

**4-WIRE NO. 5 CROSSBAR SYSTEM
 GENERAL DESCRIPTION**

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NOTICE

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 1. GENERAL	

1.01 This section describes in general terms the 4-wire No. 5 Crossbar System and its equipment components.

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

1.03 The 4-wire No. 5 crossbar is an expanded version of the 2-wire No. 5 crossbar office for switching connections on a 4-wire basis. With 4-wire switching, separate communication channels in each direction provide better performance for transmitting data, facsimile, telephoto, and encrypted voice.

1.04 The 4-wire No. 5 crossbar offices provide switching facilities for private line switched networks. Figure 1 shows an example of 4- and 2-wire combined offices and PBX private line switched networks similar to the Bell System networks.

1.05 AUTOVON networks are 4-wire switching centers of equal rank and are in two categories: home grid and external grid. The home grid (Fig. 2) is a set of switching centers surrounding and directly connected to a destination switching center. These home grid centers have sufficient interconnection to permit a call arriving at any one of these centers to be routed laterally to at least two other centers in the home grid if the call cannot be completed directly. The external grid (Fig. 3) is composed of any equal rank switching center that is not in the home grid for any destination center.

1.06 The principal features of the 4-wire No. 5 Crossbar System are as follows:

(a) **Flexibility:** The flexibility of the 4-wire No. 5 Crossbar System allows it to be used economically in comparatively small offices as well as large offices. It can handle the basic types of calls, can serve as a tandem switching center, and is arranged in non-AUTOVON private line switched networks to provide local automatic message accounting (LAMA) for sampling of calls.

(b) **Common Control:** The switching of traffic in an office is controlled by certain units of equipment which are common to all switching frames. This arrangement allows a few switching

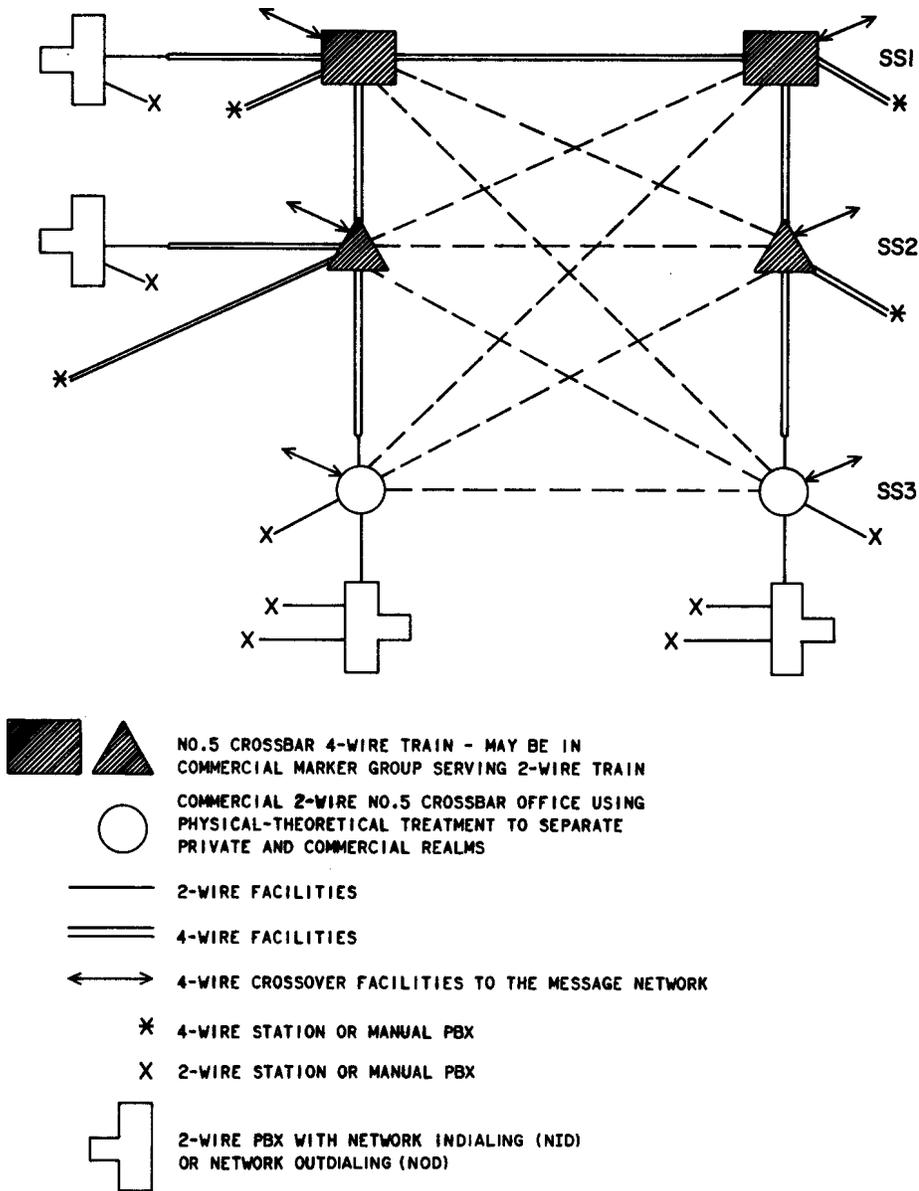


Fig. 1—Combined 2- and 4-Wire Private Network Switching Plan

circuits to set up the call, leaving the common circuits available to control the switching of other calls. These control circuits are equipped with self-checking and service safeguarding features.

(c) **Methods of Recording Service:** Automatic message accounting (AMA) is especially well suited for operation with a No. 5 crossbar office. This method makes a permanent record of service

on paper or magnetic tape and requires very little manual operation. Non-AUTOVON No. 5 crossbar offices are arranged for LAMA with automatic identification of the calling customer. Message register service can also be provided by the non-AUTOVON No. 5 crossbar offices.

(d) **Dialing Capacity:** No. 5 crossbar offices are designed to employ a numbering plan using 7 or 10 digits plus prefix access and control

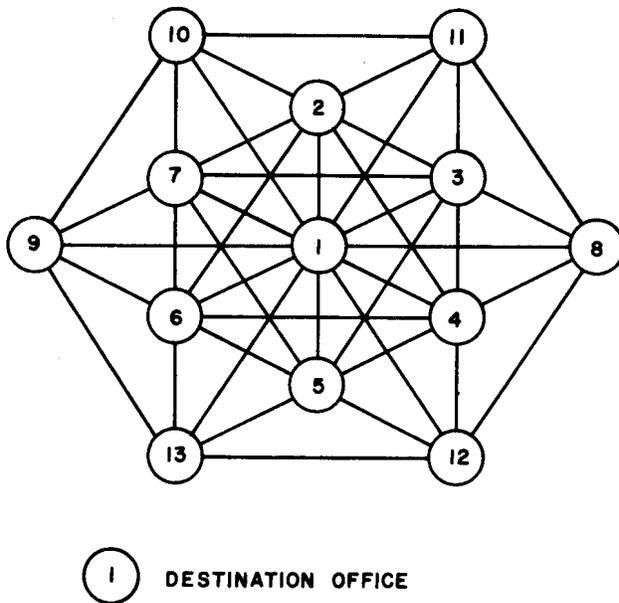


Fig. 2—Home Grid (AUTOVON), Office 1

digits as required for the features provided a particular customer.

(e) **Tandem Considerations:** Tandem switching features, as well as local office features, can be provided in a 4-wire No. 5 crossbar office.

(f) **Pulsing Considerations:** Multifrequency pulsing (15 combinations to represent 0 through 9 digits and special purpose digits) is used between 4-wire No. 5 crossbar offices. Dial pulsing is used to pulse to step-by-step PBXs and to some centrex No. 5 crossbar offices.

(g) **Maintenance:** The 4-wire No. 5 Crossbar System contains a number of self-checking features. The marker, a unit of common control equipment, has access to most of the circuits in an office and is able to determine the performance of the different circuits. When a trouble is encountered, the marker will cause the trouble recorder to make a permanent record on punched cards. The punched cards can be used by the maintenance personnel as an aid to locate the trouble.

2. SWITCHING PRINCIPLES

GENERAL

2.01 Part 2 describes how the 4-wire No. 5 crossbar office provides telephone service to customers. The switching principles are described in terms of the switching network.

2.02 The basic element in any crossbar system is the crossbar switch, which is essentially a relay mechanism consisting of 10 horizontal paths and 10 or 20 vertical paths, depending on the size of the switch unit. The points of connection are referred to as crosspoints. The switch with ten vertical paths has 100 crosspoints and is referred to as a 100-point switch; the switch with 20 vertical paths has 200 crosspoints and is referred to as a 200-point switch. A partial perspective view of a crossbar switch is shown in Fig. 4.

2.03 Horizontal Paths: There are five horizontal selecting bars mounted across the face of each switch. Each selecting bar has flexible selecting fingers attached to it, one finger for each vertical path. The bars are rotated slightly by the operation of a selecting magnet to cause the selecting fingers to go either up or down.

2.04 Vertical Paths: Twenty vertical units are mounted on the switch and each unit forms one vertical path. Each unit operates under control of a holding magnet and has ten groups of contacts, one for each horizontal path.

2.05 Each group of contacts consists of five 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.

2.06 Operation of the Crossbar Switch: The selecting fingers, in the released position, lie horizontally between two groups of contacts (Fig. 5). When a selecting magnet operates, each selecting finger associated with the rotated selecting bar lies in front of one group of contacts of each vertical unit.

2.07 The holding magnet operates, and the holding bar, using the selecting finger as a wedge, causes the group of contacts in front of the selecting finger to connect the horizontal and vertical paths. Both selecting and holding magnets must be operated

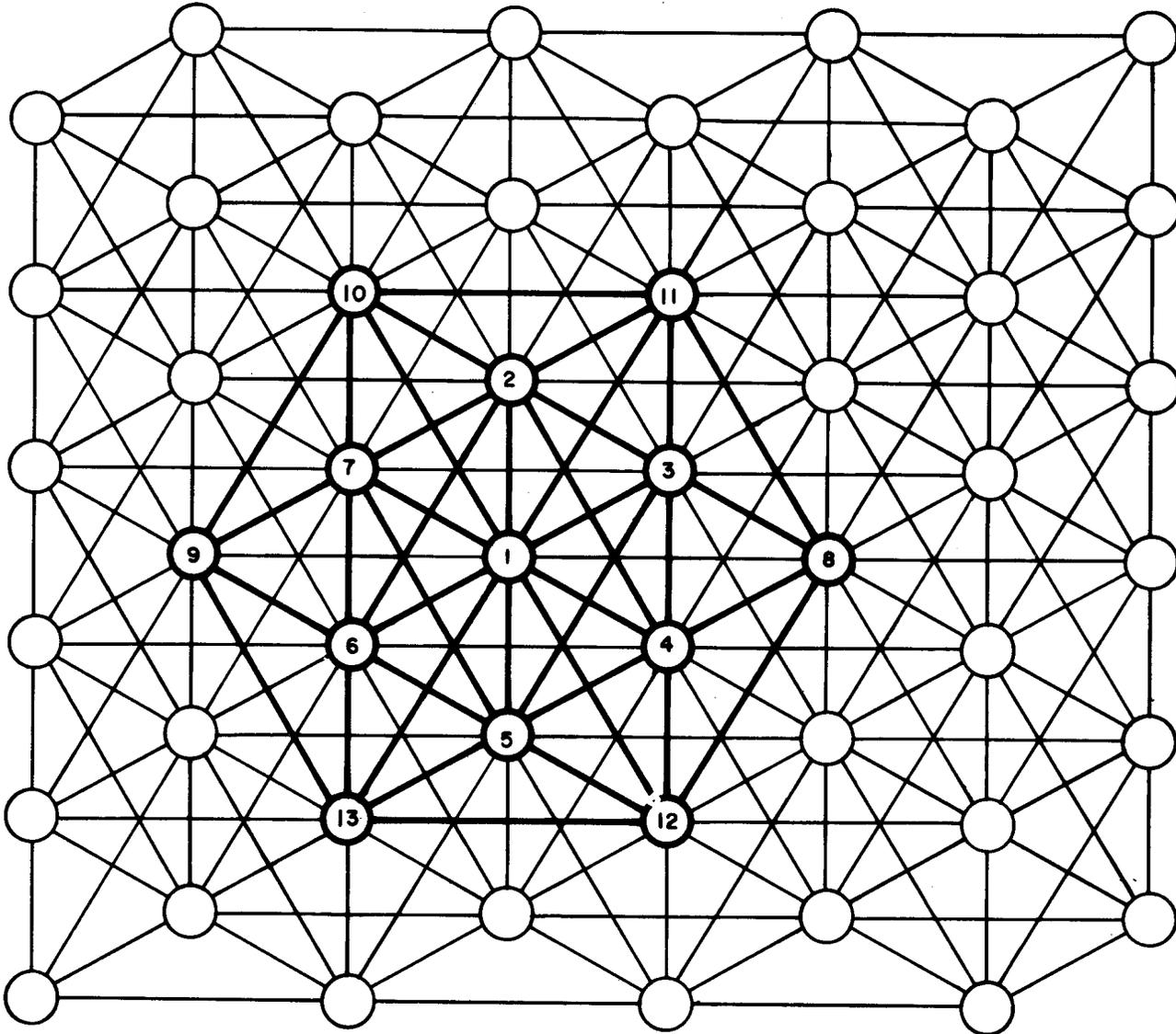


Fig. 3—External Grid (AUTOVON)

in order to close a crosspoint. The other groups of contacts on this vertical unit do not operate since there is no selecting finger between the contacts and the holding bar.

2.08 After the operation of the holding magnet, the selecting magnet is released, thereby returning the horizontal bar and the selecting fingers to normal, except those actively held by operated holding magnets. The flexible finger used to establish a connection remains wedged against the contacts by the holding bar to keep the contacts closed. When the holding magnet releases, the

connection is released and the selecting finger returns to normal. The selecting finger tends to oscillate when released and could cause a false connection if a holding magnet operated while the finger was oscillating. Damping cones are provided on the holding magnet armature to act in conjunction with the damping springs to minimize these oscillations.

SWITCHING NETWORK

2.09 All No. 5 crossbar office connections in the talking paths are established through line

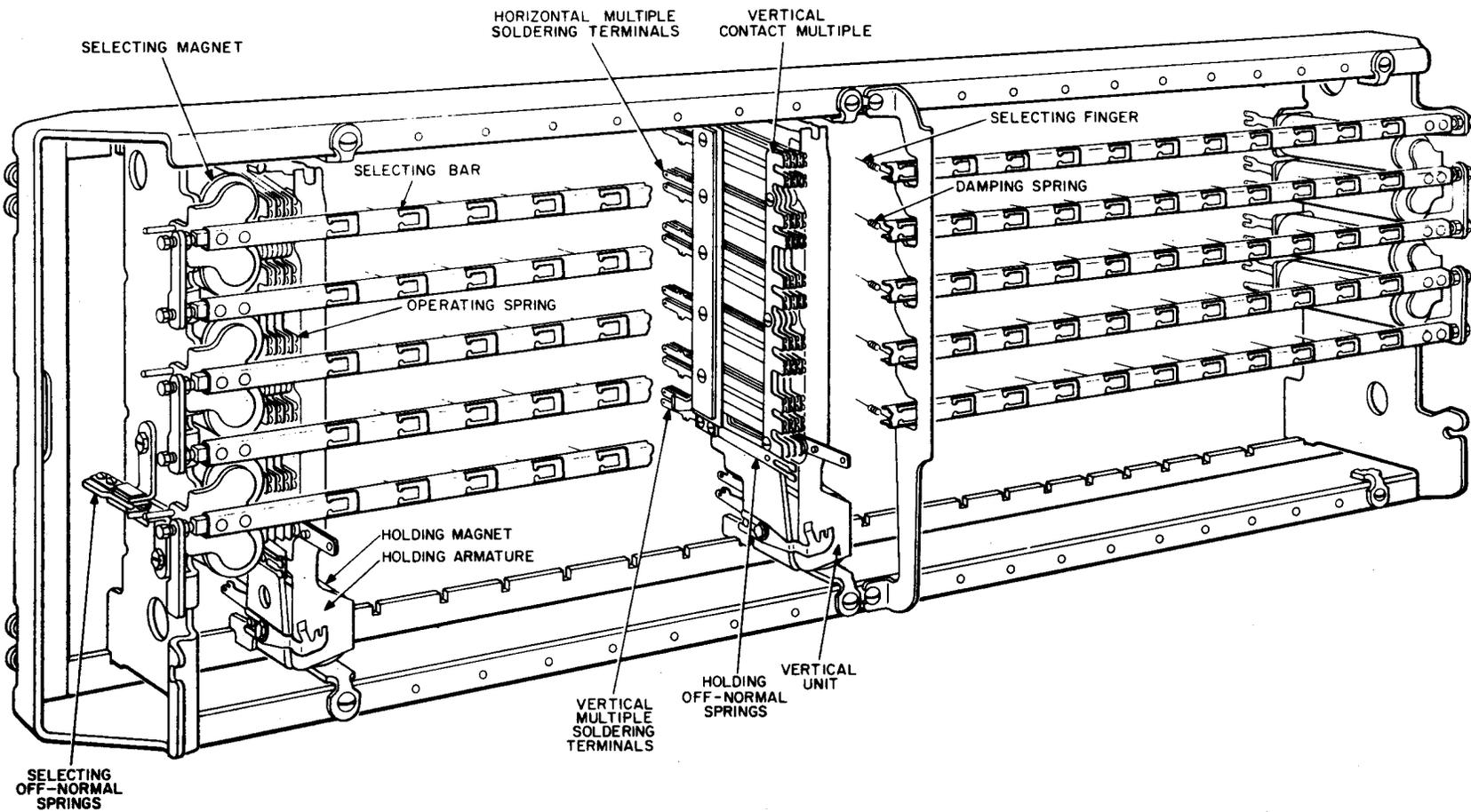


Fig. 4—200-Point Crossbar Switch for 20 Vertical Units

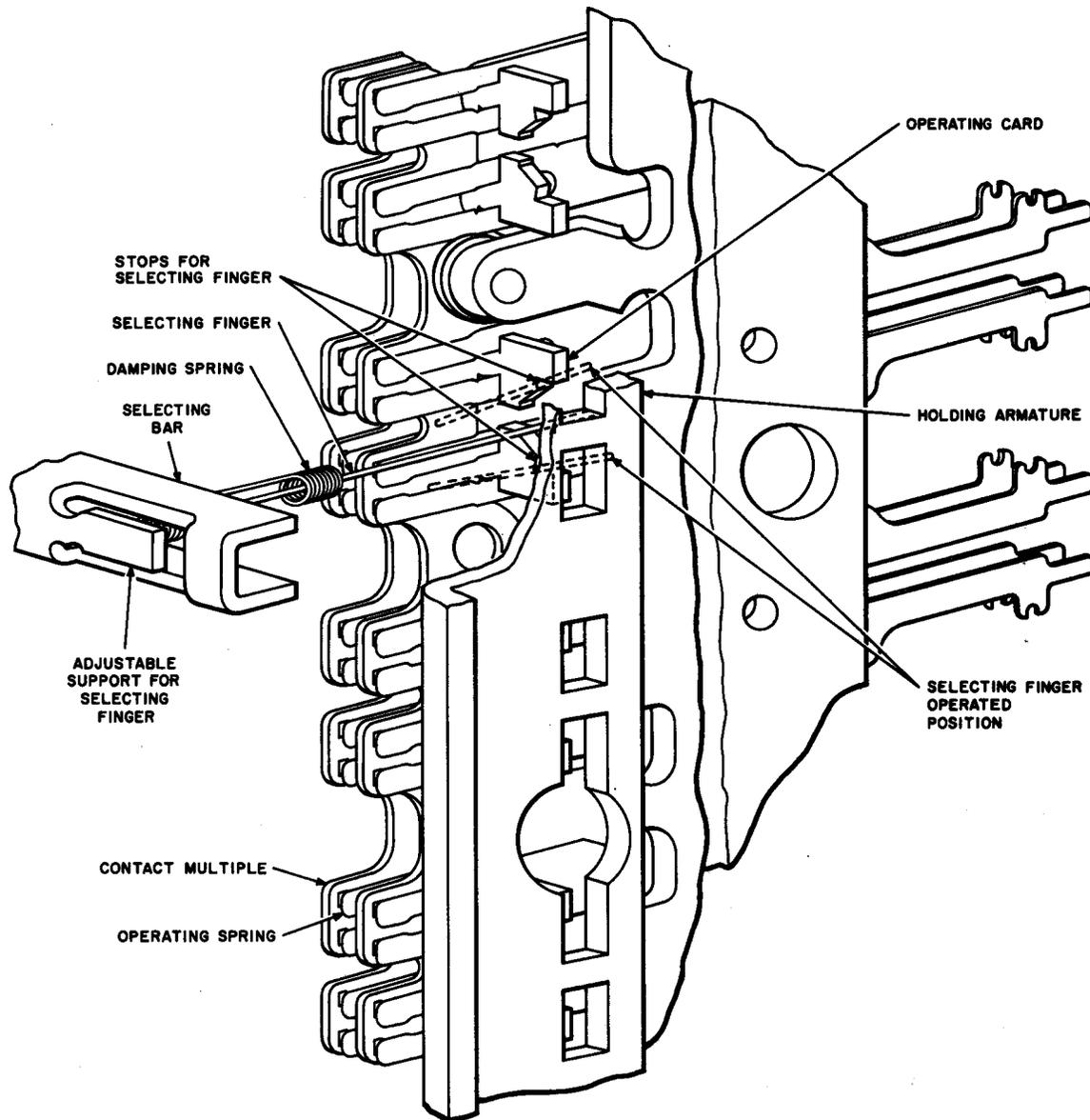


Fig. 5—Selection Elements of a Crossbar Switch

link switches, junctor switches, and trunk link switches. These switching operations are controlled by the common control equipment which includes markers and associated connectors (Fig. 6).

A. Line Link Switches

2.10 The crossbar switches on the line link frame (Fig. 7) are divided functionally into line switches and junctor switches. Customer lines, auxiliary line circuits, and some trunk circuits are connected to the line switches, and junctor circuits

are connected to the junctor switches. Line links are provided for interconnecting the line and junctor switches.

B. Line Links and Junctor Switches

2.11 Line links appear on the horizontals of the switches, ten line links on each switch. These ten line links are distributed among the ten junctor switches, one line link to one horizontal on each of the ten junctor switches. This system of line links permits each line on a line link frame to

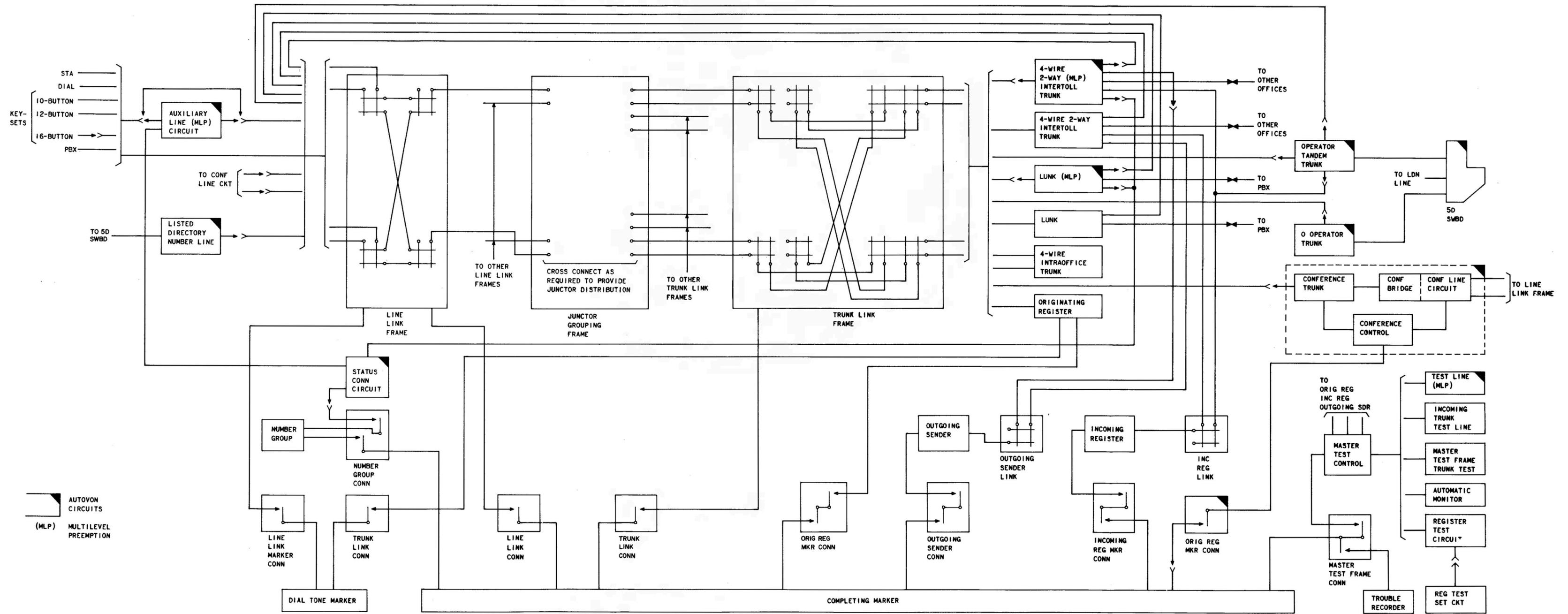


Fig. 6—4-Wire No. 5 Crossbar Office—Block Diagram

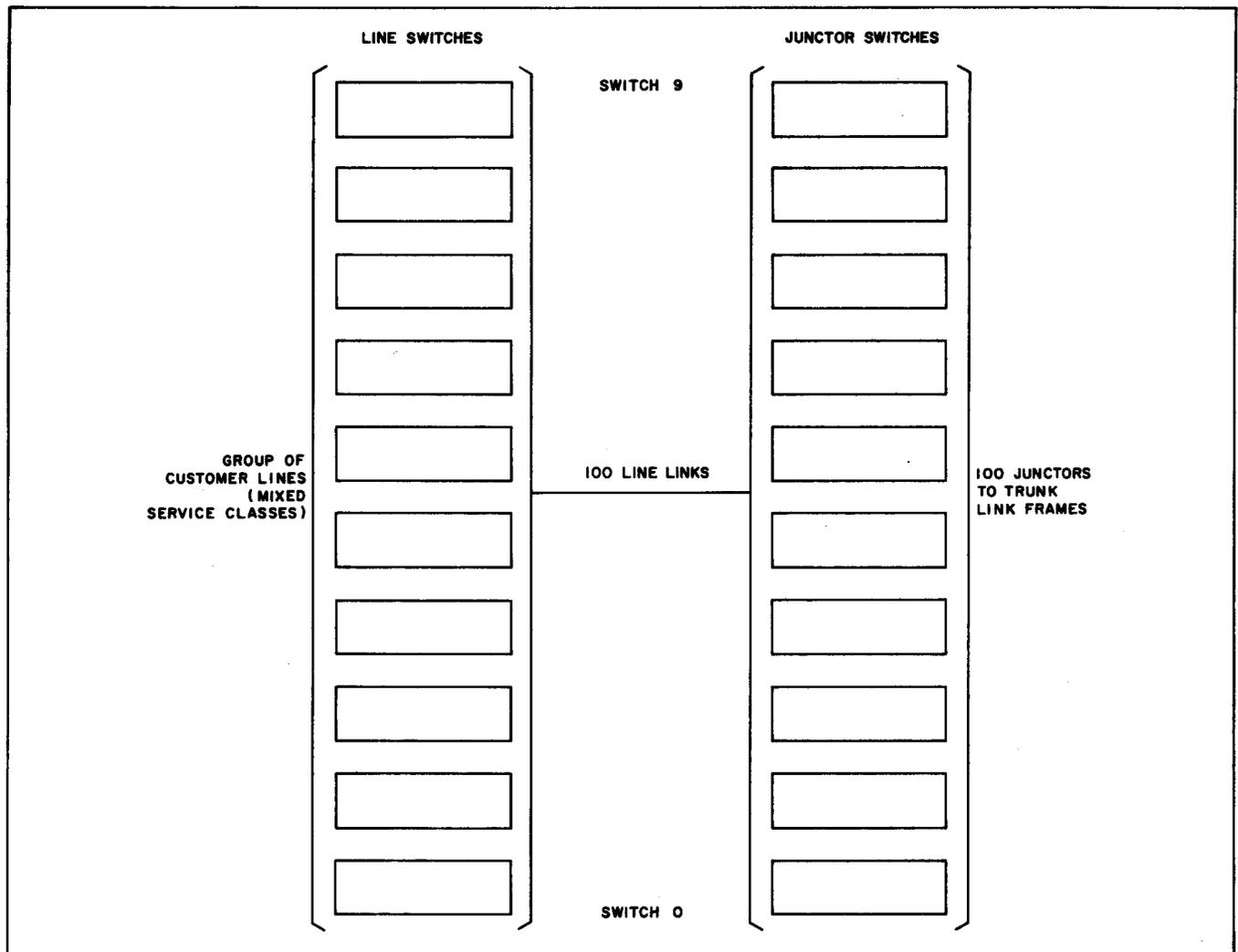


Fig. 7—Line Link Frame

reach any one of the 100 junctors serving that frame (Fig. 8).

2.12 Any particular line link can be readily identified because the line switch horizontal number of each line link is the same as the junctor switch number, and the junctor switch horizontal number of each line link is the same as the line switch number.

2.13 A feature of this line link is that the same frame can serve various classes of service. A maximum of 100 classes of service can be served.

C. Trunk Link Switches

2.14 The trunk link frame is made up of trunk switches, junctor switches, and various miscellaneous circuits. Trunks and originating registers are connected to the trunk switches (Fig. 9), and the junctors from the line link frame are connected to the junctor switches. The trunk links connect the junctor switch verticals to the trunk switch verticals. The ten trunk switches on the trunk link frame furnish A- and B-appearances for 100 trunks or trunks and registers. A maximum of ten register A-appearances is provided. These appear only on switch level zero.

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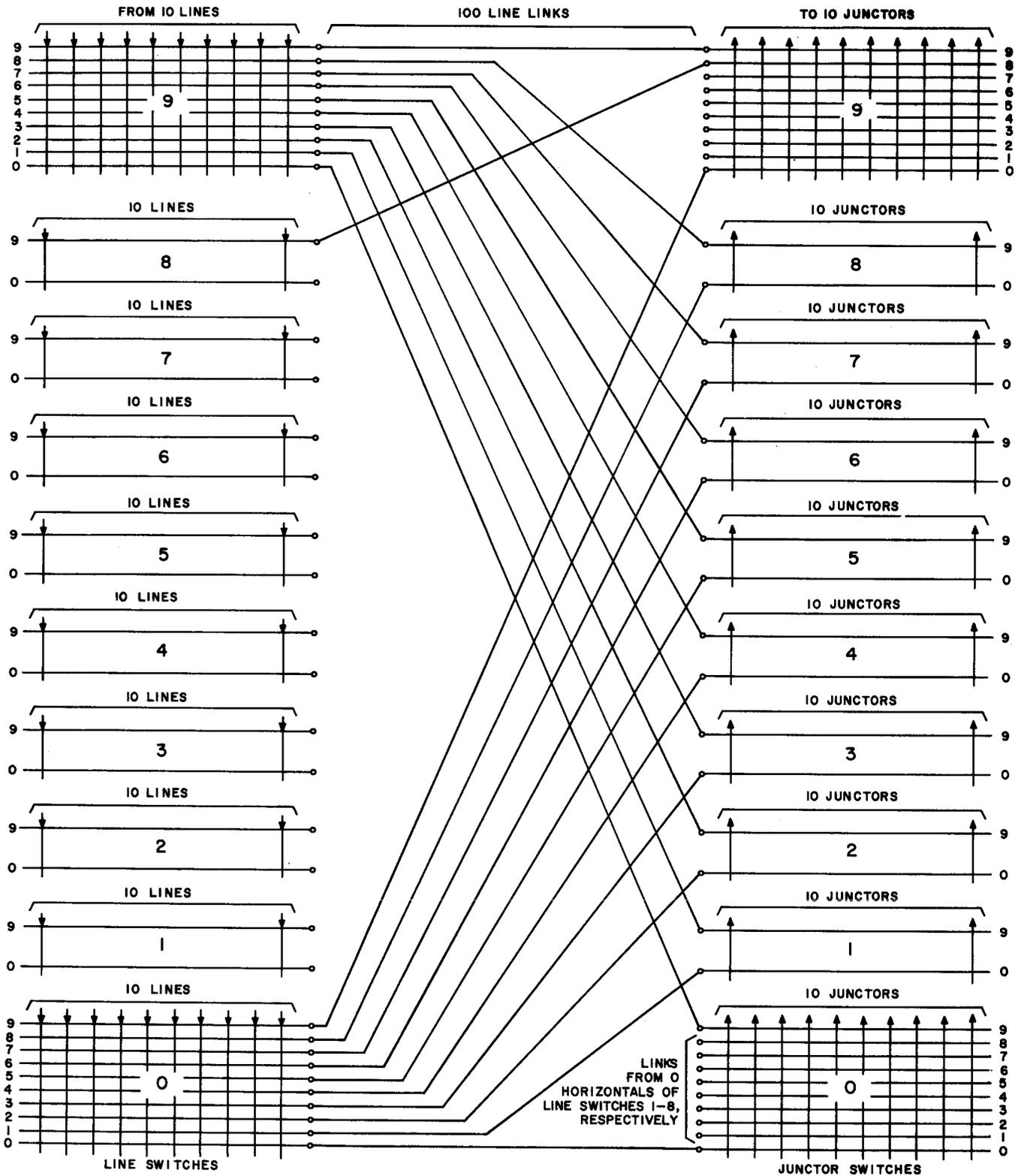


Fig. 8—Line Link Distribution

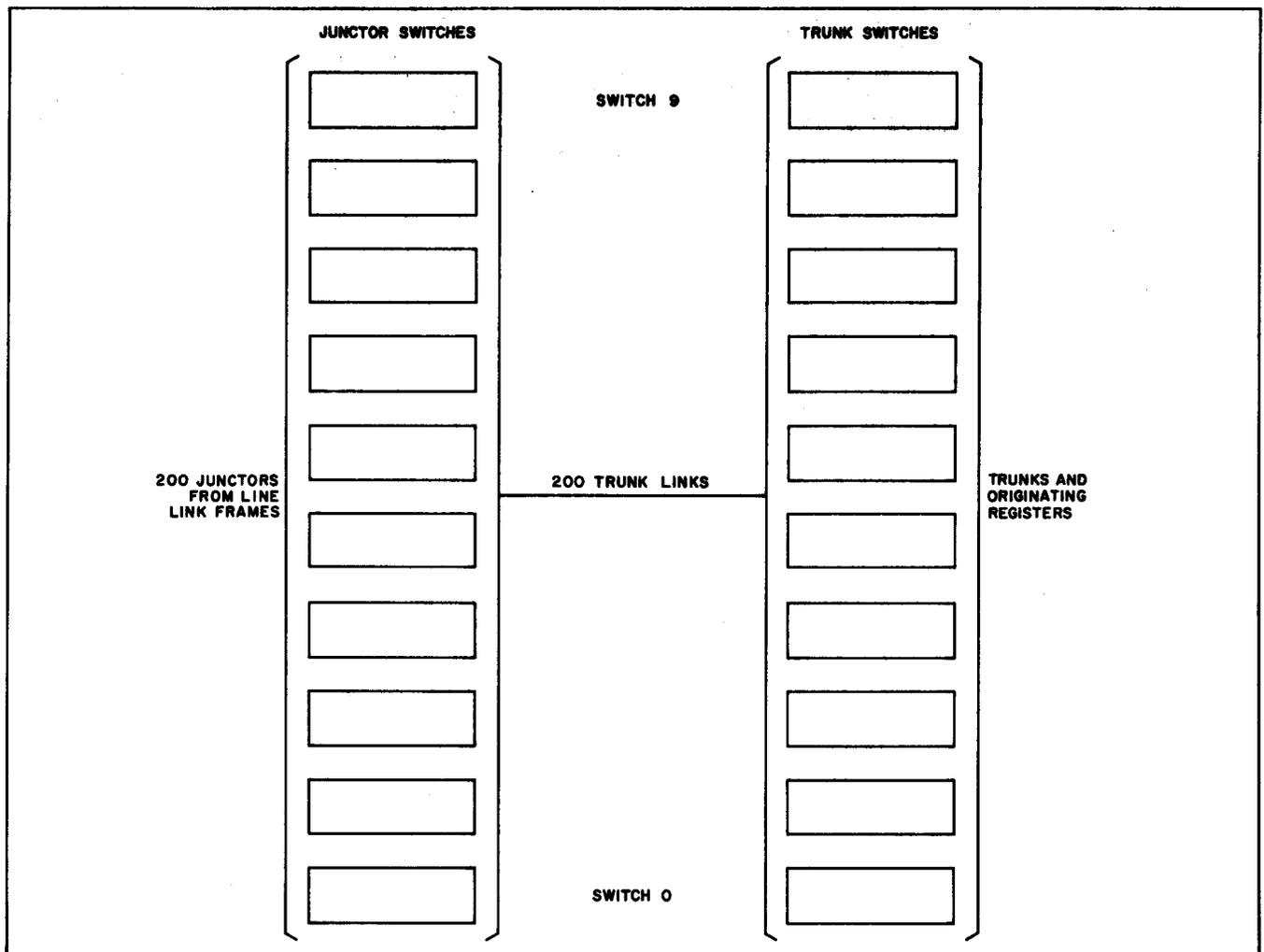


Fig. 9—Trunk Link Frame

D. Trunk Links and Junctor Switches

2.15 There are 200 trunk links and junctors on each trunk link frame. The junctors are connected to the horizontals of the junctor switches, and the trunks are connected to the horizontals of the trunk switches. In order to terminate 20 junctors on the horizontals of one 200-point switch, it is necessary to split the horizontal multiple into left- and right-half switches (Fig. 10). The numbering of the verticals in each half is identified as left and right.

2.16 The vertical number at one end of a link is always the same as the switch number at the other end of the link. In addition, a vertical

on the left half of a switch is always connected to a vertical on the left half of the switch at the other end of the link, and a vertical on the right half of a switch is always connected to a vertical on the right half of the switch at the other end of the link.

2.17 When 11 to 20 trunk link frames are involved, each junctor is multiplied to two trunk link frames in order that each junctor group contains a minimum of ten junctors. This requirement reduces the junctor capacity of the basic trunk link frames by 50 percent, and it is necessary to provide additional junctor switches for each trunk link frame. These additional switches are mounted on the extension trunk link frame.

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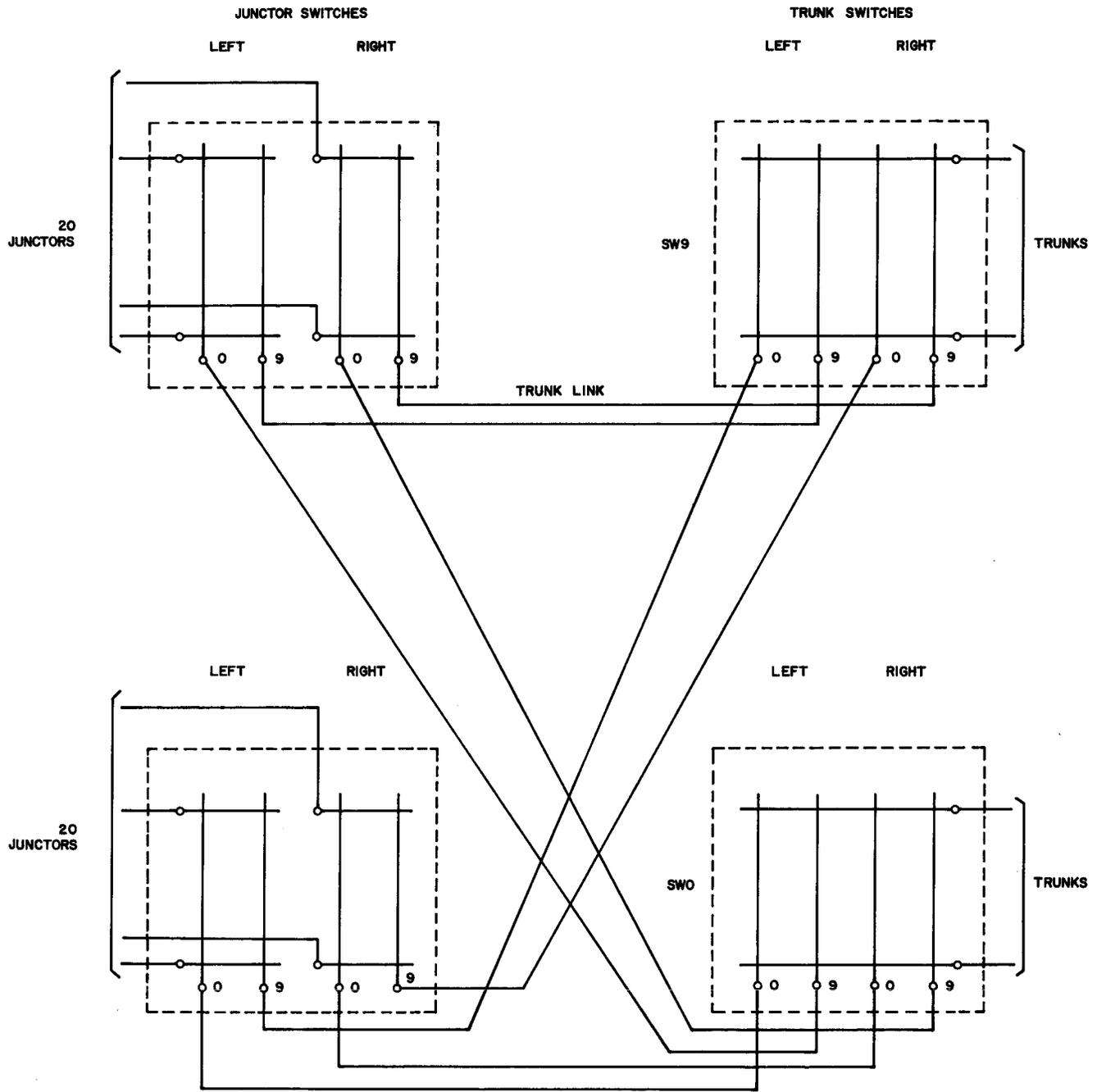


Fig. 10—Trunk Link Distribution

E. Channels

2.18 A channel is the combination of a line link, a junctor, and a trunk link formed by crosspoint closures into the transmission path that interconnects a line and a trunk (Fig. 11). Each line link, junctor, and trunk link consists of two tips, two rings, and a sleeve lead with a switch appearance at each end.

2.19 The ten or more junctors in a group connecting a line link frame with a trunk link frame are distributed over the ten junctor switches of both frames, the junctor switch number being the same on both ends for each junctor. There are ten line links serving each line or trunk on the line link frame distributed over the ten junctor switches.

2.20 There are 20 trunk links serving each trunk on the trunk link frame distributed over the ten junctor switches. Thus, when a line and a trunk for an office consisting of 20 line link and 10 trunk link frames are considered, ten channels are available for a connection. These channels are numbered according to the junctor switches on which they terminate (A of Fig. 11). An idle channel is selected by testing the ten channels at the same time. For office sizes smaller than the above, there are more than ten channels available. For example, in a 10-line link and 5-trunk link frame office, 20 channels are provided (B of Fig. 11). Additional tests are required if an idle channel is not found when the first ten channels are tested.

2.21 The channel number also corresponds to the number of the line switch horizontal on the line link frame, as well as the number of the trunk switch vertical on the trunk link frame.

3. EQUIPMENT ELEMENTS

3.01 The functions and physical appearance of the main equipment elements in a 4-wire No. 5 crossbar office are described briefly in this part.

LINE LINK FRAMES

3.02 Line link frames contain customer line appearances. All calls to or from a customer are connected through the line link frame. These frames also contain access leads for tandem trunks,

toll trunks, line link pulsing trunks, intercept trunks, and test lines.

3.03 A pair of 4-wire line link frames consists of a 2-bay frame and a one-bay frame. The left bay of the 2-bay frame contains ten combined line and junctor switches (100 lines and 100 junctors). The bottom half of the right bay contains five switches associated with the left bay and provides an additional 90 line appearances and 10 no-test verticals. The top half of the right bay contains five switches associated with the one-bay frame. The five switches on each half of the split bay have the horizontals split so that the left half serves horizontal groups 0 through 4 and the right half serves horizontal groups 5 through 9. The one-bay frame is identical with the left bay of the 2-bay frame. This pair of line link frames provides 380 line appearances, 20 no-test vertical appearances, and 200 junctor appearances.

TRUNK LINK FRAMES

3.04 Trunk link frames are 2-bay frames which provide terminations for originating registers and trunks on switching frames. Each pair of line link frames has 200 junctor terminations which are used to connect to all trunk link frames in the office. Since each trunk link frame has 200 junctor terminals for connecting to all line link frames, the ratio of paired line link frames to trunk link frames in an office is generally 1:1. There are no half trunk link frames. In an office with 13 line link frames (one 2-bay frame without a single-bay frame), there are usually seven trunk link frames; however, conditions peculiar to a particular office may cause some variation in this ratio.

EXTENSION TRUNK LINK FRAMES

3.05 Extension trunk link frames are single-bay junctor switch frames. Extension frames are required in offices equipped with more than 20 line link frames or 10 trunk link frames. The extension frames permit pairing of the trunk link frames and provide for at least ten paths between every line link frame and every trunk link frame.

JUNCTOR GROUPING FRAME

3.06 The junctor grouping frame is a single-bay frame containing terminal strips, fanning rings, and rings for jumpers. The junctor grouping frame provides means for terminating the junctors

NOTE:

THE CHANNEL NUMBER ALWAYS CORRESPONDS TO THE LINE SWITCH HORIZONTAL NUMBER OF THE LINE LINK, THE TRUNK SWITCH VERTICAL NUMBER OF THE TRUNK LINK, AND THE JUNCTOR SWITCH NUMBER. ALL OTHER ELEMENTS ARE NUMBERED INDEPENDENTLY OF CHANNEL NUMBER CONSIDERATIONS.

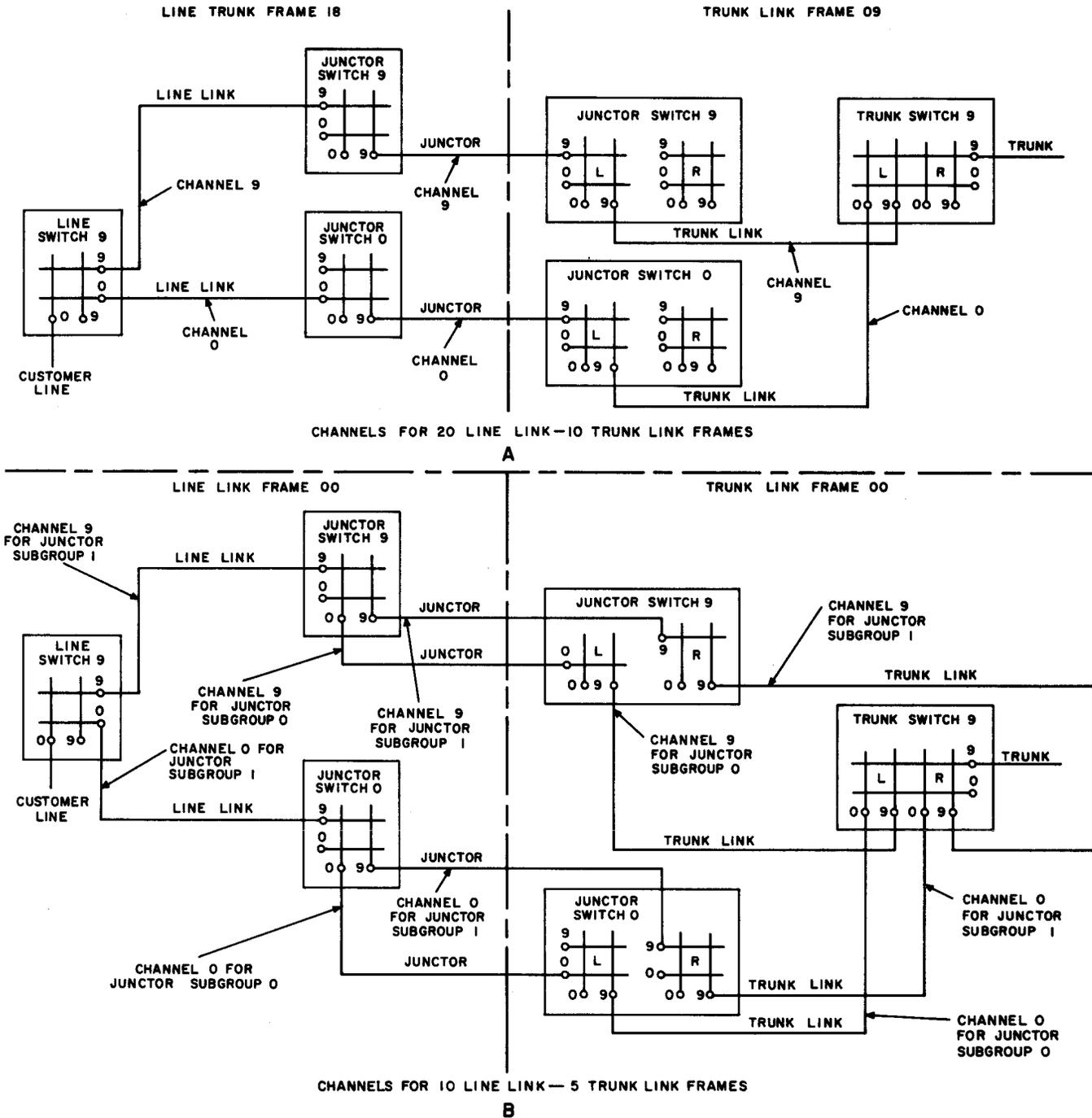


Fig. 11—Channel Distribution—Line Link to Trunk Link Frames

of the line link frames and trunk link frames. The 200 juncturers from each pair of line link frames are divided into approximately equal groups, with one group from each line link frame going to each trunk link frame. However, there is a limiting factor—for efficient service, no group can contain less than ten juncturers. Figures 12 and 13 are examples of junctor distribution for 2 and 20 trunk link frames, respectively.

MARKERS

3.07 Markers perform the major portion of the switching control in an office. Marker action is required on all customer service requests. Markers have access to routing information, customer class-of-service treatment, and other information required to establish transmission paths.

3.08 The quantity of markers in an office depends on the amount of calling traffic handled by the office. A marker group, comprised of markers and their associated equipment units, can serve a maximum of 40,000 customer numbers and 4000 trunk numbers.

A. Dial Tone Marker

3.09 The principal functions of the dial tone marker are to respond to customer demands for dial tone by establishing a connection between the calling line and an originating register and to transfer the calling line location and customer class-of-service information to the originating register.

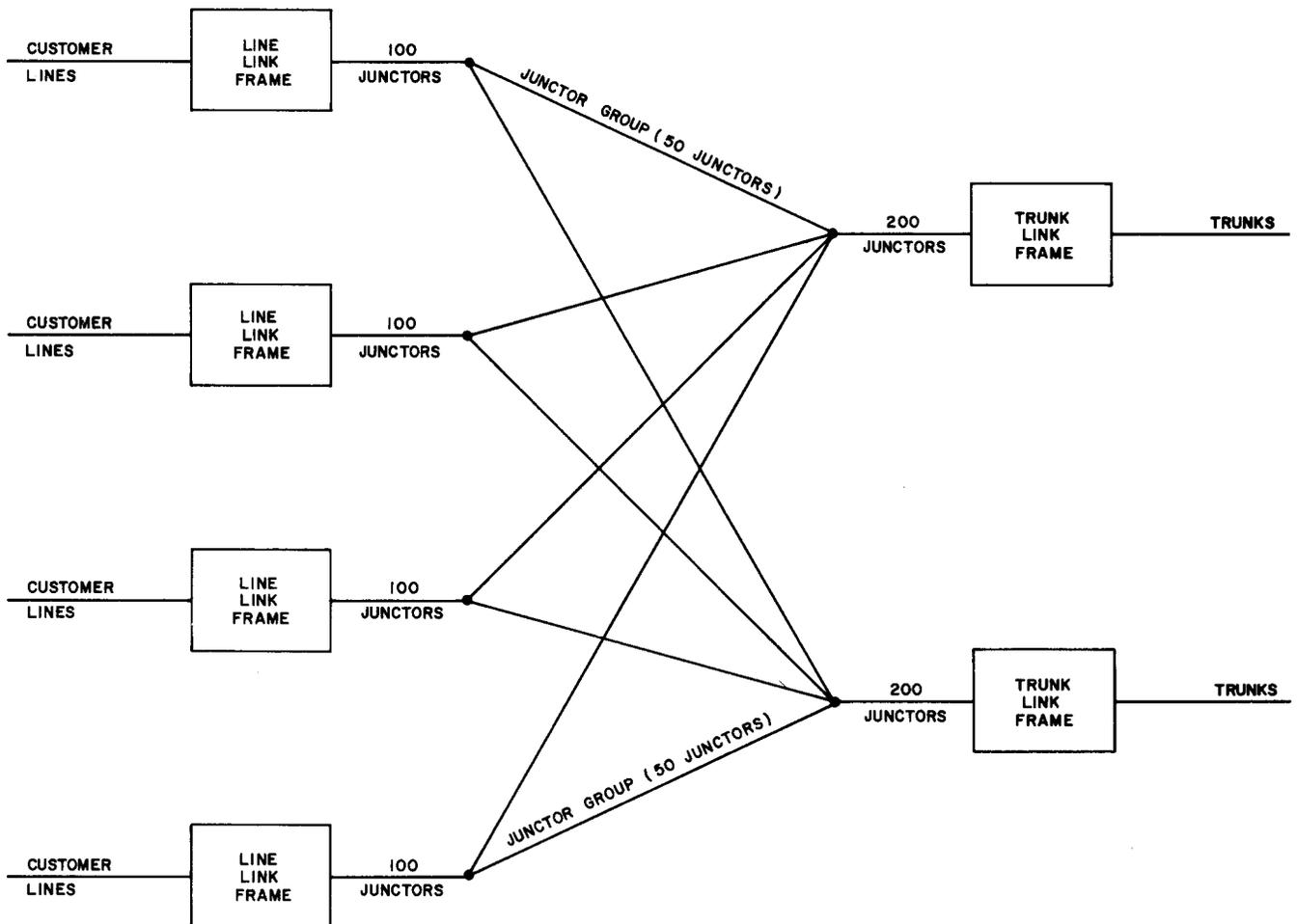


Fig. 12—Junctor Distribution—Four Line Link and Two Trunk Link Frames

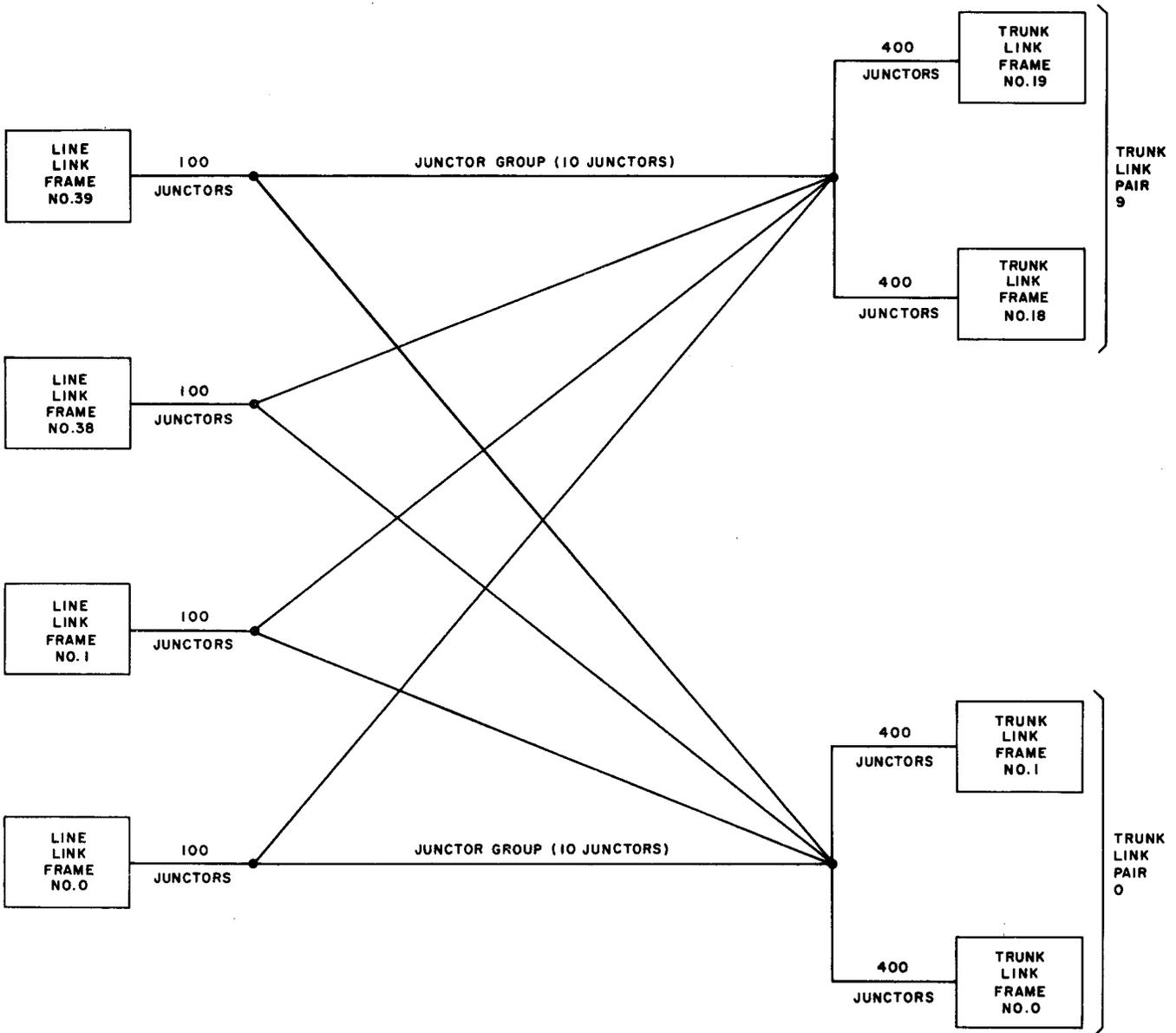


Fig. 13—Pairing of Trunk Link Frames—40 Line Link and 20 Trunk Link Frames

B. Completing Marker

3.10 The completing marker consists of several frames that function together to select and establish a connection between the switching frames for calls originating in, completing to, or switching through the No. 5 crossbar office. The principal functions of the completing marker are as follows:

(a) To determine the proper route for the call from the called number received and the

class of service of the calling customer by use of wire cross-connections placed in the marker.

(b) To connect the calling customer to a trunk or, in the case of incoming or tandem service requests, to connect a trunk to a trunk or a trunk to a customer.

(c) To select an outgoing sender of the proper type when the calling digits indicate that a sender is required. The marker then functions

to pass digit and trunk information to the sender to be used in transmitting directing information to connecting office equipment.

- (d) To determine from area or office code digits if AMA action is required and to transmit information needed to AMA recording equipment.
- (e) To connect to the correct number group frame to determine the line link location and ringing code of a called number or trunk number.
- (f) To recognize circuit busy, channel busy, line busy, vacant numbers, line intercept numbers, and trouble conditions and to control hunting operations in PBX groups.
- (g) To provide a start signal to the trouble recorder when abnormally delayed operation or trouble conditions are encountered in order to initiate a permanent card record of the trouble. This card can be used by maintenance personnel to locate and clear the trouble.

C. Marker Special Features

3.11 Two completing markers, 0 and 1, are equipped with special features for handling some test calls set up by operators, local test desk personnel, or maintenance personnel or automatically controlled by timing devices. The markers consist of the following types:

- (a) Busy verification originated by an operator or no-test calls originated by test desk personnel
- (b) Line insulation test cycles originated locally by maintenance personnel or remotely by test desk personnel
- (c) Special hunt calls originated at the local test desk
- (d) Line verification tests performed by frame personnel.

D. Marker Description

3.12 The basic completing marker frames in a No. 5 crossbar office consist of the common equipment frame, the translator and code treatment frame, and the route relay frame. For every two

completing markers, a single-bay frame is required to arrange for 4-wire features other than route control such as control and control digit screening.

- (a) The common equipment (COM EQPT) frame contains general purpose relays, connection fields, and memory relays to store customer identification information for routing and billing of service requests.
- (b) The translator and code treatment (T&CT) frame functions to translate and route called office codes, screen customers or trunk class of service, and transfer the called numbers to the number group frame.
- (c) The route relay (RR) frame provides for route information to a connecting office. It contains provisions for 100 route relays on four completing markers.

3.13 Supplementary features are available in No. 5 crossbar offices. When these features are provided, the following frames are required:

- (a) The code conversion (CC) frame enables an office code to be converted to a 2- or 3-digit arbitrary code for routing through offices such as step-by-step tandem or toll centers.
- (b) The route program (RP) frame provides route program relays and serves one completing marker.
- (c) The PBX allotter (PBX ALLR) frame serves up to four markers. Lines to large PBXs may be allotted to two or more number groups.
- (d) Supplementary service treatment (SST) and auxiliary service treatment (AST) frames increase the number of service treatment relays from 60 (a basic complement) to 120 with the addition of the supplementary frame or to 180 with the addition of the supplementary and auxiliary service treatment frames.
- (e) The originating line identifier unit is provided in small No. 5 crossbar offices where installation of dial tone markers is not economical. The function of the unit is to serve customer requests for dial tone and to identify and transmit the customer location to the completing marker.

SECTION 16

ORIGINATING REGISTERS

3.14 The functions of the originating register are to:

- (a) Transmit dial tone to the customer
- (b) Receive and store the digits of the called number including preemption and routing digits required for AUTOVON
- (c) Transfer customer location and called number information to the marker after dialing has been completed
- (d) Perform customer loop tests designed to detect trouble conditions
- (e) Accept dial pulses or TOUCH-TONE® frequencies.

Originating register circuits appear on the trunk link frame, and connections are established to these circuits by either the dial tone marker or originating line identifier unit.

3.15 The originating register frame is a double-bay frame which can be equipped with eight originating registers. The bay is also equipped with register multicontact relays associated with the marker multicontact relays located on the originating register line memory frame. This 2-bay frame is designated OR.

ORIGINATING REGISTER CIRCUIT CALLED ADDRESS TRANSLATED (AUTOVON) CIRCUIT

3.16 The originating register circuit called address translated (AUTOVON) circuit permits an individual line to reach only one 7- or 10-digit station in the system without dialing. In addition, this circuit can provide a priority and a routing digit. It is capable of translating the line location of 100 lines into 98 respective 7- or 10-digit addresses.

AUTOMATIC CONNECTION LINE CIRCUIT (AUTOVON)

3.17 The automatic connection line circuit (AUTOVON) provides the same features for one line as the originating register circuit called address translated (AUTOVON) circuit provides for 100 lines.

ORIGINATING REGISTER LINE MEMORY FRAME

3.18 The function of the originating register line memory frame is to register the calling customer line link frame location and class of service and to store this information until required by the completing marker. This frame is a single-bay frame containing multicontact relays and reed-type relays.

ROUTE TRANSLATORS

3.19 The route translators provide additional translator capacity to the marker. The marker passes the area and/or office code dialed plus one of ten customer group indications to the route translator. The route translator returns route information, such as route relay number or line route relay number, to the marker.

3.20 A one-bay translator administration and test (TAT) frame is provided for testing and loading the data into the translator manually or from an external teletypewriter.

NUMBER GROUPS

3.21 The number group translates customer directory numbers and certain trunk numbers into line equipment location. The line equipment location identifies the line link frame location. The number group also supplies the proper ringing combination and other information concerning the number, such as whether it is in a terminal hunting group.

3.22 A number group frame serves 1000 consecutive numbers. The total amount of directory, trunk, or station numbers, in multiples of 1000, determines the number of number group frames required. If the office serves both 2-wire and 4-wire customers and common number group frames are used, number group assignments must be made in groups of 100 in order to separate the services available to each type of customer. This reduces the capacity of a number group frame in blocks of 100 numbers. A maximum of 40 number group frames, including trunk number frames, can be associated with one marker group.

OUTGOING SENDERS

3.23 An outgoing sender is used on all calls requiring pulsing to the connecting office.

The type of pulses required at the connecting office determines the type of sender used to transmit the called number. Therefore, two types of outgoing senders are provided in a No. 5 crossbar office, dial pulse (DP) and multifrequency (MF). The outgoing sender frame mounts four senders of one type.

OUTGOING SENDER LINKS

3.24 Outgoing sender links connect outgoing and intermarker group senders to outgoing trunks. Information from a sender to a trunk is transmitted through this sender link. One sender link frame, designated OSL, mounts ten 200-point crossbar switches, and both outgoing senders may have appearances on one sender link frame.

INCOMING REGISTERS

3.25 The 4-wire No. 5 crossbar provides for MF pulsing between offices. The 4-wire MF incoming register, in conjunction with a multifrequency receiver, is designed to receive pulses on a 2-out-of-6 frequency basis from either a keyset or an outgoing sender. The register may be arranged to receive a maximum of ten digits and three information (control) digits. The information digits are used to establish priority and special routing for AUTOVON customers.

INCOMING REGISTER LINKS

3.26 The incoming register links (IRLs) on incoming register frames connect incoming trunks to incoming registers. The eight crossbar switches on this frame provide 160 nonbylink trunks with access to a maximum of ten incoming registers. One, two, or three frames may be used together as one link group with MF or DP registers.

CONNECTORS

3.27 A connector is a relay-type switching device for interconnecting two equipment units by a relatively large number of leads. A specific method is used to designate connector titles. If a particular type of equipment originates action toward a marker, the connector title includes both the originating and the terminating equipment. For example, the line link marker connector action is originated by the line link frame and terminates in the marker. The originating circuit must be

mentioned because many circuits can originate action toward a marker.

3.28 When a marker originates action toward another type of equipment, the connector is named according to where the connector action terminates but does not contain the word marker in the title. Table A lists the principal connectors in a No. 5 crossbar office.

TRUNKS

3.29 Trunks have their switch frame appearances on trunk link frames and carry calls from one office to another and from customer to customer within the office. Various types of trunks, mounted on relay rack frames, are provided to serve the traffic in an office.

3.30 Principal categories of trunks are listed below. Many miscellaneous types are not listed.

(a) *Two-way 4-wire trunk (LUNK)* is used to complete outgoing calls to a PBX via an appearance on the trunk link frame and to accept incoming calls from the PBX on a line link frame appearance. This circuit combines the features of a trunk and a line (LUNK).

(b) *Two-way intertoll trunks* are used to complete calls between two offices and have the following features:

- Two-way MF pulsing.
- Direct access through trunk link frames.
- Line link frame and number group frame appearance.
- Can be arranged for local originating or local originating and tandem AMA records.
- Equipped for glare detection. (This feature enables the marker to check for simultaneous seizure from both ends of the trunk.)
- Echo suppression control.
- E- and M-lead signaling.
- Forwards priority signals (AUTOVON).

TABLE A
CONNECTORS

CONNECTOR	CONNECTS FROM	CONNECTS TO
Line Link Marker Connector	Line Link Frame	Dial Tone Marker
Originating Register Marker Connector	Originating Register	Completing Marker
Incoming Register Marker Connector	Incoming Register	Completing Marker
Auxiliary Originating Register — Incoming Register Marker	Originating Register and Incoming Register	Completing Marker
Line Link Connector	Dial Tone or Completing Marker	Line Link Frame
Trunk Link Connector	Dial Tone or Completing Marker	Trunk Link Frame
Auxiliary Trunk Link Connector	Completing Marker	Trunk Link Frame
Outgoing Sender Connector	Completing Marker	Outgoing Sender
Number Group Connector	Completing Marker	Number Group
Transverter Connector	Outgoing Sender	Transverter

(c) **Intraoffice Trunks:** Two 4-wire intraoffice trunks are used to complete calls between customers in the same office. One is arranged for flat rate and the other for flat rate or LAMA. The LAMA trunk requires the use of an MF sender to transfer the AMA information to the transverter. Neither trunk has a switchboard appearance nor is arranged for transfer, but each trunk has two trunk link frame appearances.

(d) **Two-way off-net access lines (ONALs)** are used to complete calls from a switched service network to the Bell System network or to allow a customer in the Bell System network to complete a listed directory number call to a network PBX so that the operator can complete the call using network facilities.

(e) **Two-way local off-net access lines (LONALs)** are used in the same manner as ONALs except on a local basis.

(f) **No-test trunks** are used by the local 5D switchboard attendant for verification of

line-busy conditions. This trunk is arranged to operate on a 4-digit basis without a control digit. It may be arranged for preempt operation (AUTOVON).

(g) **Recording completing or vacant code intercepting trunks** are used to complete special service and assistance calls from 2-wire and 4-wire stations in a 4-wire No. 5 crossbar office to a 5D switchboard in the same building. Vacant code calls may also be routed to this trunk or to a separate group. Separate trunk groups are required for priority (AUTOVON) and nonpriority calls.

(h) **Line link frame intercept trunks** are used to route incoming calls to intercept at a 5D toll switchboard when these calls involve calls to a changed or disconnected number.

(i) **Tone, announcement, and permanent signal overflow trunks** are used to return busy tone when a called line is busy or return overflow tone when circuits are busy. These

trunks may also be used to connect vacant code and partial dial calls to an announcement machine.

- (j) *Outgoing station trunk circuits with E- and M-lead supervision* are used to route calls to a 4-wire station which is restricted to receiving only conference calls.

AUXILIARY LINE CIRCUITS (AUTOVON)

3.31 Auxiliary line circuits are used to provide additional features for the line circuits. Two major categories of auxiliary line circuits are as follows:

- (a) *Auxiliary line circuits* are used for AUTOVON to store the priority of a call. In addition, this line circuit provides the following features:

- Recognizes an off-hook condition at the station or PBX end when a call is initiated and indicates this condition to a marker
- Provides the types of ringing required by the PBX or station equipment connected on a terminating call
- Operates as a preemptible or nonpreemptible auxiliary line circuit
- Provides a preempt tone to the station or PBX when a connection facility is preempted
- Provides line lockout on permanent signal or trunk preemption conditions
- Provides an optional fast release feature to prevent a calling party hold.

- (b) *Auxiliary line circuits* are used for AUTOVON which is served by carrier or some other means using E- and M-lead supervision. This line circuit converts dial pulsing to battery interruptions on the M-lead for calls outgoing from the station and converts a wink pulse on the E-lead to ringing for a call incoming to the station.

LOCAL AUTOMATIC MESSAGE ACCOUNTING (LAMA) EQUIPMENT

3.32 Non-AUTOVON 4-wire No. 5 crossbar offices are equipped for full LAMA operation. There are three principal uses for LAMA records:

- (a) For internal control by the customer of the calls using the private network
- (b) For point-to-point engineering and administration data
- (c) For toll billing of calls that cross over to the message network.

Recorders, call identity indexers, transverters, and transverter connectors are used by both 2-wire and 4-wire lines. Since both of these configurations can be in the same office, separate translator frames are required for 4-wire line link frames.

A. Transverters

3.33 The transverter provides a common circuit in the path between senders and recorders and is used to pass information to the recorder concerning initial entries on service and test calls. The transverter receives information registered in the sender by way of the transverter connector, transmits part of the information in its original form, and converts the remainder of the information to a form suitable for controlling the recording. For 4-wire operation, the following modifications have been made:

- (a) To differentiate between 2-wire and 4-wire calls
- (b) To recognize 4-wire local and 4-wire tandem calls
- (c) To translate control digits into office indexes
- (d) To provide a key which allows or prevents an AMA record on nondetail billed calls
- (e) To record an incoming tandem trunk number instead of a line number on tandem AMA calls

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- (f) To distinguish message billing index signals received on 4-wire calls from those received on 2-wire calls
- (g) Not to seize a translator on a tandem AMA class call
- (h) To permit functioning with separate translators for 2- and 4-wire lines.

B. Translators

3.34 The translator frame provides a means for translating a customer line equipment location (line link frame, horizontal group, vertical group, and vertical file numbers) to a directory number that is entered on LAMA tape for record purposes. A translator frame may have a capacity of 1000 or 2000 customer line equipment numbers. The directory numbers associated with the 1000 or 2000 lines of each translator frame may have a maximum of 30 office indexes.

PRECISE TONE SUPPLY (AUTOVON)

3.35 Precise signaling in addition to normal signaling between offices, trunks, and auxiliary line circuits is required in AUTOVON offices. These signals are used to inform the calling and called customers on an established call that preemption is occurring and, in effect, to cause release of the existing call.

3.36 A precise tone supply plant can provide four call progress or information tones at two voltages. These tones are applied to lines and trunks by originating registers and to line circuits arranged for multilevel preemption by intertoll trunks, LUNKs, and auxiliary line circuits.

4-WIRE STATION SET (AUTOVON)

3.37 The station telephone set provided for operation with the 4-wire No. 5 Crossbar

System is similar in appearance to the 500-type 6-button key telephone set. Generally, it will be equipped with a 16-key TOUCH-TONE dial. In some cases, rotary dials may be used for technical reasons or for compatibility with other dial systems reached by the same set. Both 4-wire network and 2-wire local lines may terminate on these sets.

4. METHOD OF OPERATION

GENERAL

4.01 This part describes, without detailed reference to circuit operations, how the various types of calls in a 4-wire No. 5 crossbar office are handled. Special features provided for AUTOVON are identified when covered.

4.02 The calls in a No. 5 crossbar office are of four general types: intraoffice, tandem, outgoing, and incoming. A dialing connection is established in the office for the intraoffice and outgoing types of calls as shown in Fig. 14.

4.03 An intraoffice call is a call between customers served by the same office. The talking connection in the office consists of two channels established between the customer lines through an intraoffice trunk as shown in Fig. 15. A customer who makes an outgoing call to another office is connected through a channel to an outgoing trunk as shown in Fig. 16. The incoming call is connected to the called customer by means of a channel between the incoming trunk and the called customer as shown in Fig. 17.

DIAL TONE CONNECTION

4.04 A dialing connection is established between the calling customer and an originating register in the central office after the calling customer lifts the receiver from the switchhook and gains access to a line circuit in the office. In the common control switching arrangement (CCSA)

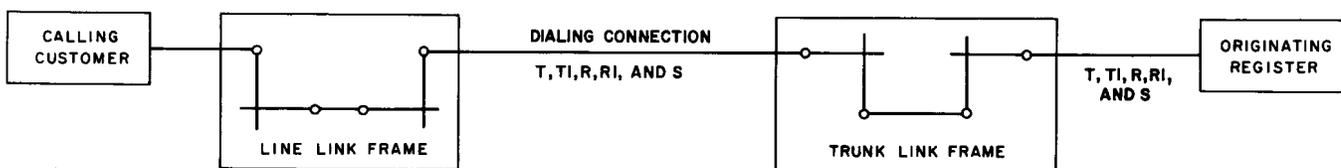


Fig. 14—Dialing Connection

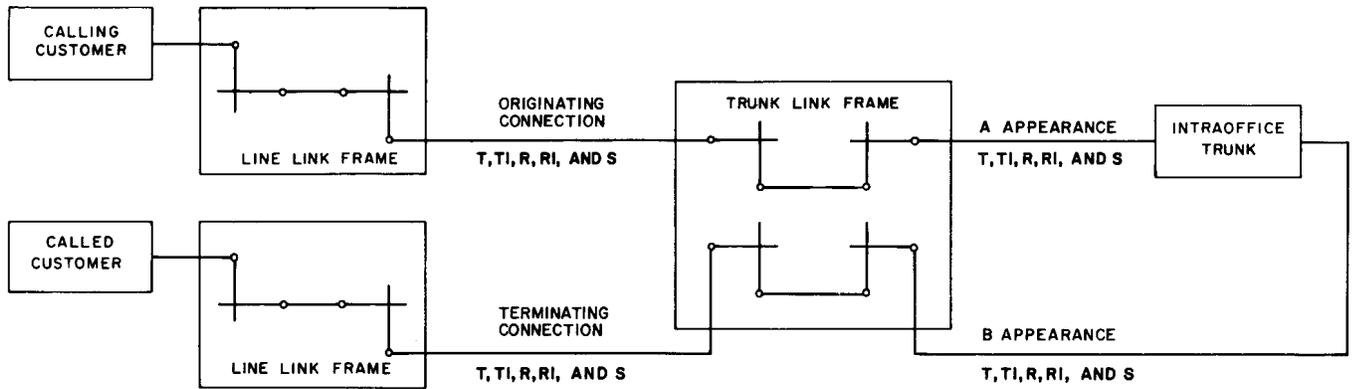


Fig. 15—Intraoffice Trunk Connection

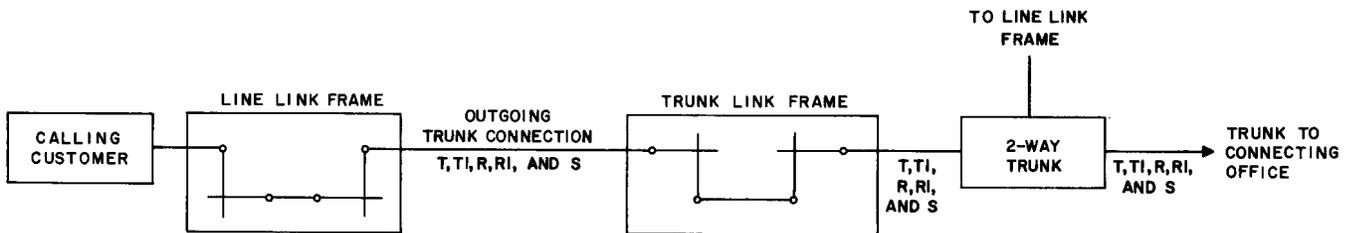


Fig. 16—Outgoing Trunk Connection

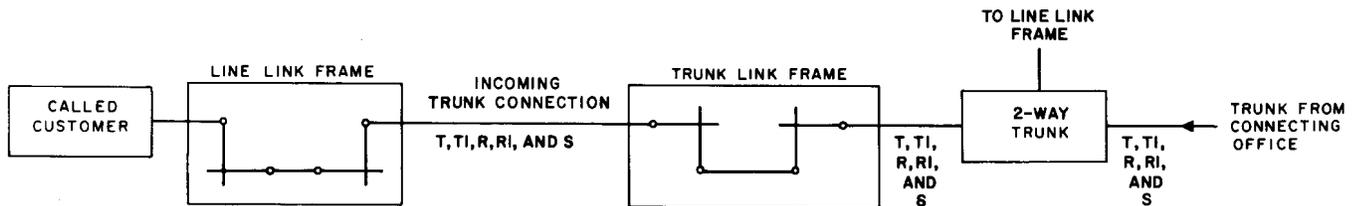


Fig. 17—Incoming Trunk Connection

network, the customer dials an access digit to gain access to the office through a PBX. AUTOVON stations may receive direct dial tone or may be required to dial the PBX operator, who will bid for dial tone from the central office. The centrex central office customer will receive the dial tone directly from the central office. Dial tone, the signal to start dialing, is returned to the calling customer from the originating register.

A. Establishing Dialing Connection

4.05 When a bid for dial tone is made, the line relay on the line link frame is operated to inform the line link marker connector that a dial tone marker is required. The line link marker connector selects an idle dial tone marker and transmits the location of the calling line. The only time the line link marker connector seizes a marker

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is when a dialing connection is to be established (Fig. 18, connection 1.)

4.06 In order to establish a dialing connection between the customer line and an idle originating register, the marker must determine:

- (a) The class of service and equipment location of the calling line
- (b) The trunk link frame location of an idle originating register
- (c) That a channel between the line and the register can be obtained.

The calling line class of service and equipment location will be stored in the originating register by the marker for subsequent use on marker intraoffice or outgoing trunk jobs.

4.07 The equipment location of the calling line is identified in terms of the line link frame number, vertical group, horizontal group, and vertical file numbers.

4.08 A vertical group of customer lines is five verticals wide and ten switches high for a total of 50 lines. There are four vertical groups in a line link frame pair. A horizontal group is one switch high and extends across all the vertical groups on a frame. There are always ten horizontal groups on a frame. A vertical file is one vertical wide and ten switches high for a total of ten lines. The number of vertical files on a frame depends on the number of lines on that frame. The division of the frame into vertical groups, horizontal groups, and vertical files is illustrated in Fig. 19.

4.09 The number of the line link frame, vertical group, and horizontal group in which the line appears is transmitted to the marker via the line link marker connector. Therefore, at this point,

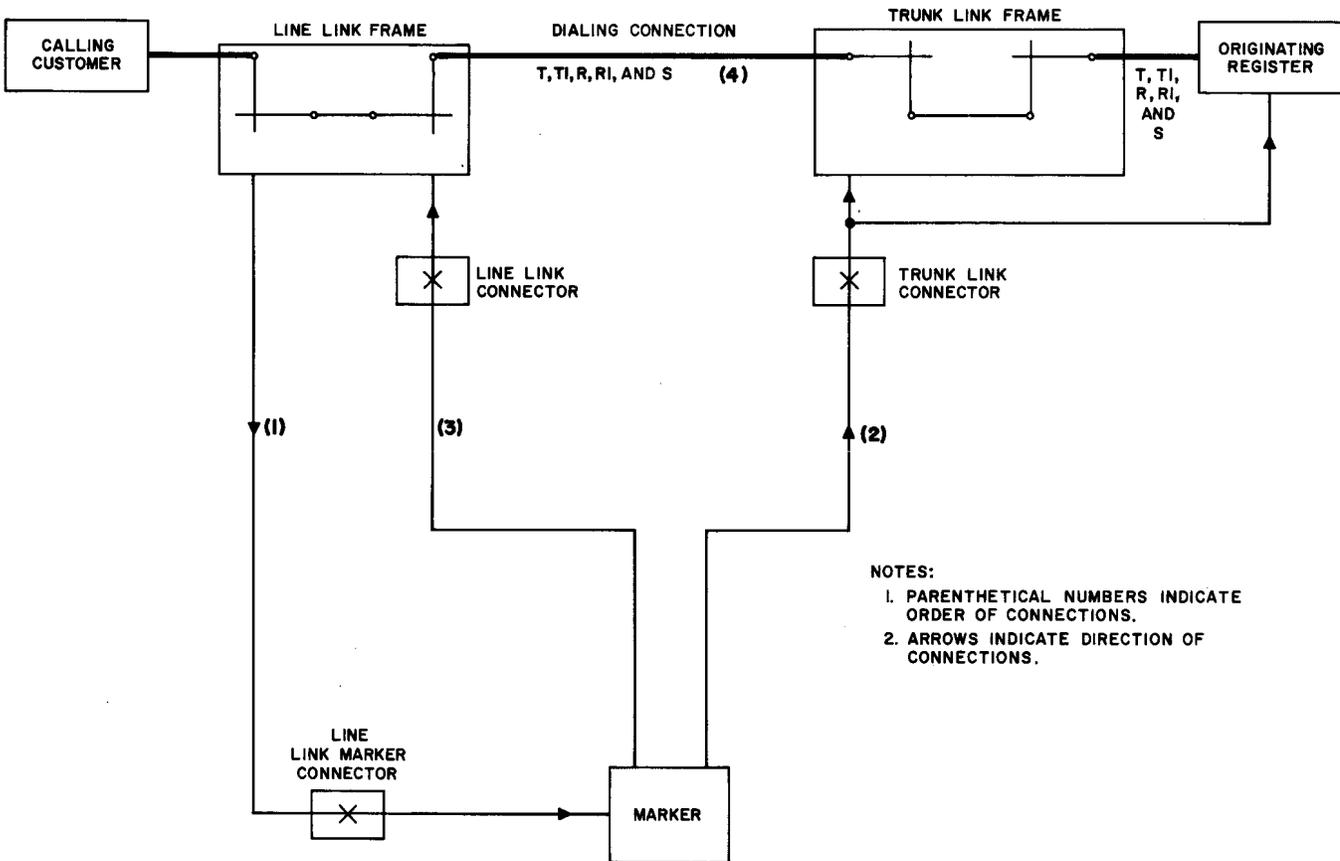


Fig. 18—Establishing Dialing Connection

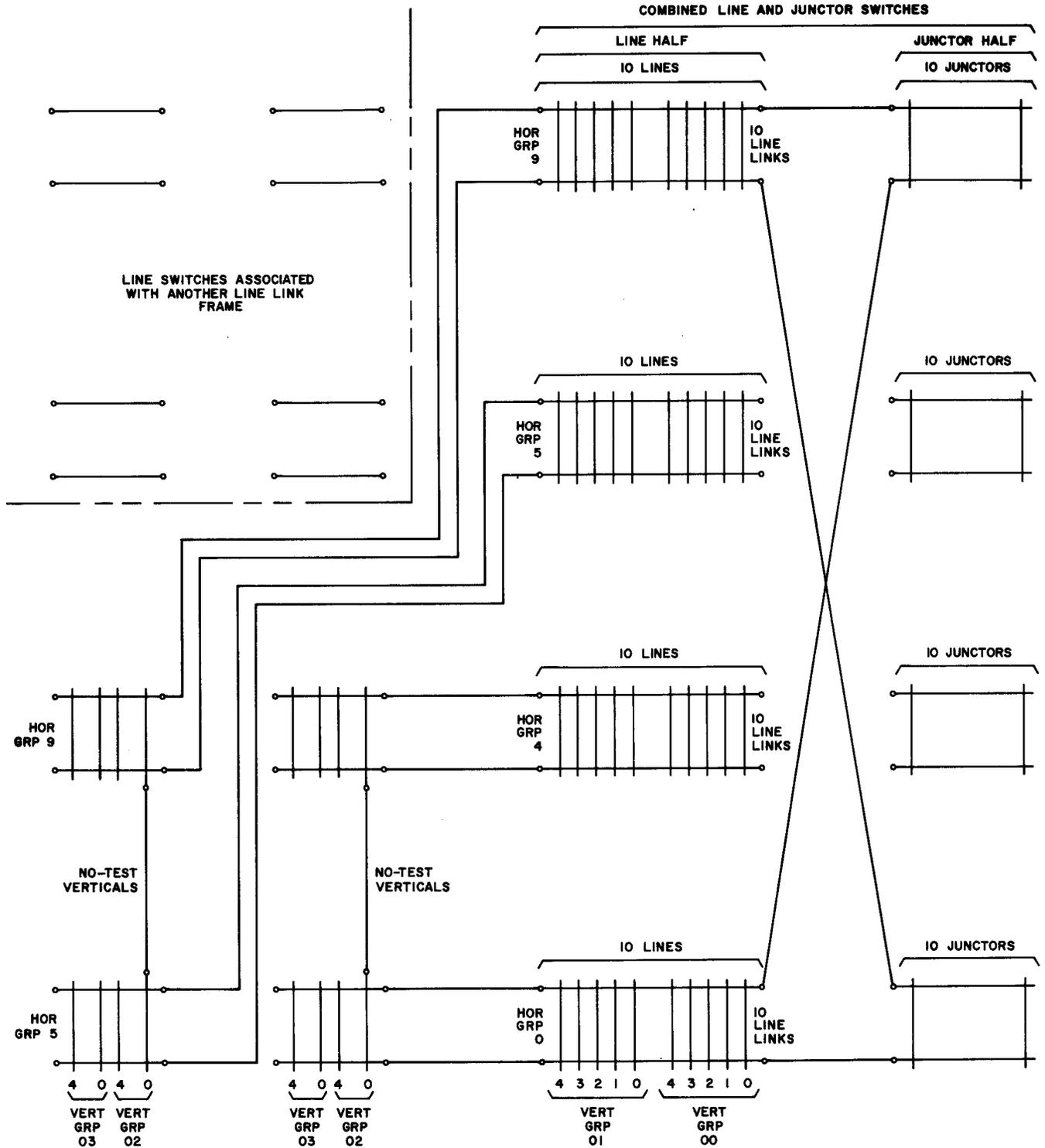


Fig. 19—Basic Line Link Frame—Split Frame—190 Lines—Schematic—Wiring Side

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the calling line location is identified as one of a group of five lines. The other information required by the marker to completely identify the line location within the frame is the vertical file number. This is obtained from the line link frame through the line link connector associated with the frame.

4.10 While the marker is recording the line location information, except the vertical file number, an idle originating register is selected. Originating registers are distributed as equally as possible over all trunk link frames. Test leads indicate which frames have an idle register not being held busy by other markers. In a preference sequence, an idle frame having an idle register is connected to the marker through a trunk link connector (Fig. 18, connection 2). The marker selects an idle register on that frame in a preference sequence.

4.11 After a trunk link frame has been selected, additional leads are connected between the marker and line link frame via the line link connector. The vertical file number is transmitted to the marker which now has all the data for locating the position of the line on the line link frame.

4.12 Identification of the class of service of the calling line is passed to the marker from the line link frame via the line link connector after the vertical file number has been recorded. Normally, all lines on the same vertical file have the same class of service. If necessary, an arrangement is available to permit customers having different classes of service to be assigned to the same vertical file. The marker transmits the equipment location and class of service of the calling line to the originating register where this information is stored.

4.13 The marker now must select an idle channel between the customer line and the originating register. Channels are arranged in groups of ten so that the marker can check ten channels at one time. When the marker finds an idle channel, it operates the selecting and holding magnets required to close through the channel. The marker then indicates to the originating register the identity of the line link used in the channel, and the register stores this information for later use.

4.14 Before the marker transfers control of the channel to the originating register, it checks the connection for continuity (Fig. 18, connection

4). The marker then releases the associated connectors and itself. The register now furnishes dial tone to the customer and is ready to receive the digits. Normally, it takes less than 1/2 second to establish the dialing connection and return dial tone to the calling customer.

4.15 When the digits are registered in the originating register, it seizes a marker and transmits the registered digits.

B. Pretranslation

4.16 Pretranslation determines from the first, second, or third digits how many digits the register expects to receive on a call and is required when the total number of digits varies. Pretranslation can take place in the originating register.

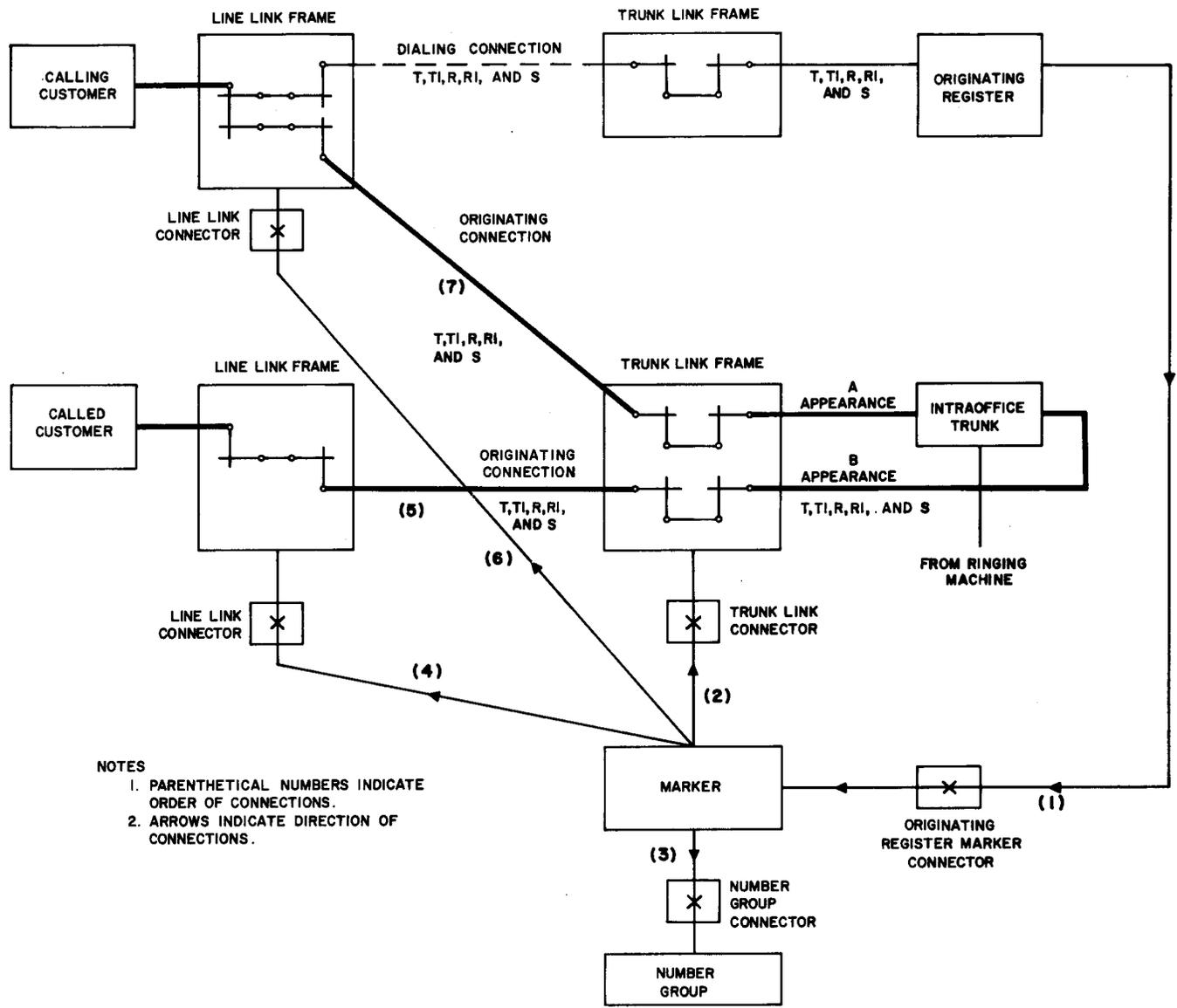
INTRAOFFICE CALLS

4.17 After the number is dialed, the originating register engages a marker through an originating register marker connector (Fig. 20, connection 1). The register transmits the line equipment location of the calling line and the dialed digits to the marker. The marker translates the office code and determines that the called number is assigned to the same marker group as the calling line.

4.18 The marker proceeds to perform an intraoffice trunk job—the establishment of a terminating and an originating connection. The terminating connection is set up between the called line and the B-appearance of the intraoffice trunk; the originating connection is set up between the calling line and the A-appearance of the intraoffice trunk.

A. Establishing Terminating Connection

4.19 The terminating connection is established first so that if the called line is busy the marker can immediately connect the calling line to a tone trunk and save holding time on equipment. Before the terminating connection can be set up, the marker must obtain from the number group the equipment location of the called number and an indication as to whether or not terminal hunting is necessary.



NOTES
 1. PARENTHETICAL NUMBERS INDICATE ORDER OF CONNECTIONS.
 2. ARROWS INDICATE DIRECTION OF CONNECTIONS.

Fig. 20—Establishing Intraoffice Trunk Connection

B. Nonterminal Hunting

4.20 The marker gains access to the number group connector (Fig. 20, connection 3). The proper number group frame is determined from the thousands digit. When the hundreds, tens, and units digits of the called number are transmitted to the number group frame, these digits are translated into an equipment location in terms of line link frame, vertical group, horizontal group, and vertical file numbers for transmission back to the marker. The number group also informs the marker of the correct ringing code.

4.21 While the marker is obtaining this information from the number group, an intraoffice trunk on an idle trunk link frame is selected (connection 2). Through the line link connector, the marker gains access to the line link frame on which the called customer line is located (connection 4). If not busy, the terminating channel is set up between the B-appearance of the intraoffice trunk on the trunk link frame and the called line (connection 5).

4.22 If there is no idle channel available, the marker recycles by releasing the intraoffice trunk it was holding and selecting another one

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(usually on another frame). If there is no idle channel on this recycle, the marker reroutes the call to a tone trunk.

C. Terminal Hunting

4.23 A customer with more than one terminating line is assigned one directory number per line, usually the lowest number listed in the directory. These lines form a terminal hunting group and are usually numbered consecutively. If the listed number is called and is busy, the marker tests the next higher number in the group and completes the call to the lowest idle number. The marker hunts in the same manner if one of the intermediate numbers is called and is busy.

4.24 Each number group is divided into ten blocks, each containing ten blocks of ten numbers. One hunting group can spread over more than one hundreds block or more than one tens block. Two or more hunting groups, other than blank number or intercept trunks, may appear in any tens block. Nonhunting terminals may appear in the same tens block with hunting groups, except when the block select method or the allotted PBX hunting group feature is used. Where there are more than 10 but less than 100 trunks, the block select method can be used. Using this method, the marker hunts first through the lines located in the directory number tens block and, finding them all busy, selects the lowest block containing an idle line without testing the intermediate blocks containing all busy lines. The allotted PBX hunting group feature can also be used. With this feature, the line numbers of a hunting group may be assigned in more than one number group (eight number groups maximum). The marker recognizes the thousands, hundreds, and tens digit before connecting to any number group and steers the call to a tens block containing idle lines to the PBX. Because the marker initially does not observe the units digit, the tens block containing the listed directory number must not contain numbers of any other customer.

D. Establishing Originating Connection

4.25 After the terminating channel is established, the marker proceeds to set up an originating channel between the calling line link frame and the A-appearance of the intraoffice trunk (Fig. 20, connection 7). The marker seizes the line link frame of the calling customer (connection 6); and

before it releases the dialing connection, the marker determines if there is an idle channel. If there is an idle channel, the dialing connection is released immediately. If no idle channel is available, the marker recycles. If no idle channel is found on the recycle, overflow tone is returned from the originating register through the dialing connection.

4.26 After the originating channel has been established, the marker sets up ringing in the terminating connection and releases itself and the originating register from the intraoffice connection. The trunk now controls the ringing and supervision of the call. The ringing is tripped when the called party answers. When the call is finished, the originating and terminating connections are released, and the intraoffice trunk is released.

E. Timed-Release Feature

4.27 A timed-release feature is provided in order to prevent either party from holding a line out of service indefinitely by failing to hang up the receiver. The timed-release feature disconnects the line 13 to 35 seconds after either customer hangs up.

MULTILEVEL PREEMPTION AND PRIORITY

4.28 Multilevel preemption permits lines and trunks used to establish a connection to be marked with a level of priority, P0 (highest) through P4 (lowest). On subsequent calls, the common control equipment is permitted to preempt this connection when a new call, having a higher priority, encounters an all-trunks-busy or a line-busy condition. When a connection has been preempted, an audible signal to the customer is given to indicate that a preemption has occurred.

CALL PRIVILEGE

4.29 Call privilege control provides special classes of service to stations served directly by a 4-wire office. Such privileges include priority treatment, access to special grade trunk facilities, and crossover to message networks. Pushbutton telephones are equipped with auxiliary buttons, or rotary dial stations may use a 1X code to request a particular privilege combination.

INTEROFFICE CALLS—OUTGOING

4.30 Outgoing calls are established to customers in a connecting office or to operator assistance and service code calls. Calls to connecting offices require the services of an outgoing sender, but assistance calls and service code calls usually do not.

Establishing Outgoing Trunk Connections

4.31 When the customer has dialed the called number, the originating register engages a marker (Fig. 21, connection 1). The register transmits to the marker the equipment location, class of service of calling customer, number of the line link frame used in the dialing connection, and called number.

4.32 The marker determines from the office code that the call is to be completed to a connecting office and the type of pulsing the office requires. The marker gains access to an outgoing sender that generates the type of pulses the connecting office requires (connection 2).

4.33 When the outgoing sender connector is engaged, the marker, by means of the trunk link connector, gains access to an idle 2-way trunk on an idle trunk link frame (connection 3). The sender is connected to the marker through the outgoing sender connector and receives the called number from the marker. The marker also sets up a connection between the 2-way trunk and the outgoing sender through the sender link.

4.34 As soon as the trunk link frame is seized, the marker connects to the line link frame of the calling customer (connection 4) and establishes a channel between the customer and the 2-way trunk (connection 5). The dialing connection is released if the marker finds an idle channel. If no idle channel is available, the marker recycles the call by releasing the 2-way trunk it was holding and selects another one. If there is no idle channel on the recycle, the marker reroutes the call to a tone trunk on a trunk link frame.

4.35 The outgoing sender then makes a trunk test. If the trunk test fails, overflow tone is returned to the customer from the trunk. As in an intraoffice call, the marker releases upon completion of its functions. The sender transmits the called number to the connecting office, then

disconnects itself and the sender link. The 2-way trunk maintains supervision of the call.

INTEROFFICE CALLS—INCOMING

4.36 An incoming call is the continuation and completion in a called office of an outgoing call from a connecting office. In the called office, the trunk from the originating office is a 2-way trunk. The incoming connection consists of a channel between a 2-way trunk and the called customer.

Establishing Incoming Trunk Connection

4.37 As soon as the 2-way trunk is activated by a call originating in a connecting office, an incoming register is seized through an incoming register link (Fig. 22, connection 1). After the trunk is seized in the called office, the incoming register is connected to the 2-way trunk and receives the digits of the called number. The register records the number of the trunk link frame with the 2-way trunk appearance so that the marker will later be able to reach that 2-way trunk. After the digits of the called number have been registered, the register gains access to a marker (connection 2) and transmits to it the called digits and the trunk link frame number.

4.38 The marker seizes the trunk link frame (connection 3), then selects the proper number group frame from the called number thousands digit (connection 4). The number group translates the called hundreds, tens, and units digits into the called line location to permit the marker to seize the proper line link frame and performs the line-busy test on the called line (connection 5). If the called line is busy, the marker sets the trunk to return busy signal. If the called line is idle, the marker sets up a channel between the trunk and the called line (connection 6) and sets the ringing in the trunk. If the marker cannot find an idle channel, it sets the trunk to return a reorder signal and releases itself from the connection.

4.39 As soon as the marker has finished these functions, it disconnects the incoming register, the register link, and itself from the connection. The trunk now controls the ringing and further supervision of the call.

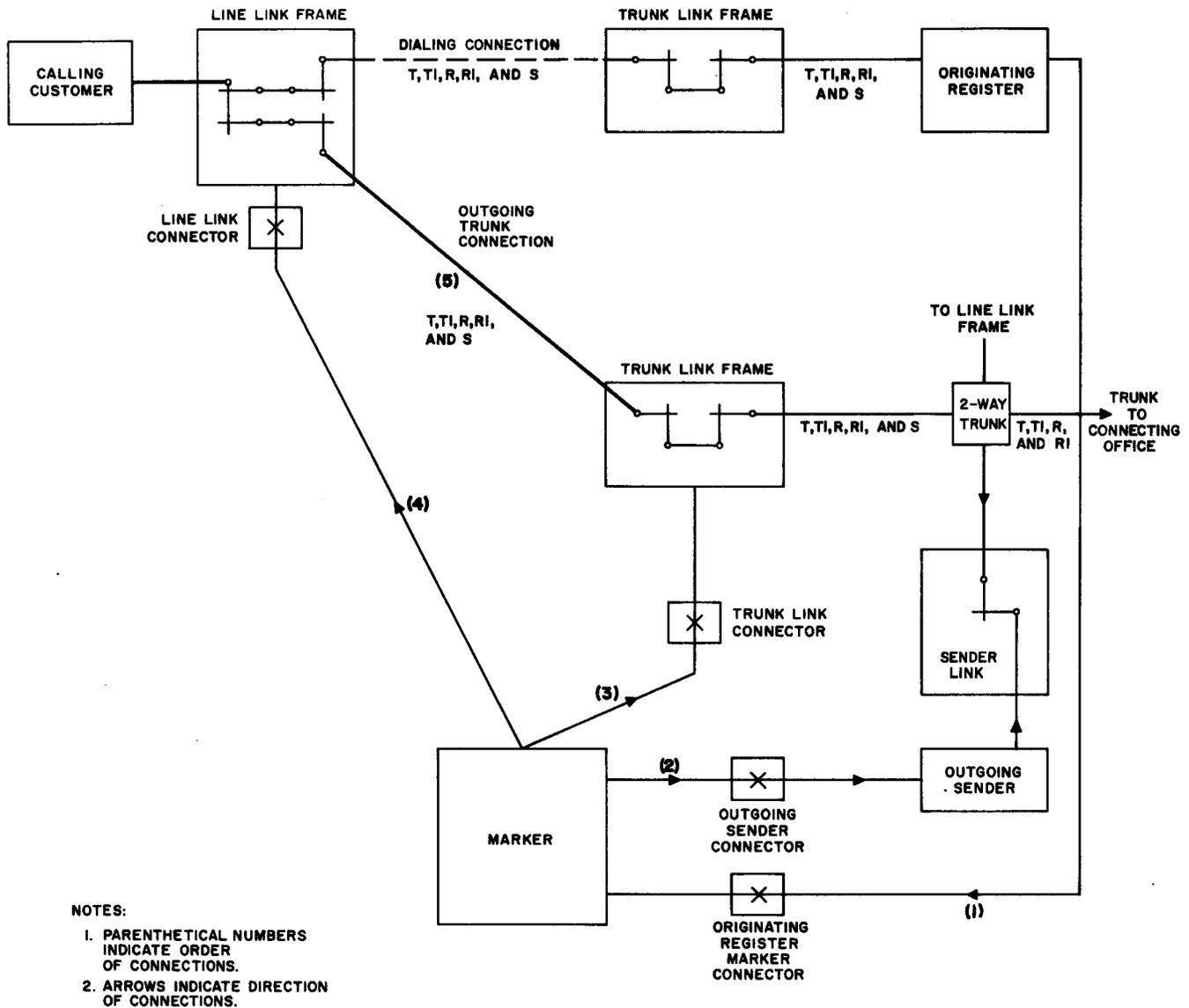


Fig. 21—Establishing Outgoing Trunk Connection

VARIOUS CALL CONDITIONS

A. Permanent Signal

4.40 A permanent signal may result from faulty handling of the station equipment or from trouble conditions in the telephone plant.

4.41 After dial tone has been sent to the calling line, the originating register allows 20 to 37 seconds, under normal traffic conditions, for the receipt of the first digit. If it does not receive the first digit in time, the register refers the call

to a marker as a permanent signal. The marker then connects the calling line to a permanent signal trunk to an operator. The operator challenges on the trunk and, if no answer is received, takes the necessary action as covered by local instructions.

B. Partial Dial

4.42 After recording the first digit, the register waits 20 to 37 seconds under normal traffic conditions for each succeeding digit.

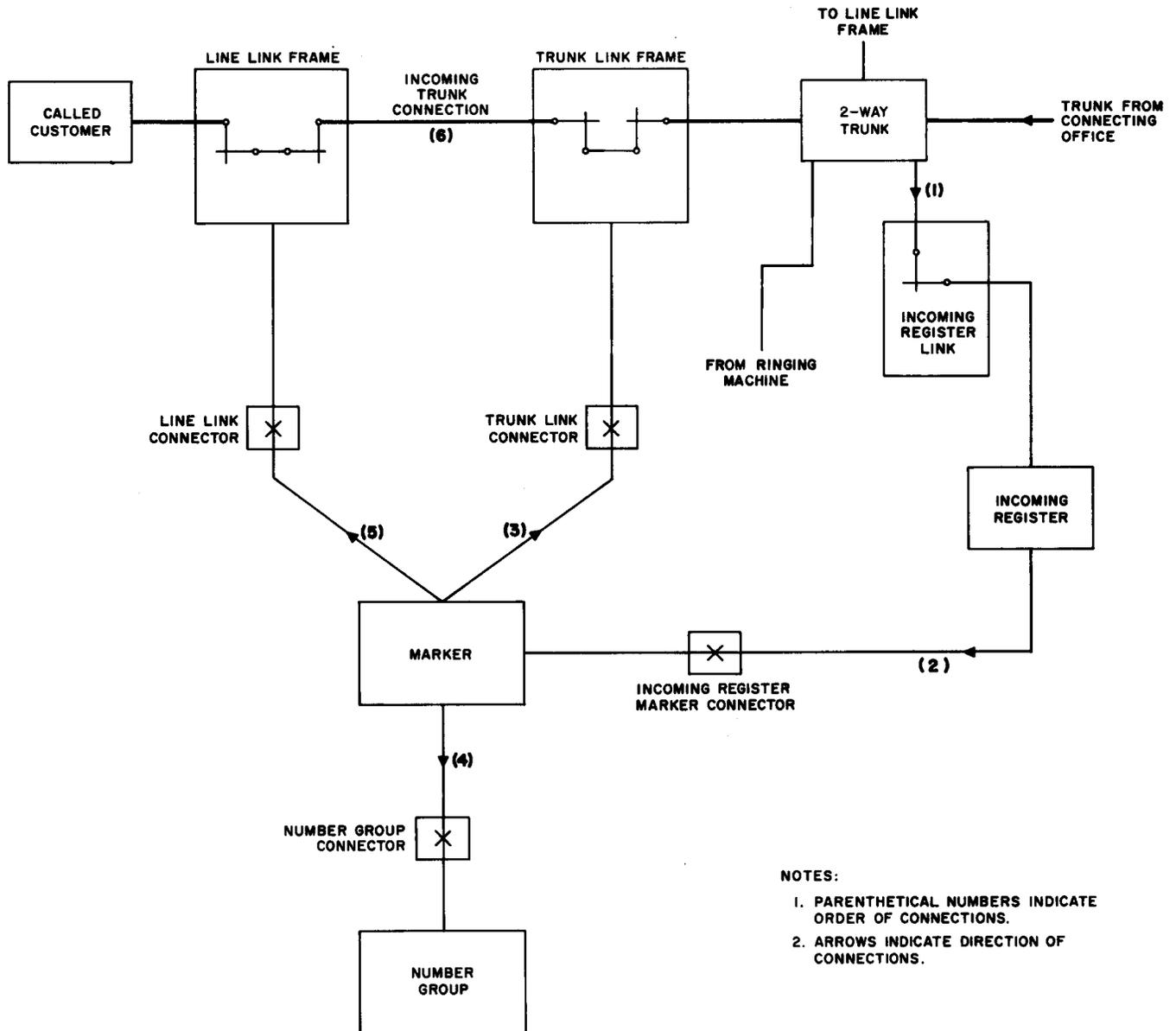


Fig. 22—Establishing Incoming Trunk Connection

4.43 If the customer fails to dial a digit within this specified time interval, the register refers the call to a marker as a partial dial. The marker may connect the calling line to a tone trunk or connect the calling line to an outgoing trunk which terminates before an announcement or an operator. The method used depends on the procedures of the individual office.

C. Dialing Before Receipt of Dial Tone

4.44 If a customer starts dialing before receiving dial tone, the first digit may be distorted so that the originating register will record an incorrect code or the register will record an insufficient number of digits. If the code which the register records is a working one, the calling

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customer may get a wrong number. However, if the digits recorded by the originating register constitute a vacant code (a code not in current use), the calling party will be connected to an operator, to a tone, or to an announcement trunk.

4.45 If pretranslation is not provided, the originating register does not recognize the vacant code; therefore, it waits for the full directory number or partial dial time-out before it engages a marker. The marker then recognizes the vacant code and routes the call to an operator or to a tone or announcement trunk.

D. Intercepting

4.46 A call is intercepted if it is made to any of the following:

- (a) Temporarily disconnected number
- (b) Changed number
- (c) Out-of-order number and arrangements have been made to intercept incoming calls
- (d) Permanently disconnected number
- (e) Unassigned number
- (f) Blank number
- (g) Vacant code
- (h) Denied code.

4.47 When a number on intercept for (a), (b), or (c) of 4.46 is called, the calling party is routed to an intercept operator over an intercept trunk. Blank numbers, permanent disconnects, and unassigned numbers are also treated in this manner, except that a recorded announcement may be connected to the end of the trunk. Vacant codes and denied codes may be routed to either machine announcements or operators over trunks appearing on the trunk link frame. The routing for each of these conditions is determined by cross-connections in the completing marker.

LAMA SERVICE

4.48 LAMA equipment is used for traffic sampling information and takes the place of message registers. The LAMA equipment is located in the

marker group. Sampling is performed on 20 percent of the traffic. This information may be provided to the customer when the traffic study is complete. While a connection is being established, the following information is being recorded on the punched tape or magnetic tape by the LAMA equipment (initial entry):

- (a) Calling number
- (b) Called number (when applicable)
- (c) Numbering plan area code (when applicable)
- (d) Message billing index
- (e) Other miscellaneous details to identify the call.

4.49 When the called party answers and the conversation terminates, separate entries are made on the tape. The time of day and information to identify the call involved are included in each entry. These are answer and disconnect entries. Each time an item of data on a given call is entered on the tape, the identity of the transmission circuit engaged on the call is entered. With this arrangement, the entries (initial, answer, and disconnect) on a given call can be made as the call progresses with entries from other calls interspersed. The punched tapes or magnetic tapes are processed through the accounting center, and the customer calls are tabulated and arranged in chronological order.

OPERATION OF NO. 5 CROSSBAR OFFICE WITH 5D SWITCHBOARD (AUTOVON)

4.50 The switchboard in this description is a 5D switchboard located in the same building with the No. 5 crossbar office. The difference between having the switchboard in the same building or in another building is the type of trunks used. The method of operation is the same for both arrangements. The types of calls which may be handled by switchboard operators are 0 operator, listed directory number, permanent signal, partial dial, and vacant code. Permanent signal, partial dial, or vacant code calls may be handled by intercept trunks to announcement machines or to switchboards according to the practice in individual offices.

4.51 Each incoming trunk to the switchboard has a lamp appearance before an operator which indicates that a call should be answered and appropriate action taken. This operator has access to various types of outgoing trunks for calls extended from the switchboard.

A. 0 Operator Calls

4.52 After a customer dials a zero, the originating register engages a marker (Fig. 23, connection 1) to establish a channel between the calling line and a 0 operator trunk and releases (connections 2, 3, and 4). The circuit is arranged to hold the connection after the operator answers if the customer hangs up. This prevents accidental loss of the connection.

B. Calls From Switchboard Completed to No. 5 Crossbar Customer

4.53 The operator can complete calls to customer lines in the No. 5 crossbar office. These trunks have appearances at the switchboard, trunk link frame, and line link frame (Fig. 24). The operator plugs into an operator tandem trunk (connection 1). The trunk is connected to an incoming register through an incoming register link (connection 2). The operator keys seven digits. (A directing or priority digit may be prefixed as required.) The call then proceeds in the same manner as a regular incoming call (connections 3 through 7).

C. Calls From Switchboard to Connecting Office

4.54 By means of an operator tandem trunk, an operator located in the same building as the No. 5 crossbar office can gain access to the outgoing trunks in that office. Operator tandem trunks have appearances at the 5D switchboard, on a line link frame, and on a trunk link frame. Operators use these trunks to gain access to the outgoing trunks in the office to switch a call to a connecting office.

4.55 In Fig. 25, a calling customer reaches an operator and gives the operator the called number. From this number, the operator determines the route for the call, plugs into an operator tandem trunk, and keys the called number (connection 1) when the trunk has been connected to an incoming register through an incoming register link (connection 2). After the called number, the trunk

number, and the trunk link location of the operator are set in the incoming register, the register seizes a marker and transfers this information to the marker via an incoming register marker connector (connection 3). Directed by the trunk number, the marker obtains the line link frame location of the trunk from the number group (connection 4).

4.56 The marker seizes and transmits the called number to an outgoing sender through an outgoing sender connector (connection 5). By means of a trunk link connector, the marker seizes an idle trunk link frame with an idle 2-way trunk or LUNK on that frame (connection 6), then connects the outgoing sender to the outgoing trunk through the sender link. Through a line link connector, the marker seizes the line link frame on which the operator tandem trunk appears (connection 7). At this point, the marker sets up a channel between the operator tandem trunk and the 2-way trunk. The sender transmits the required digits to the connecting office through the sender link and the outgoing trunk, releases, and then releases the sender link. The marker releases upon completion of its functions, and the operator has supervision of the call (connection 8).

D. Listed Directory Number Calls

4.57 When a customer dials the listed directory number (LDN) of the 5D switchboard, the call is handled as any other incoming or intraoffice call, except an LDN trunk appearance at the 5D switchboard is used to connect the call. The LDN trunk also has a line link frame appearance.

NO. 5 CROSSBAR OFFICE TANDEM SWITCHING FEATURES

4.58 Since it is not economical to have a sufficient number of direct trunks to handle all of the traffic between offices, intermediate switching points are provided to handle traffic between offices that have no idle direct connections. This type of operation is known as tandem switching. A No. 5 crossbar office can be used to provide tandem switching service. An incoming trunk arranged for handling tandem traffic can also handle traffic for completion to this office. To permit this dual use, it is necessary to provide such trunks with both trunk link and line link frame appearances. The trunk link frame appearance is used when a call terminates in the local office, and the line

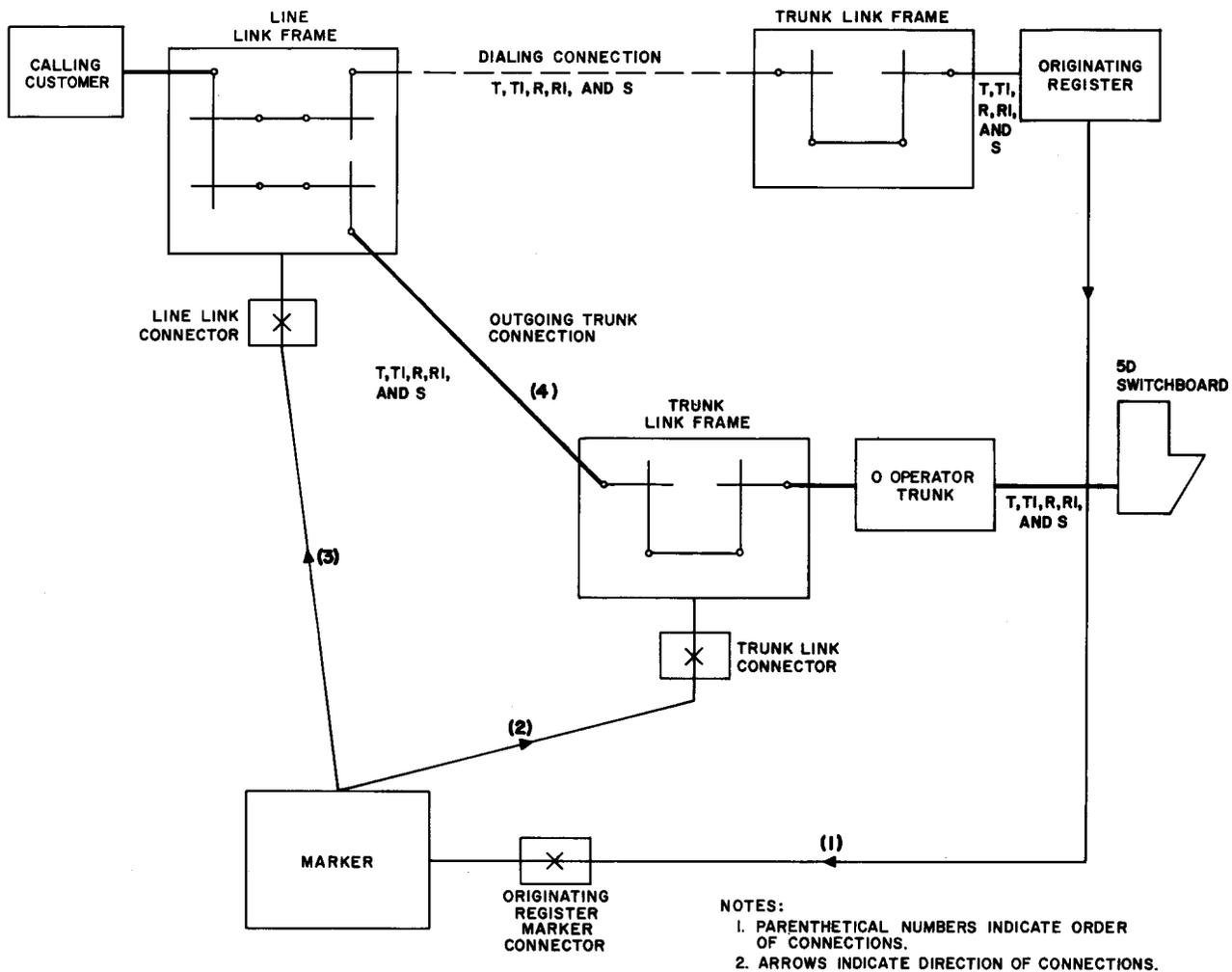


Fig. 23—0 Operator Call (AUTOVON)

link frame appearance is used when a call is to be switched to a connecting office.

A. Establishing a Tandem Connection to a Connecting Office Through a No. 5 Crossbar Office

4.59 A calling customer served by office X (Fig. 26) originates a call to a customer served by office Z. In this case, there are no direct trunks connecting offices X and Z, and the call is routed from office X to office Y which has 4-wire, 2-way intertoll trunks to office Z. In a No. 5 crossbar office, an intertoll trunk incoming from another office (connection 1) is connected to an incoming register through an incoming register link (connection 2). The following information is transferred to the incoming register: priority and

route control digits (AUTOVON only), called number, trunk number, and class mark of the incoming intertoll trunk. The trunk number is an arbitrary 3-digit number (000 through 999) assigned to each trunk for the purpose of obtaining the line link equipment location of the trunk. These trunk numbers appear either in a separate trunk number group frame or in a customer number group frame. The requirements of each individual office determine which arrangement is used. If there are too many trunk numbers to be handled by the customer number group, a separate trunk number group frame is provided. The called number consists of seven digits, a 3-digit office code, and four numerals.

4.60 The incoming register seizes a marker and transmits the information in the register to

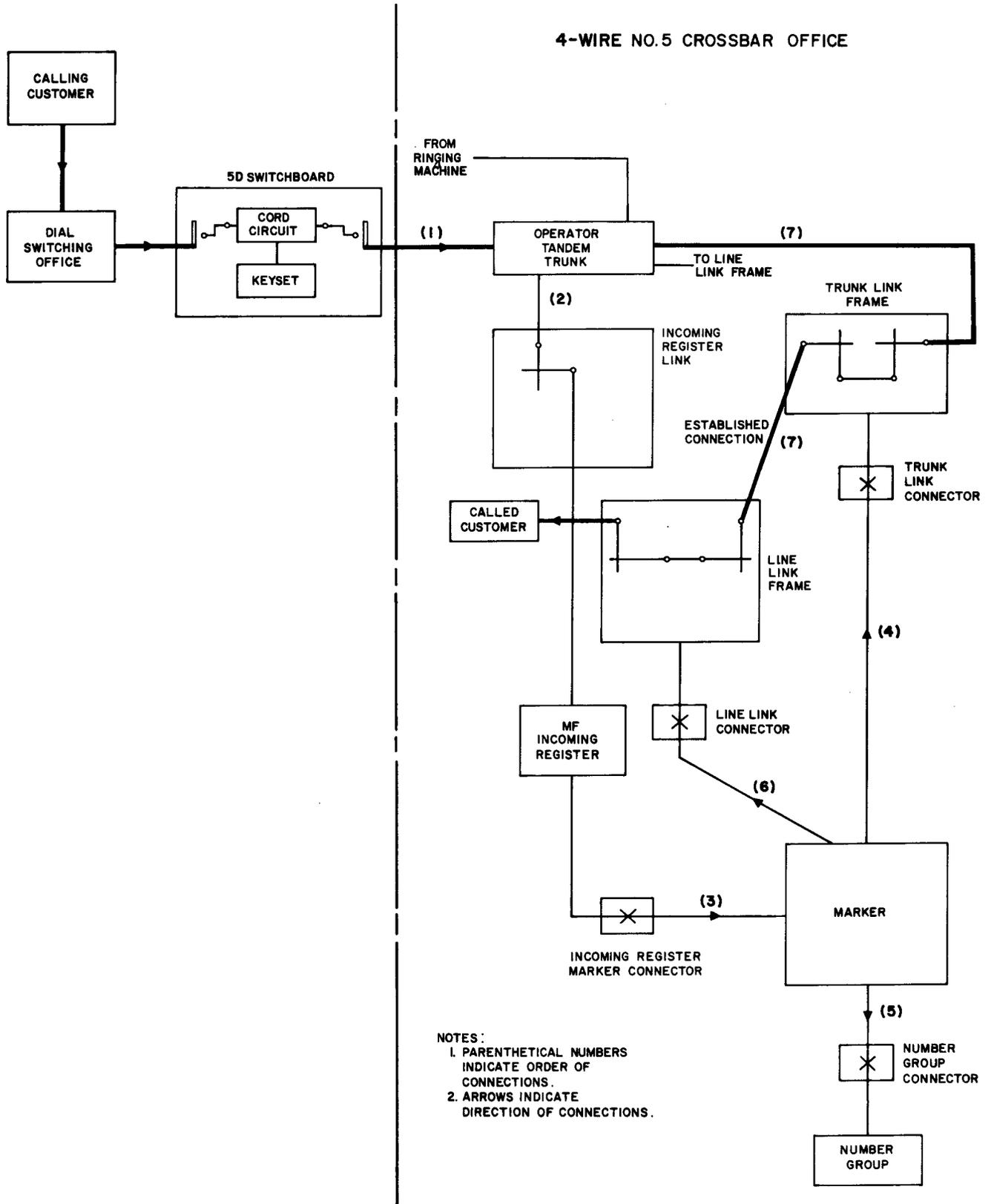


Fig. 24—Call From 5D Switchboard Completed to 4-Wire No. 5 Crossbar Customer

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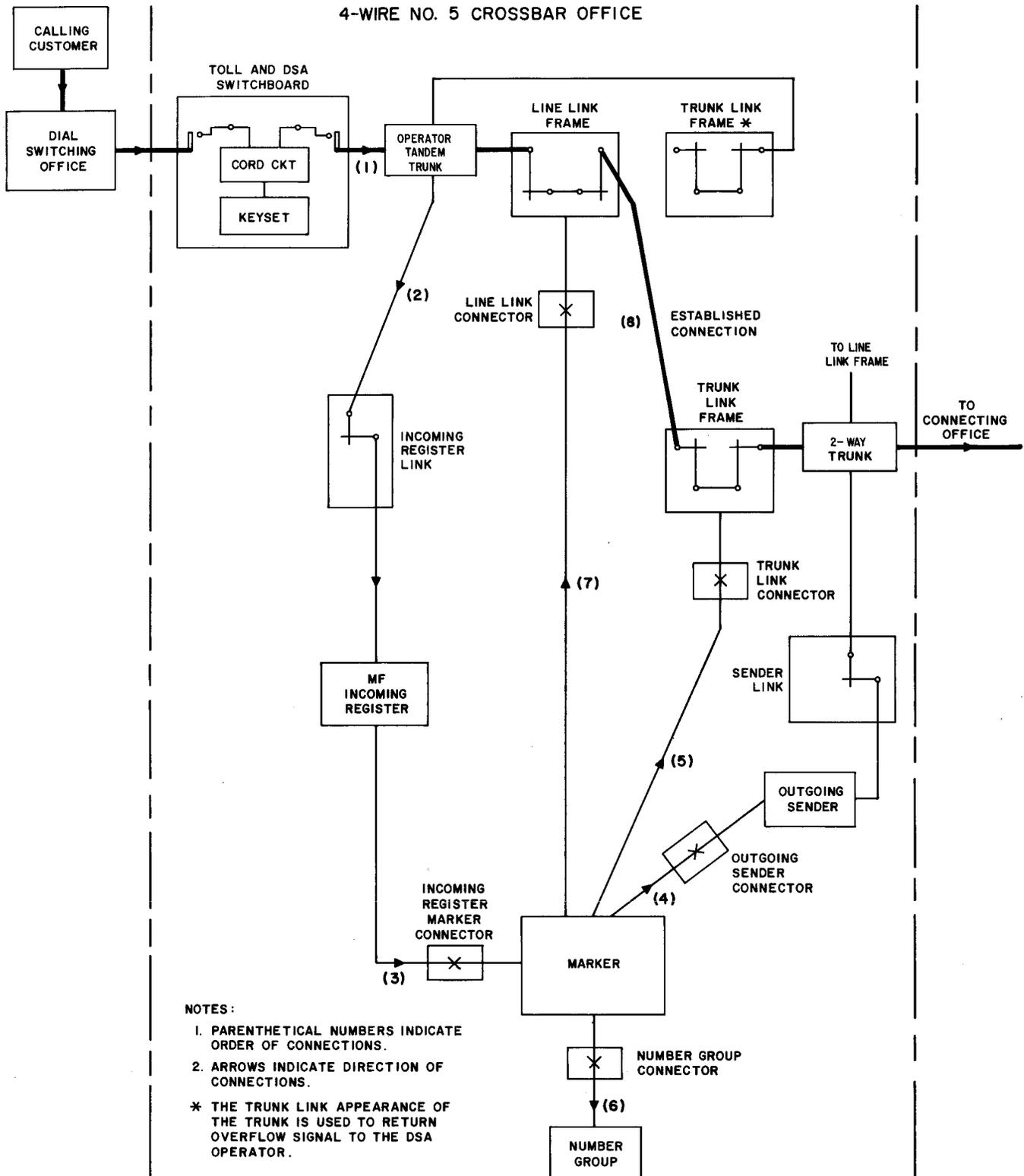


Fig. 25—Call From 5D Switchboard Associated With 4-Wire No. 5 Crossbar Office to Connecting Office

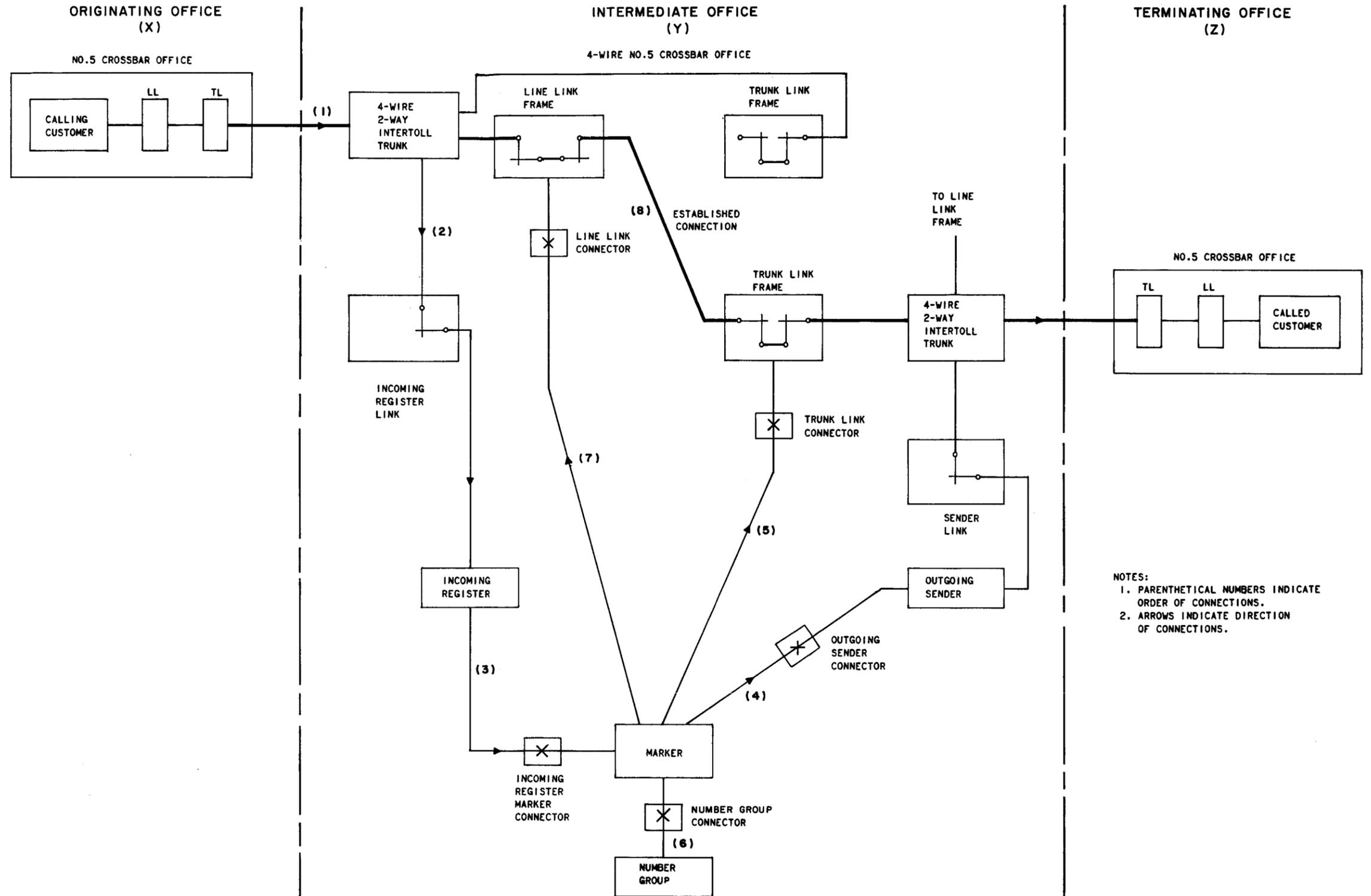


Fig. 26—Tandem Call Through a 4-Wire No. 5 Crossbar Office

a marker through an incoming register marker connector (connection 3). From the called office code, the marker determines that a tandem job is necessary. The marker seizes an outgoing sender through an outgoing sender connector (connection 4), proceeds to engage an intertoll trunk on an idle trunk link frame (connection 5), and connects the outgoing sender and the intertoll trunk by means of the sender link. At the same time, the marker seizes from the trunk number the proper number group frame through a number group connector and obtains the line link frame location of the incoming intertoll trunk (connection 6). The marker then seizes the line link frame on which the incoming intertoll trunk appears via a line link connector (connection 7). A channel is established between the incoming intertoll trunk and the outgoing intertoll trunk by the marker (connection 8). The marker then releases the incoming register and itself from the connection, and the incoming tandem trunk is left in control of the supervision of the call.

4.61 A feature referred to as tandem screening is available to permit denial of service from specific intertoll trunk groups to selected office codes available to other customers. For example, with this feature, customers in other offices can be given unlimited access to the 2-wire part and be denied access to the 4-wire part of the No. 5 crossbar office which serves switched service network customers. The intertoll trunks used for this purpose are given tandem class-of-service treatment.

MULTIOFFICE OPERATION

4.62 A No. 5 crossbar marker group can be arranged to handle a maximum of 40,000 numbers (directory and trunk). When an office is equipped for more than 10,000 numbers, at least one office code must be assigned for each number series (0000 through 9999). A particular marker group may have as many as six number series. The major reasons for using additional office codes in a marker group are for discrimination between network customers and to have ample line numbers for the lines required to load the marker group. More than one office code may be needed whenever the customers served by one marker group are different network customers. Assignment of a distinct office code to each customer enables the equipment to provide distinctive routing to the customer equipment. When a PBX customer has

less than 10,000 stations, more than one PBX customer can share the same office code. Up to 10 PBX customers can share the same office code provided each PBX customer has less than 1000 stations.

DIRECT AND ALTERNATE ROUTE ARRANGEMENTS IN NO. 5 CROSSBAR SYSTEM

A. Direct Routes

4.63 In a small- or moderate-sized switched service network, each office may have direct trunks to all other central offices in that area. Such an arrangement permits the interconnection of any two customers in the network. When setting up an interoffice call, the marker determines whether a trunk link frame has idle trunks before seizing the frame. After a frame has been seized, the marker can test a maximum of 20 trunks at a time on the frame. Since each frame is limited to a maximum of 20 trunks per route, the total number of trunks per route in the marker group is limited to 20 times the number of trunk link frames. For example, if office X has five trunk link frames, the marker can determine if any of 100 trunks to office Y are idle by the single trunk link frame test.

4.64 In the above example, if the 100 trunks of office X (five trunk link frames) are not adequate to handle the amount of traffic to office Y, then more than 100 (but not more than 200) trunks are provided. The trunks are divided into two subgroups, 100 trunks maximum per subgroup. These subgroups are spread over the five trunk link frames, a maximum of 20 trunks of each subgroup on a frame. Note that the subgroup in such an office cannot be more than 100 trunks because the marker is limited to testing 20 trunks after the frame has been seized. To use both subgroups effectively, the marker allots calls into each subgroup by testing one subgroup on one call to office Y and the other subgroup on an alternate call. If the marker tests for idle frames with idle trunks in one subgroup but finds no trunks available, it tests the second subgroup in an effort to complete the call successfully before routing it to overflow.

B. Alternate Routes

4.65 The alternate route principle is a combination of direct and tandem routing. Direct trunk groups are supplied from office X to office Y, but

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these groups will not carry all of the traffic during heavy loads. Office X will always attempt to route calls over the direct group to office Y first; and therefore, the high load on that group keeps it working efficiently. When all of the trunks of the direct group are in use and another call is originated to the same destination, the marker in office X will attempt to complete the call over the direct group but, in this case, will find all trunks busy. The marker then attempts to complete the call over the alternate (tandem) route as a tandem call. In large networks where trunking becomes more involved, more than one alternate route may be available for a call. For example, office X can reach office Y over the direct route trunks and also through tandem offices 1 and 2.

4.66 The marker in office X routes calls for office Y over the direct route trunks as long as any of them are idle. Additional calls are then routed to office Y through tandem office 1. The route through tandem office 1 is called the first alternate route. If both the direct route and the first alternate route trunks all test busy, the markers in office X attempt to route additional calls for office Y through tandem office 2 (second alternate route). The No. 5 Crossbar System can handle two alternate routes in addition to the direct route. If a call cannot be completed over any of these routes, overflow tone is returned to the calling customer.

C. Polygrid Routing

4.67 For AUTOVON networks, an elaborate routing plan (polygrid routing) is provided and used in conjunction with preemption. Each originating call may have up to nine routes. These routes are divided into groups called triples: most direct triple (MDT), best alternate triple (BAT), and second best alternate triple (SBAT).

CALLS INVOLVING EQUIPMENT IRREGULARITIES

A. Stuck Originating Registers

4.68 An originating register may be stuck so that, after dialing is completed, it cannot obtain a marker. In this case, the register times out and releases itself and the dialing connection after 20 to 37 seconds. The originating customer is given another dial tone connection. During periods of heavy traffic, the time-out period may be reduced to 10 to 18 seconds. If the originating

register is stuck so that it cannot register any of the dialed digits, the call is treated as a permanent signal; and if the originating register is stuck so that it registers part of the dialed digits, the call is treated as a partial dial.

B. Stuck Outgoing Senders

4.69 An outgoing sender being used in an outgoing connection may not be able to outpulse or complete pulsing because of an equipment irregularity. In this case, a DP sender will time out after 19 to 37 seconds, and an MF sender will time out after 13 to 24 seconds. After timing out, the sender sets the outgoing trunk to give a reorder signal to the calling customer and releases itself from the connection.

4.70 An outgoing sender may not be able to outpulse because of a shortage of incoming registers or senders in the connecting office. To prevent overloads in connecting offices from affecting the equipment in the No. 5 crossbar office, all senders are provided with an intersender timing of 4 to 8 seconds. If the start-dial signal is not received within this time, the sender records this fact and continues to time. However, if a completing marker discovers that all senders in a desired group are busy, it will initiate a sender group release signal to release all senders whose intersender timers have timed out. Before releasing, these senders will set their associated trunks to return a reorder signal. If the trunk test which the sender performs fails, the sender times out to release after first setting the outgoing trunk to return reorder signal.

C. Stuck Incoming Registers

4.71 An equipment irregularity may prevent an incoming register from calling in a marker or from transmitting all of the necessary information to a completing marker after the register has seized the marker. In the first case and under normal conditions, a DP or MF register times out after 19 to 37 seconds, and the register releases from the incoming trunk. In the second case, the marker, having been seized and lacking receipt of the call information, will time for 0.45 to 0.61 or 2.6 to 4.3 seconds, depending on which information is missing, and then signal the incoming register to make a second attempt. If this attempt fails, the second marker signals the incoming register to release and, if conditions permit, sets the incoming

end. The time-out period for DP incoming registers is reduced to 4 to 8 seconds during heavy traffic; the time-out period for MF registers remains the same.

D. Marker Irregularities

4.72 If for any reason, while handling a call, a dial tone marker encounters a trouble condition, it signals its associated marker connector to select another marker. If the second marker encounters trouble, the process is repeated. In this way, as long as there is an off-hook condition on the calling customer line, the line link marker connector continues to select a marker until the customer hangs up or the call is completed. Each marker which encounters trouble causes the trouble recorder to make a trouble record before it releases.

5. GLOSSARY

5.01 The following is a glossary defining terms used throughout this section.

A- and B-Appearances for Trunks on Trunk Link Frame These are the two possible trunk switching connections on a trunk link frame. Trunks are assigned to these appearances according to the traffic engineering practices of an office. Originating registers are always assigned to the A-appearances.

Alternate Routing A method of advancing a call at any point by diverting it to a trunk group other than the first choice group when the first choice group is busy. Arrangements for three alternate routes are provided. AUTOVON provides three route combinations.

Assistance Call A call which the customer could or could not dial directly but on which a zero is dialed to contact the operator for assistance.

Automatic Monitor A unit of equipment which attaches itself to registers and sends on a progressive basis. It records the signaling input without distortion and compares this with the output. The unit causes the trouble recorder to record any incorrect operation and may be used under manual control for testing senders and registers.

AUTOVON The abbreviation for automatic voice network (a 4-wire switched service network).

Blank Number A number outside the assigned capacity for a particular office.

Call Versus Job The word call is used only if the function is inclusive of all equipment. (See **Job**.)

Channel A combination of a line link, junctor, and trunk link which, by crosspoint closures, forms a path to connect a line with a trunk or a trunk with a trunk.

Channel Number A composite number identifying the line switch horizontal number of the line link, trunk switch vertical number of the trunk link, and junctor switch number in a channel.

Class of Service The term used in switched network applications to designate the privileges to which a customer is entitled, such as off-net dialing or denied off-net dialing.

Code Point A terminal punching located in a cross-connection field in the marker and energized by registration of a 1-, 2-, or 3-digit code.

Common Control Equipment All switching equipment exclusive of line link frames and trunk link frames.

Connector A relay-type switching device for interconnecting two equipment elements over a relatively large number of leads.

Dial Pulsing (DP) A system of dc pulsing in which the digits are transmitted by the interruption of the dc circuit a number of times, one of ten interruptions corresponding to the digits 1 through 0 on the dial.

Dial Tone A tone used in dial telephone systems to indicate that the equipment is ready for the dialing operation.

Directing Code Digits, such as 11, 0X, and X1X, dialed ahead of the directory number of the called station. These enable a customer or operator to dial a number in an area out of the basic numbering plan area of the customer or operator.

Directory Number The full complement of digits required to designate a customer in the directory. The directory number consists of the office code followed by four numerals.

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Extheo Contraction of the words extra and theoretical. (See **Theoretical Number**.)

Home Area The numbering plan area in which a calling customer is located.

Horizontal Group All of the lines served by the same ten line links.

Incoming Register The register which receives the pulsing (dial or multifrequency) from the incoming trunk and transmits it to the marker through an incoming register marker connector.

Incoming Register Link A switching arrangement for connecting incoming trunks to incoming registers.

Incoming Trunk A trunk incoming to a local central office switching unit for use in terminating calls on the customer lines of the unit. Also, a trunk incoming to a local toll, tandem, or PBX switchboard or switching unit.

Interoffice Trunk A trunk between two switching units regardless of type. This term is confined largely to trunks between local offices in the same area.

Intertoll Office Trunk or Intertoll Trunk A trunk between toll switchboards or toll switching systems in different offices.

Intraoffice Trunk A trunk between two points in the same central office or switching unit.

Intermarker Group Trunk A trunk between two marker groups located in the same building. There are three types of these trunks:

- (a) Customer-to-customer
- (b) Customer-to-trunk
- (c) Trunk-to-customer.

Junctor A circuit extending between frames of a switching unit and terminating in a switching device on each frame.

Junctor Group The junctors which extend from a particular line link frame to a trunk link frame. The size of the junctor group depends on the number of trunk link frames or pairs of trunk link frames.

Junctor Grouping Frame A frame which functions to facilitate the distribution of the 100 junctors from each line link frame to all of the trunk link frames so that each line link frame will have equal access to all trunk link frames.

Line Link A switching arrangement for connecting customer lines to junctors on originating calls and junctors to customer lines or trunks of terminating or through calls.

Line Link Frame A frame containing line links with associated equipment and customer line relays.

Line Link Pulsing A feature that provides direct inward dialing (DID) to PBXs over trunks terminated on line link frames.

Local Automatic Message Accounting (LAMA) System An equipment arrangement used for traffic sampling with the information recorded on paper or magnetic tape.

Local Central Office or Local Office A switching unit in a telephone system serving primarily as a place of termination for customer lines. It has a maximum of 10,000 numbers. Services can be provided on both a physical and theoretical office basis. This arrangement is considered as one local central office.

Local Service Area The area within which are located the stations which a customer may call at local rates in accordance with the provision of the local tariff.

LONAL Local off-net access line.

Main Distributing Frame (MDF) A frame for terminating the permanent inside and outside wires in a central office and for effecting flexible connections between them. It generally carries the central office protective devices and functions as a test point between line and office.

Marker Equipment which establishes communication paths between calling customers and trunks, between trunks and called customers, and between trunks.

Marker, Completing A marker which performs all marker operations except the dial tone job.

Marker, Dial Tone A marker which performs marker dial tone job only.

Marker Group A common group of markers which serve one or more central offices. A marker group is arranged to handle a maximum of six office code groups spread over six number series with a maximum of 40,000 numbers. The term marker group is also used to refer to the equipment served by a marker group.

Marker Job The single marker usage (from seizure to release) involved in completing any one of its designated functions. Marker jobs are indicated accordingly as follows:

- (a) Dial tone
- (b) Intraoffice trunk
- (c) Outgoing trunk
- (d) Incoming trunk
- (e) Toll trunk
- (f) Tandem trunk.

Master Test Frame A unit of equipment which provides for the testing of the equipment units of a marker group.

Master Test Frame Connector A connector by which markers and other equipment obtain access to the master test frame.

Message Rate Service A customer classification of local service which is measured in terms of messages or message units for the purpose of charging for the service.

Message Register A counting device which records message units on originating traffic for calls to points within the one message unit charge area. In the No. 5 Crossbar System, message registers can be used only in connection with individual and 2-party message rate classes of service.

Message Unit The unit of measurement for charging for message use by the translation into equivalent message units of ticket or AMA charges for calls within a specified area.

Multifrequency (MF) Pulsing A method of pulsing in which the identity of the ten digits (0 through 9) and the start and end signals are each determined by combinations of two of six frequencies. The

two frequencies for each digit, or signal, are transmitted simultaneously over the trunk.

No-Hunt Call A call made from the outgoing trunk test frame or the message register rack which will not hunt in a terminal hunting group. If the line associated with the dialed number is busy, busy signal is returned.

No-Test Call A call from an operator or a test desk which will connect to the dialed customer line regardless of whether or not it is busy. If the line is idle, the connection is established through a regular channel; and if the line is busy, the connection is established through the no-test connector and a no-test vertical on the line link frame.

No-Test File The ten vertical units which are used for no-test operation and are located one above another on a line switch bay of the basic line link frame.

No-Test Vertical Vertical file 0 in vertical group 02 of each line link frame contains ten no-test verticals. These no-test verticals are used when a connection is established between a busy line and a no-test trunk through the no-test connector. No-test verticals 0 through 4 are multiplied, as well as no-test verticals 5 through 9, so that only two no-test calls may be simultaneously established through the no-test connector between no-test trunks and busy lines of one line link frame.

Number or Numericals The digits which identify a customer in a central office.

Numbering Plan The arrangement of digits as listed in local area directories. For example, a directory number with three code digits and four numericals is in a 7-digit numbering plan.

Numbering Plan Area The United States and Canada are divided into numbering plan areas. In general, the subdivisions follow state and province boundaries. However, where there is a high telephone density, a state or province may have two or more areas within its geographical boundary. Each numbering plan area is assigned a national code in the X0X and X1X code series. Within a numbering plan area, there can be no local office code conflicts.

Number Series Ten thousand or less nonconflicting numbers between 0000 and 9999. They may be

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associated with one, two, or three office code groups.

Number Series Group Thirty thousand or less numbers that are associated with three or less office code groups. There is a maximum of two number series groups, designated group A and group B, each consisting of a maximum of three number series with a maximum of three office code groups. Number series groups A and B have the same significance as offices A and B (in past terminology) when each number series group consists of a single number series.

Number Group (NG) Frame A frame containing 1000 consecutive numbers that can be associated with one, two, or three office code groups. A maximum of 40 number groups is associated with one marker group.

Office A—Office B The terms which refer to each of the two number series groups in a marker group.

Office Code A code consisting of three digits which appear in front of the numerals of a directory number. The office code is often used in switched service networks to identify a customer or customer group.

Office Code Group One or more local office codes, associated with 10,000 or less directory numbers, given the same rate or number treatment (office code or codes grouped together to operate the same local completion relay in the marker).

ONAL Off-net access line.

Originating Register A register connected to a customer line via line and trunk links for giving dial tone and for recording the customer-dialed or keyed pulses.

Originating Stage That portion of the switching process involved in extending the connection from the selected intraoffice trunk to the originating line. The originating stage is a subdivision of the marker intraoffice trunk job.

Outgoing Trunk A trunk used for calls terminated outside a switching unit.

Overflow Tone A tone returned to the calling customer to indicate that the call could not be

completed because the marker was unable to find an idle channel, outgoing sender, or trunk to use in the connection. Overflow tone is usually interrupted 120 times per minute.

Partial Dial or Partial Digits A failure of the originating register to receive sufficient digits to complete the call. It may result from a customer dialing before dial tone or failing to dial or key sufficient digits after receiving dial tone.

Permanent Signal The condition caused by the operation of a line relay followed by no dialing or keying. After a measured interval, the customer line is connected to a permanent signal trunk in order to conserve register usage and to ensure proper maintenance action in case of trouble on the line.

Physical Number An arbitrary designation for the numbers associated with only one of three office codes using the same number series. The numbers associated with the other office code only are designated as theoretical or extheo numbers.

Physical-Theoretical Discriminating Feature The feature which indicates to the marker whether the physical or the theoretical office is wanted and whether the number is a physical or a theoretical number.

Precedence The term used to indicate the importance of a call. There are four levels of precedence.

Preemption The act of releasing a call of lower precedence to establish a call of higher precedence when no idle circuits are available to the higher precedence call.

Pretranslation This operation takes place after a fixed number of digits (usually the office code) has been recorded to determine how many additional digits, if any, are required for the complete translation of the directory number. This feature is designed to reduce time delay in transmitting the call from the register to the marker where the total number of digits which can be dialed or keyed is variable.

Priority The importance of a call. (See **Precedence**.)

Priority Digits The prefix digits dialed to establish the priority level of a call. There are five priority levels, P0 through P4. P0 indicates the highest, and P4 indicates a routine or lowest priority call.

Pulse Conversion The operation of changing, when necessary, the type of pulsing between connecting offices in order to meet their particular transmission requirements.

Pulsing The act of transmitting digit information over a circuit to a switching unit for the purpose of reaching a called customer or operator.

Recycle The action which releases the initially selected trunk and permits an attempt to establish the connection to another trunk of the same route but using a different group of junctors and trunk links.

Route Control Digits Prefix digits which can be dialed to control the number of routes that will be attempted to establish a call.

Sender A unit of equipment in the dial switching system which receives digits from the marker and transmits them as pulses to a distant office.

Sender Link A switching arrangement for connecting outgoing senders and trunks.

Service Code Call A customer call to a service desk, such as repair, test, or long distance, which is identified by the code dialed (usually an X11 code).

Special Hunt Test Call A call made from the test desk to a customer line for the purpose of making voltmeter and other tests on the line. Special test calls use a special marker and certain tests which are made on regular calls are omitted.

Tandem Central Office or Tandem Office A central office used primarily as an intermediate switching point for traffic between other central offices. Unless qualified by a prefix or other explanation, this term is restricted by usage to an office used primarily for the interconnection of local central offices.

Terminal Hunting The function performed by the switching equipment in a dial office in searching

for an idle line in a PBX or other terminal hunting group.

Terminating Stage The switching process involved in extending the connection from the selected intraoffice trunk to the terminating line. The terminating stage is a subdivision of the marker intraoffice trunk job.

Theoretical Number An arbitrary designation for the numbers associated with only one of three office codes using the same number series. The numbers associated with the other offices codes only are designated as physical or exteoo numbers.

Toll Call Any call for a destination outside of the local service area of the calling station.

Tone Trunk A trunk which supplies tone to the calling customer. The marker attempts to route a customer to a tone trunk for conditions of overflow, partial dial, vacant code, or line busy on an intraoffice call.

Trunk Link A switching arrangement for connecting originating registers and trunks to junctors.

Unassigned Number A number within the assigned capacity for a particular office but unassigned to a customer.

Vacant Code or Vacant Code Point A code point which is unassigned. If a call is directed to a vacant code point, it is routed to an operator or vacant code trunk.

Vertical File The ten vertical units of a crossbar switch, located one above another on a line link frame.

Vertical Group The five vertical files making up the left or right half of a column of lines.

Note: One of the vertical groups of each line link frame contains the no-test file. Consequently, this vertical group has only 40 instead of 50 lines.