Panel Call Indicator Pulsing:*** The number is dc-keypulsed into the PCI pulse generator and from there it is PCI pulsed through the trunk into a sender.

5.36 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

5.37 This test line consists of two 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.

Both circuits appear on an office link frame in the same trunk group. The former 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 the proper test line through the switches.

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

5.38 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

5.39 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.

5.40 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.

5.41 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 is 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.

5.42 This test circuit can also be used to test any desired trunk on a manual basis.

K. Manual Outgoing Trunk Test Frame

5.43 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 multipled to the office secondary switch multiple. (One jack per trunk appears on the test frame.) 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.

6. PLANT REGISTERS

6.01 The following plant registers are available.

Sender Link and Controller

(a) Trouble — one per controller circuit

(b) Link False Start — one per controller circuit

Senders

(a) Partial Dial — one per DP or RP sender group

(b) Awaiting Registration — one per RP or MF sender group

(c) Awaiting Dialing — one per RP sender group

(d) Stuck Sender — one per sender group per type of outpulsing for the DP and MF CAMA-type senders — one per sender group for all other senders

(h) Awaiting Registration — one per MF sender group

(i) Revertive Pulse Reorder — maximum of two per marker group

(j) Foreign Area Translator—one per foreign area

Overflow

(a) Trunk Link Frame — one per frame

(b) Office Link Frame — one per pair of office link frames

(c) Outgoing Trunk Group — one per trunk group

Group Busy

(a) Sender — one per group of senders

Load Registers

(a) Sender — one per group of senders or one per group of 80 or less senders

7. TRAFFIC MEASURING FACILITIES

A. Traffic Registers

7.01 The following traffic registers are available.

Peg Count

(a) Trunk Link Frame — one per frame for each type of sender

(b) Marker — one per marker

(c) Office Link Frame — one per pair of office link frames

(d) Outgoing Trunk Group — one per trunk group where traffic separation is provided

(e) Traffic Separation — ten per marker

(f) Partial Digits — one per DP or MF sender group

(g) Permanent Signal — one per MF sender group

B. Traffic Usage Recorder

7.02 The traffic usage recorder is a measuring facility used in obtaining traffic load information on the following circuits.

(a) Incoming Trunks

(b) Outgoing Trunks

(c) Two-way Trunks

(d) Trunk Links

(e) Office Links

(f) Sender Links

(g) Senders

(h) Markers

7.03 The traffic load is measured by making repeated scannings of the busy test terminals for the circuits under study. The number busy is scored cumulatively. At the end of any period of time, the average traffic load carried can be determined by taking account of the number of scans and of the total number of busy conditions.

7.04 A detailed description of the traffic usage recorder is given in Section 951-510-100.

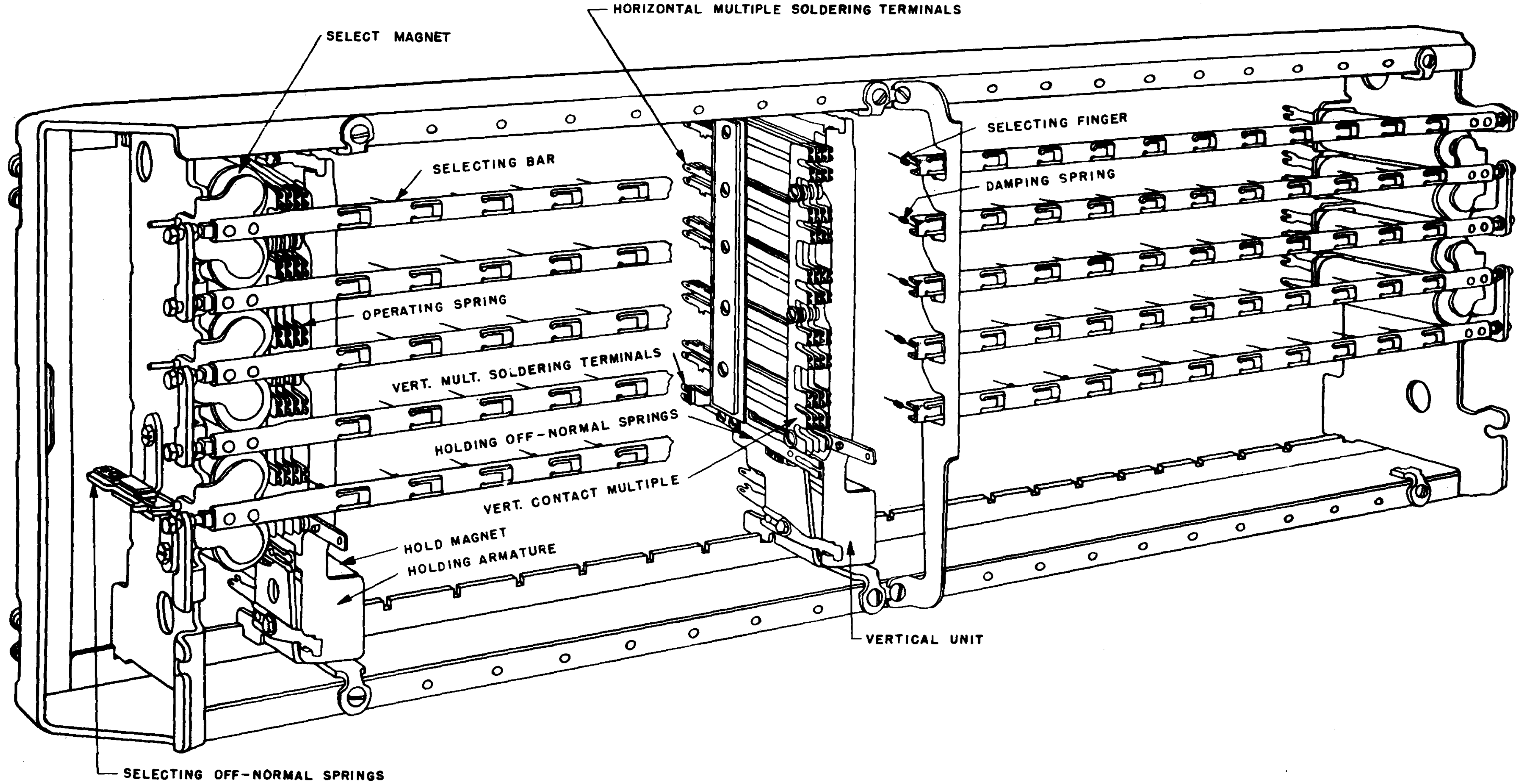


Fig. 13 — Partial Perspective View of 20 Vertical Unit Crossbar Switch (200 point)

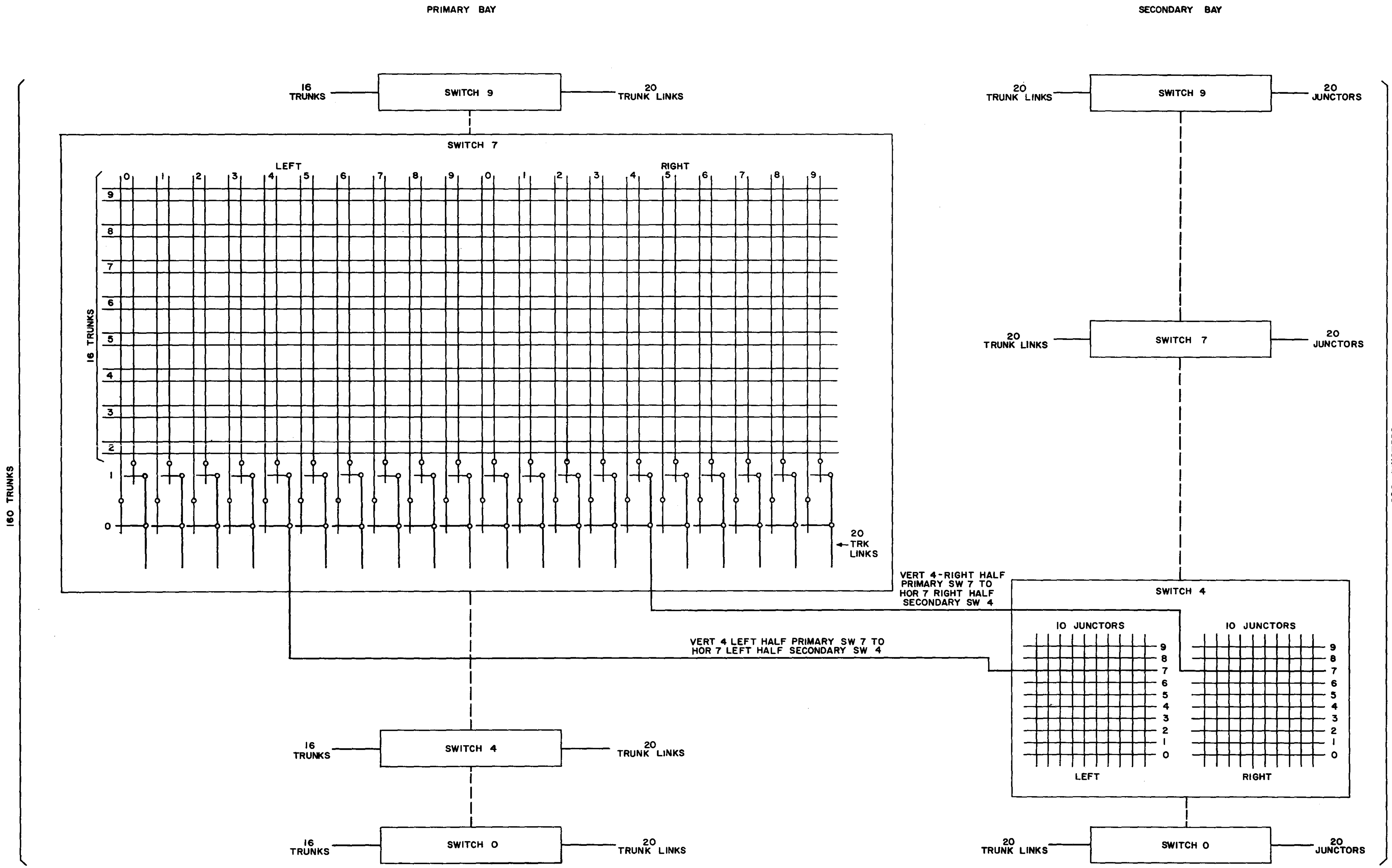


Fig. 17 — Distribution of Trunk Links

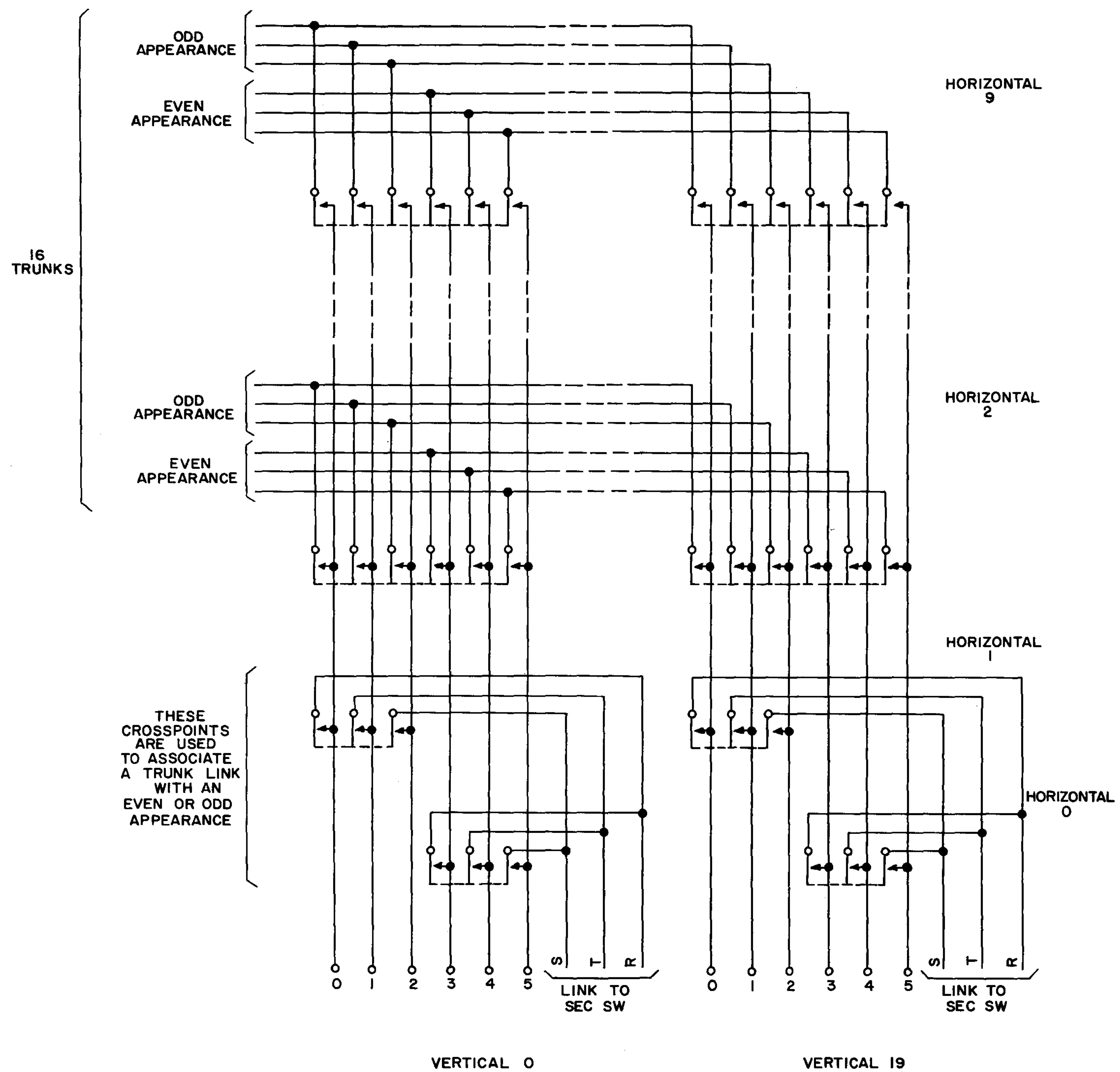


Fig. 18 — Switch Arranged for 16 Trunk Appearances

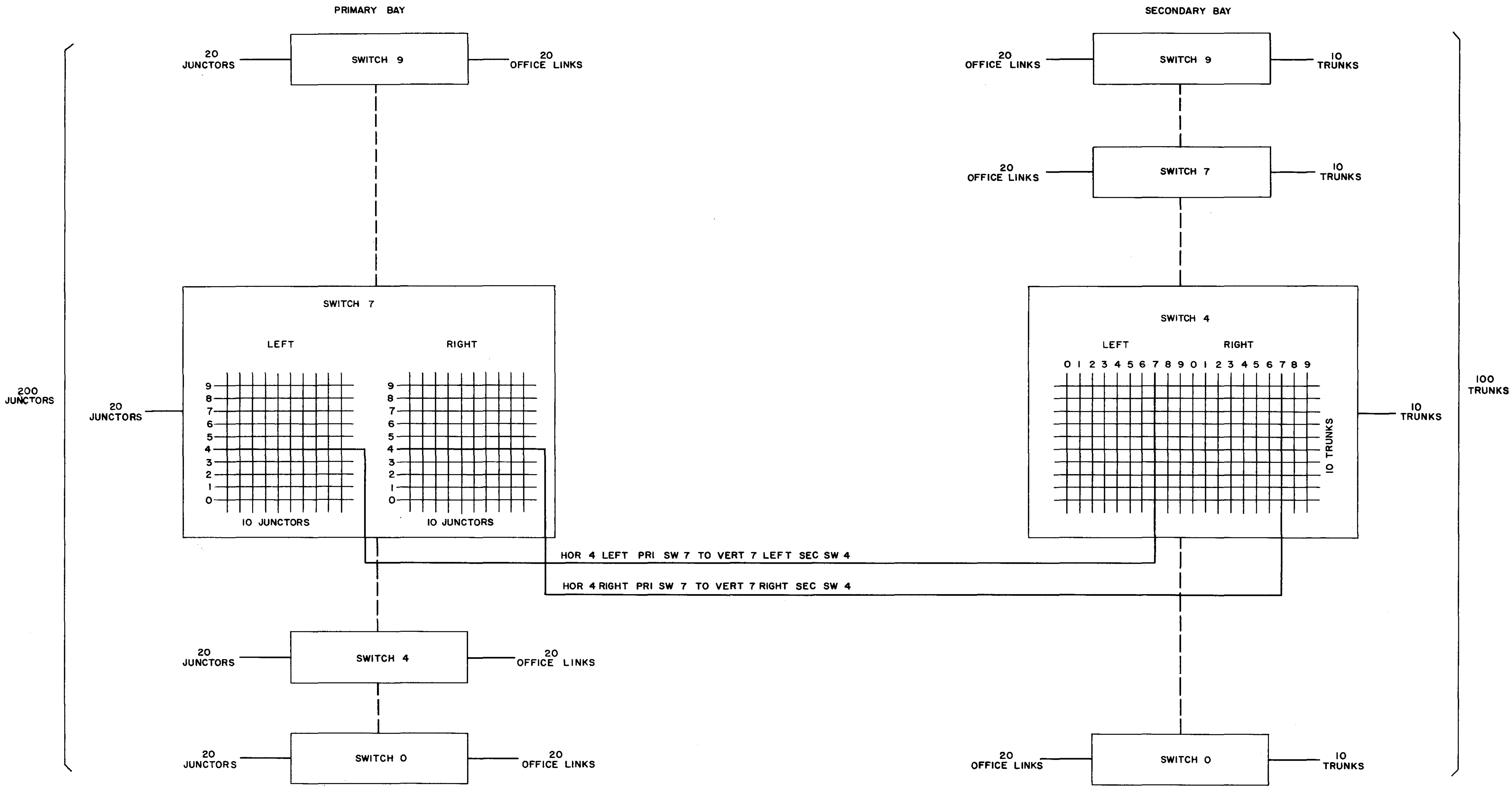
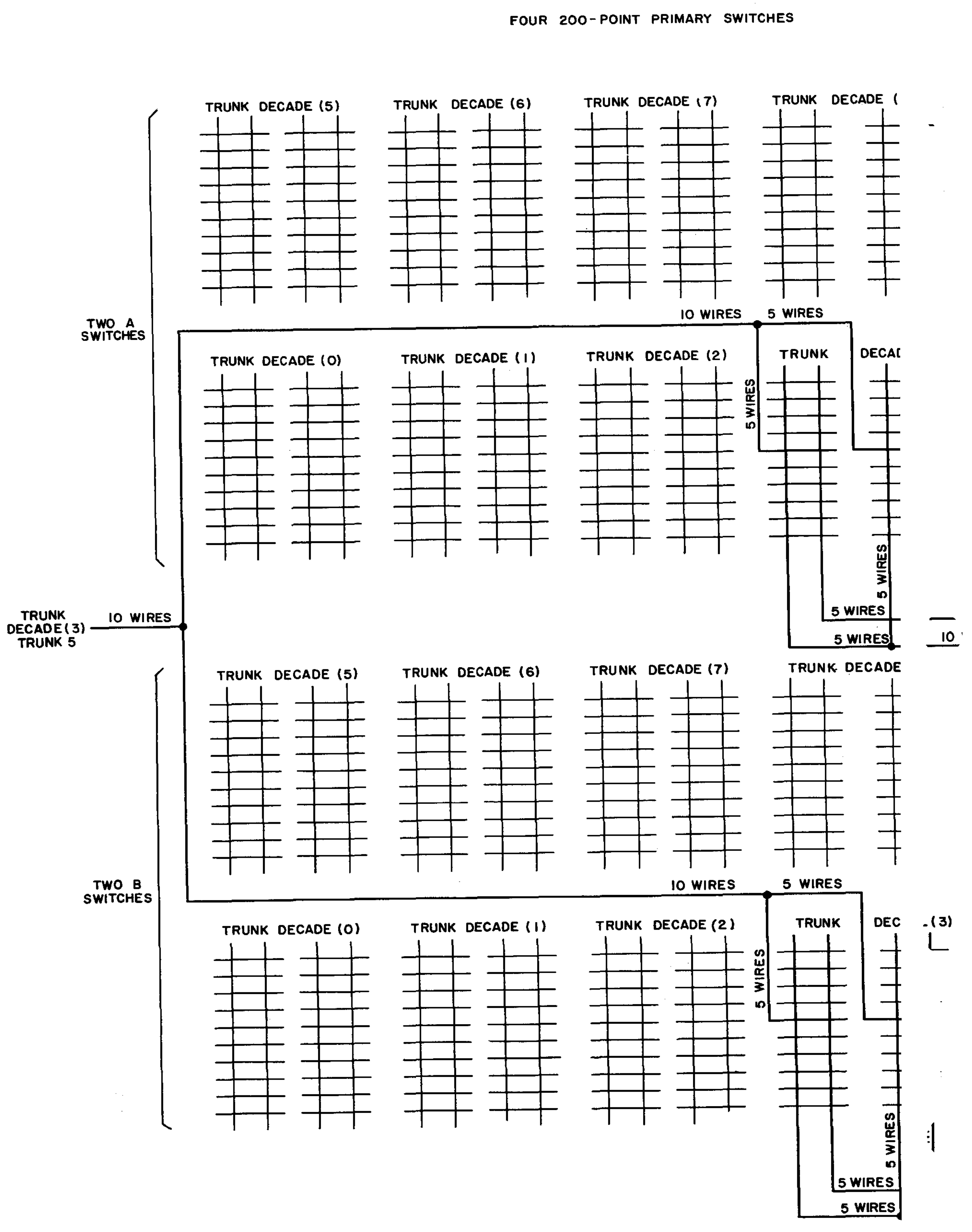


Fig. 21 — Distribution of Office Links



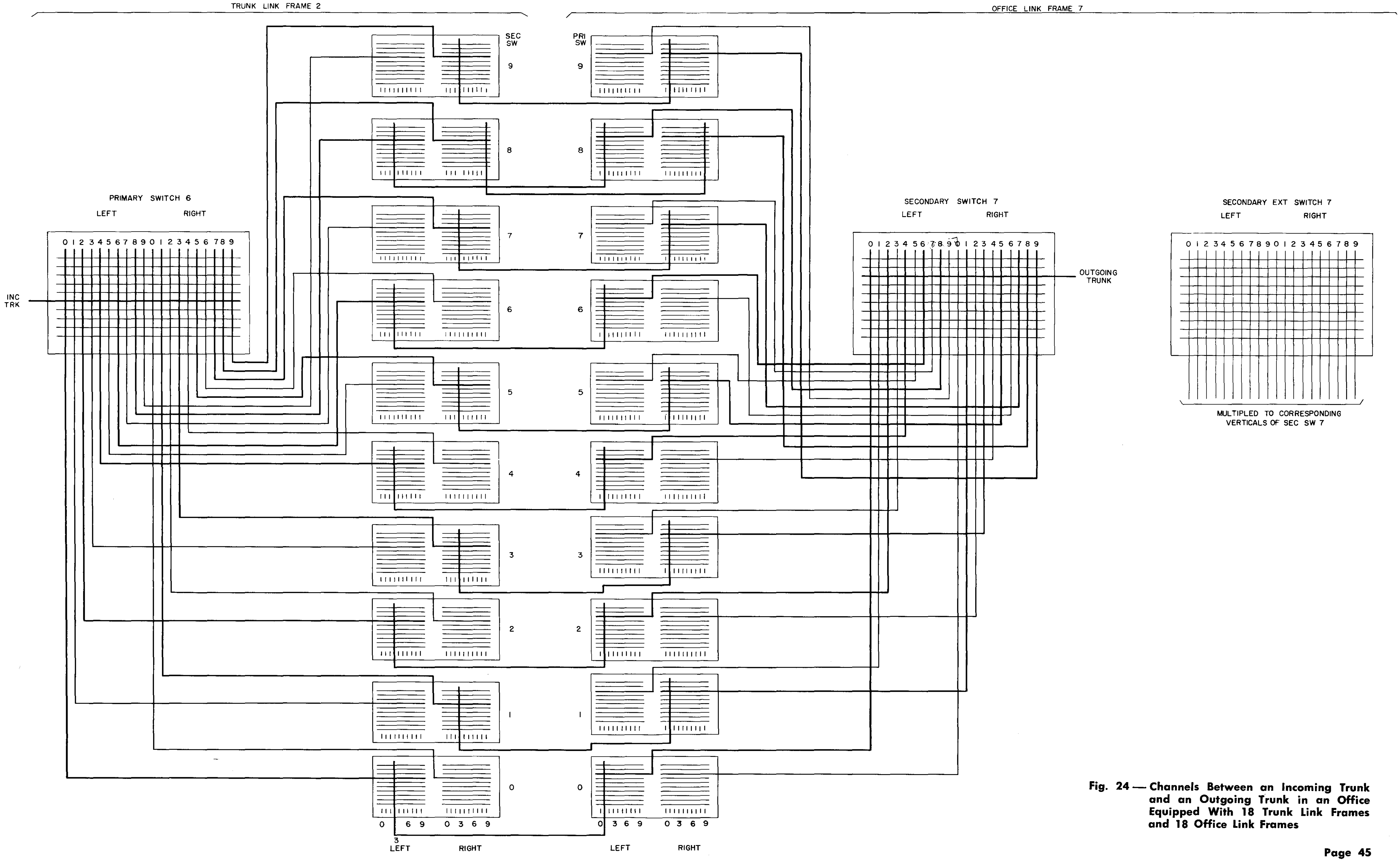


Fig. 24 — Channels Between an Incoming Trunk and an Outgoing Trunk in an Office Equipped With 18 Trunk Link Frames and 18 Office Link Frames

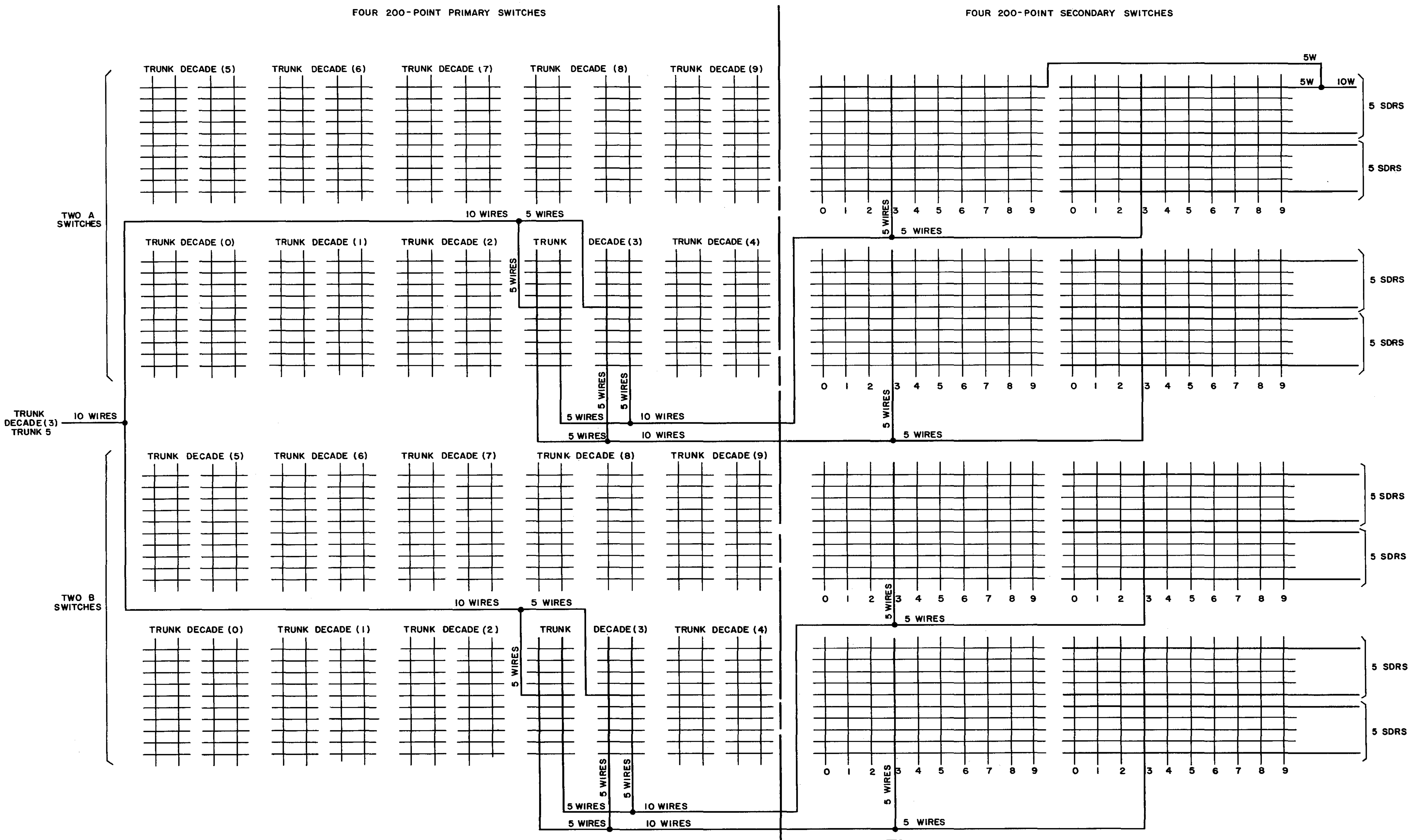


Fig. 27 — Sender Link Frame — Arrangement of Switches