Lesson No. 1

FUNDAMENTALS OF TELEPHONY

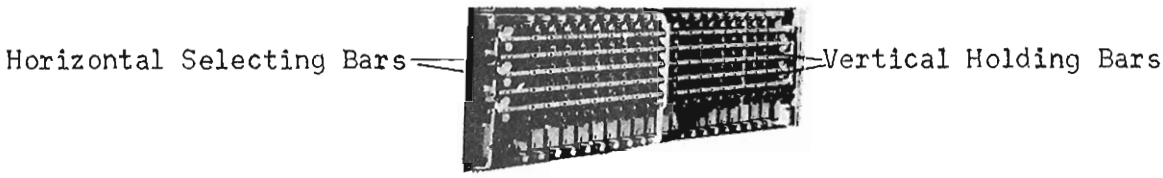
Section 11

The Crossbar Dial Switching System

CONTENTS

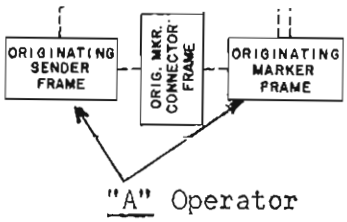
THE CROSSBAR DIAL SWITCHING SYSTEMS

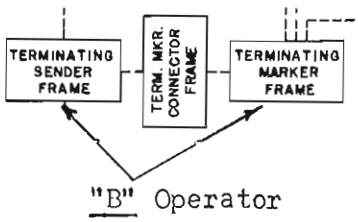
Crossbar - So called because of Horizontal Selecting Bars mounted across, and in front of, Vertical Holding Bars on the Crossbar Switch, the main Switching Device in building up a Talking Path between two Subscribers.



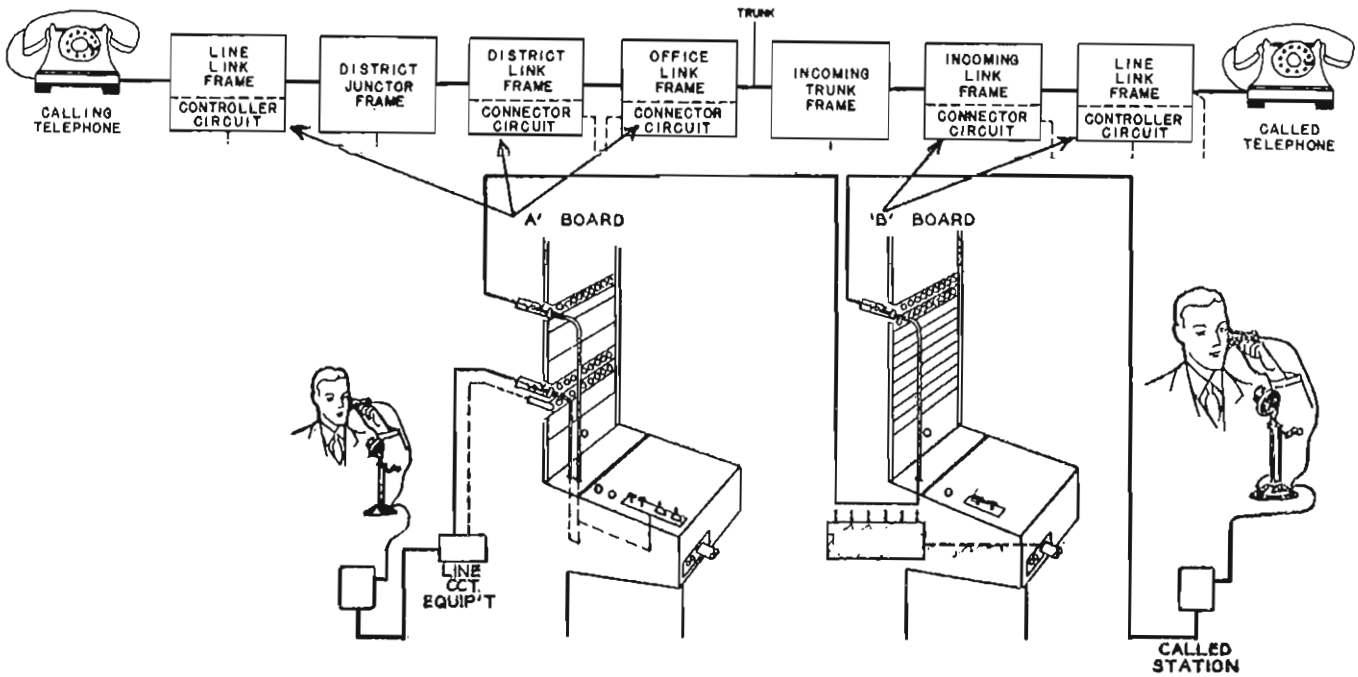
Main Divisions of Crossbar Switching Equipment (No. 1 Crossbar Dial System):

1) The Common Control Equipment, which replaces Switchboard Operators, builds up a Talking Path by operating Crossbar Switches on the Frames making up the Switching Network.

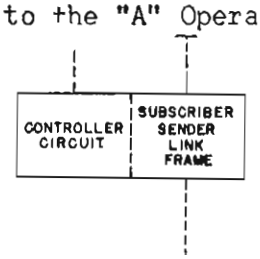


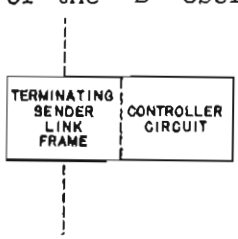


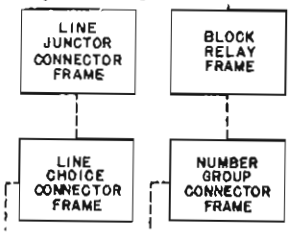
2) The Switching Network, which replaces the Switchboards, consisting principally of Crossbar Switches on which the Talking Path is built up.



3) Connector and Sender Link Frames - Afford the Common Control Equipment access to the Switching Network Frames in setting up a Call. Corresponds to the "A" Operator's Listening Key or the "B" Operator's Position Circuit.

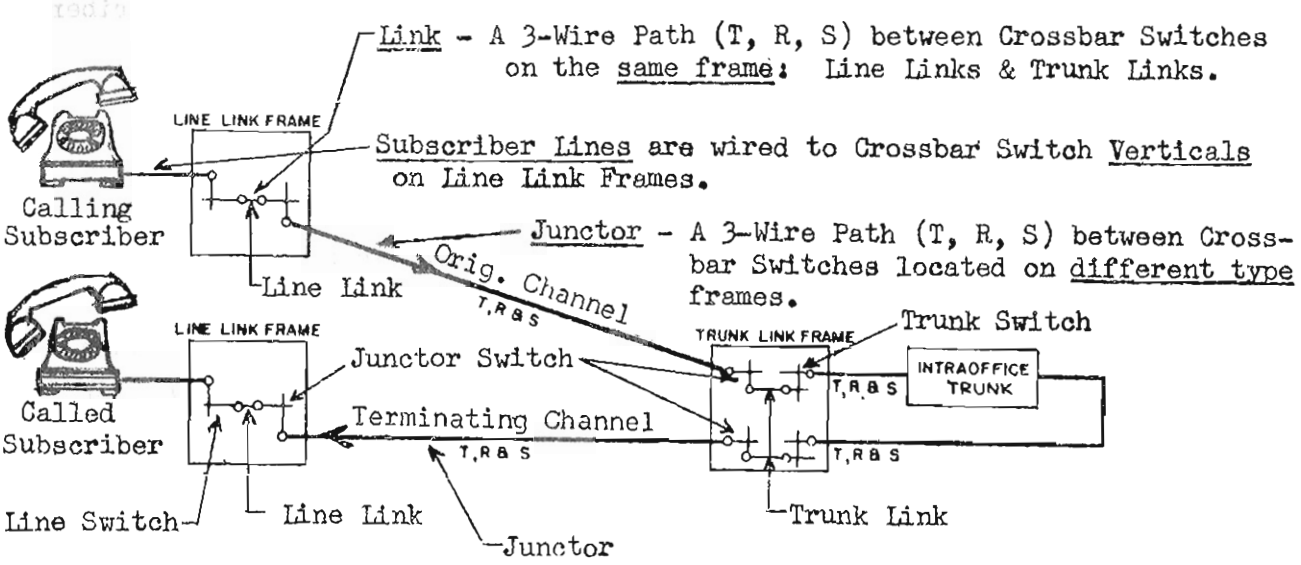






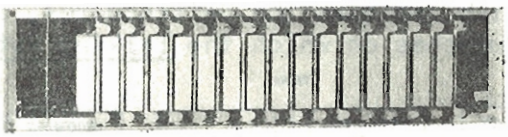
Crossbar Dial Subscriber Lines and Trunks are cabled to Crossbar Switches mounted on the Switching Network Frames.

NO. 5 Crossbar Dial System



Crossbar Frames are made up of 3 Major Apparatus Items:

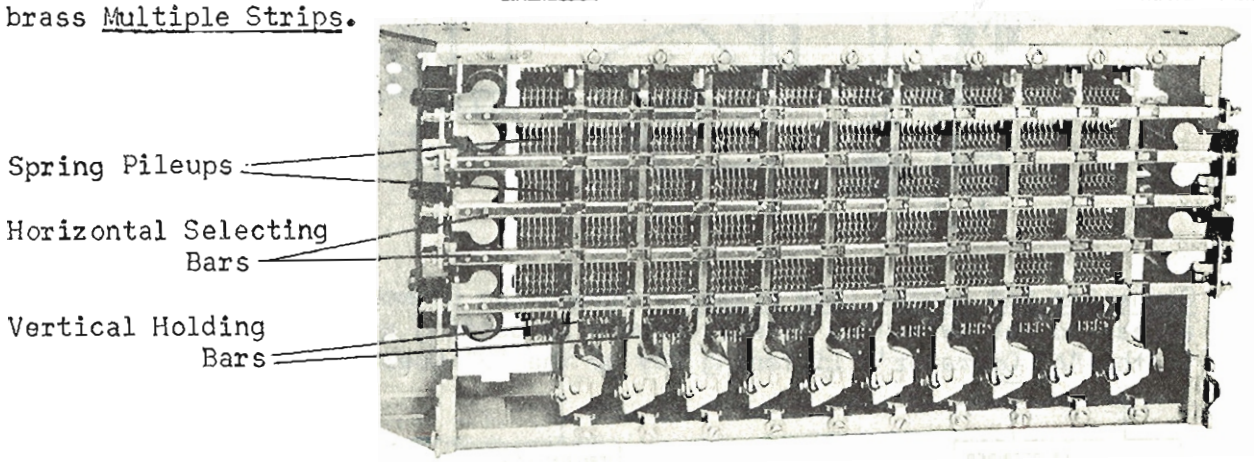
1) Crossbar Switch - Used principally in building up the Talking Path.
2) Multicontact Relays - For connecting a large number of leads between Frames in setting up a Call.



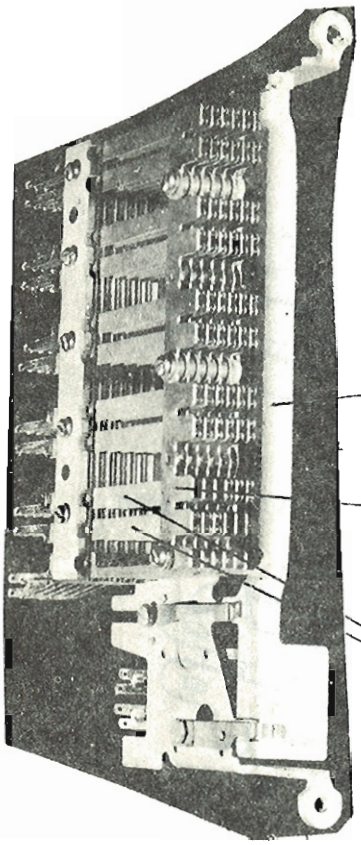
3) General Purpose Relays - Used in Trunk Circuits and Control Circuits, Registers, Senders, Markers, etc.

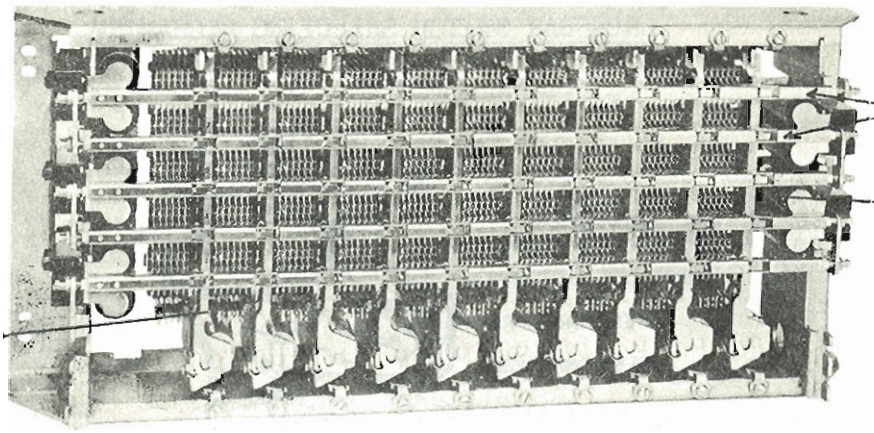
THE CROSSBAR SWITCH

A "2-Step" Relay made up of a large number of "make" contacts on Operate Springs, arranged in Horizontal Rows or Levels, and stationary mate contacts on Vertical brass Multiple Strips.



100-Point Crossbar Switch





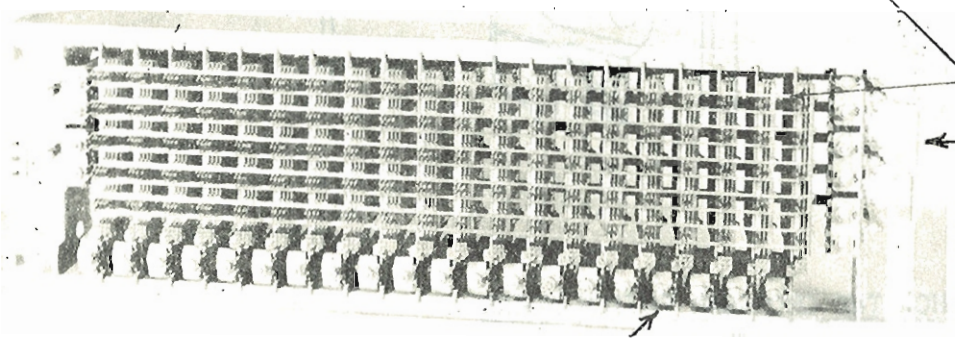
Brass Multiple Strip (Precious Metal Contacts)

Horiz. Multiple
Vert. Multiple

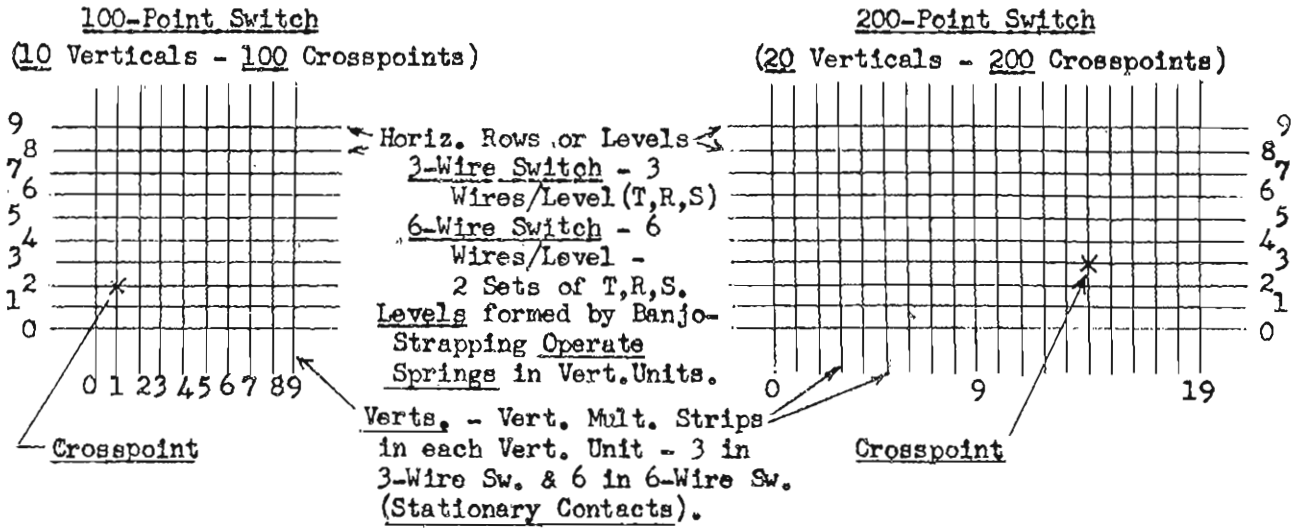
Crossbar Switch Convention

Bifurcated (Split) Operate Springs with Twin Precious Metal Contacts

Crossbar Switch Vertical Unit

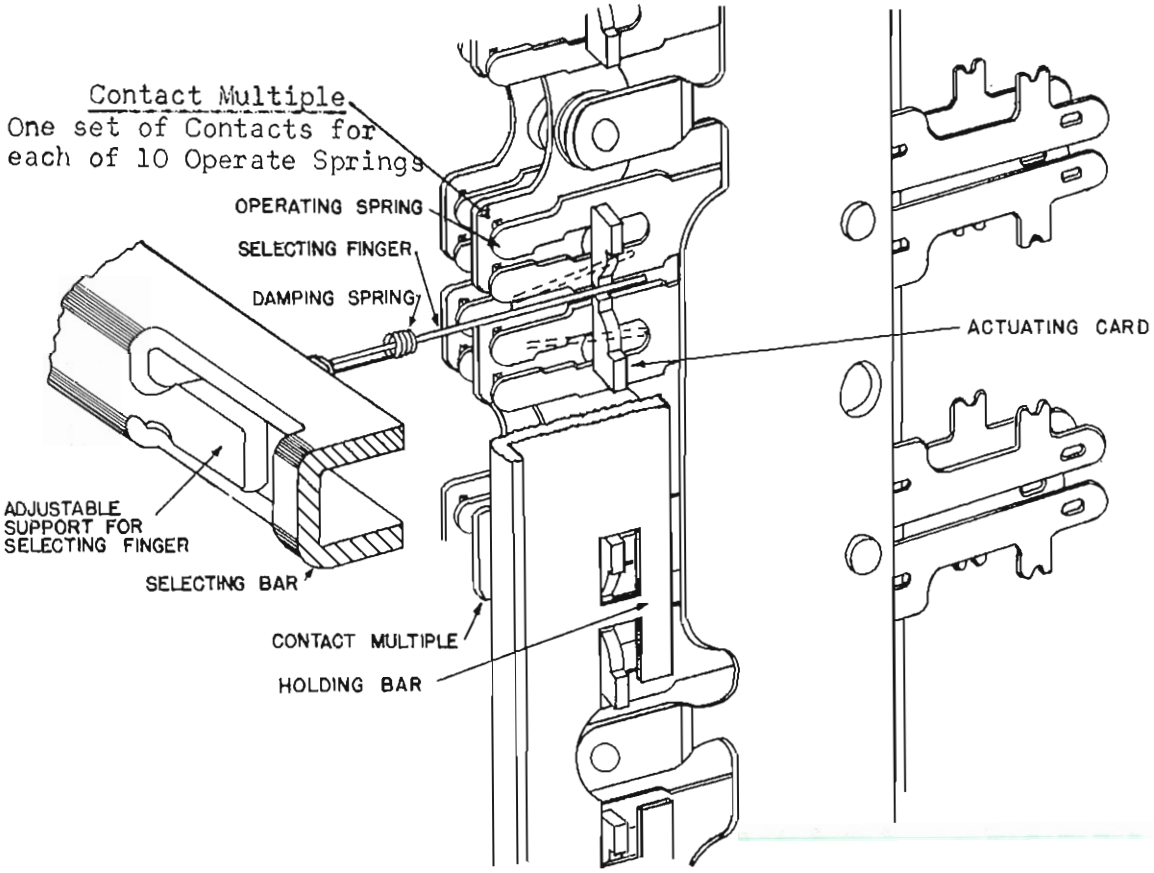


Rear View of Crossbar Switch Showing Horizontal (Banjo) Strapping of Operate Springs.

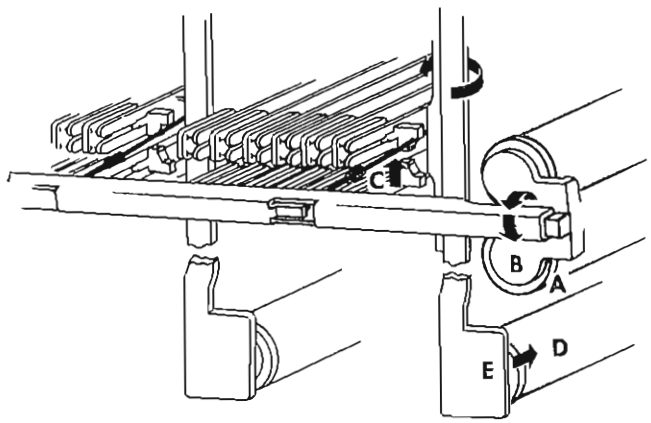


A Crosspoint is closed by operation of a Selecting Magnet (located at the end of the Switch), followed by operation of a Holding Magnet on one of the Vertical Units. After operation of the Holding Magnet, the Selecting Magnet releases.

CROSSBAR SWITCH SELECTING MECHANISM



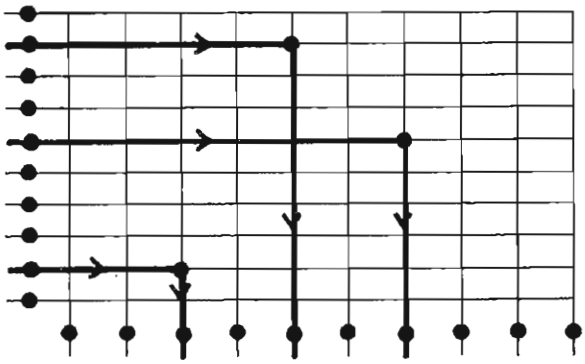
HOW THE CROSSBAR SWITCH WORKS



(1) The electromagnet marked (A) pulls the ear-like projection (B). This tilts the horizontal bar so that a wire (C) projecting from the bar into the switch mechanism is raised into position.

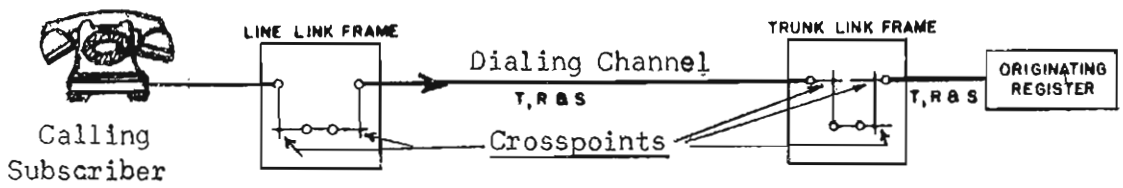
(2) The electromagnet (D) now operates and pivots the vertical bar (E) inward. The vertical bar pressing against the projecting wire (C) closes the contacts and completes the connection.

3 of 10 Possible Paths Through a Crossbar Switch

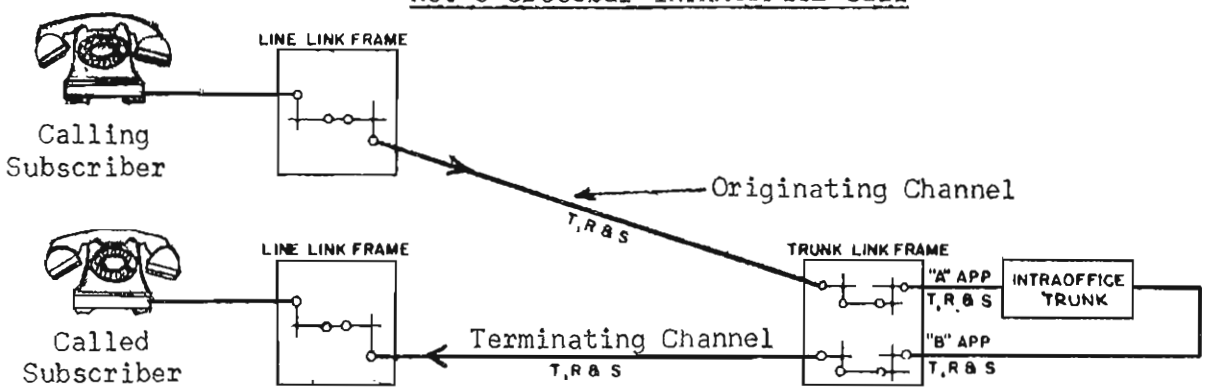


Common Control Equipment operates Crossbar Switches, closing a set of Crosspoints (on Switching Network Frames - For example: Line Link and Trunk Link Frames in No. 5 Crossbar) to pick up the "free ends" of one set of short pieces of circuits (Links and Junctors, wired to Crossbar Switch Verticals or Horizontals.), and "ties" them together to build up a Talking Path.

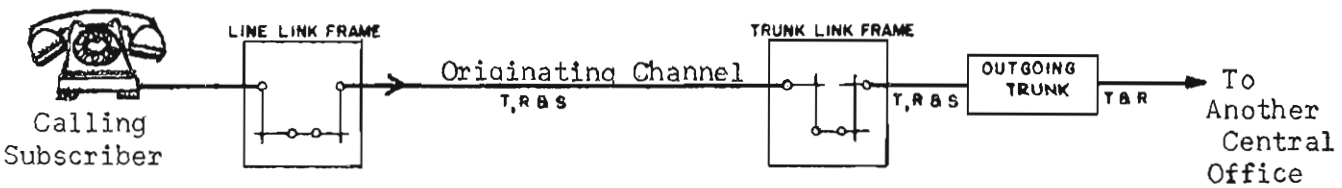
No. 5 Crossbar DIALING Channel



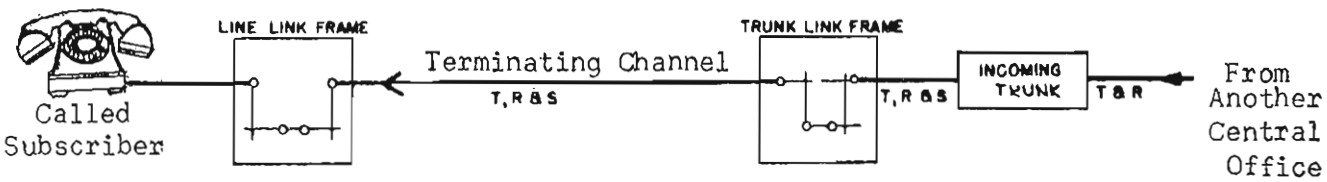
No. 5 Crossbar INTRAOFFICE Call



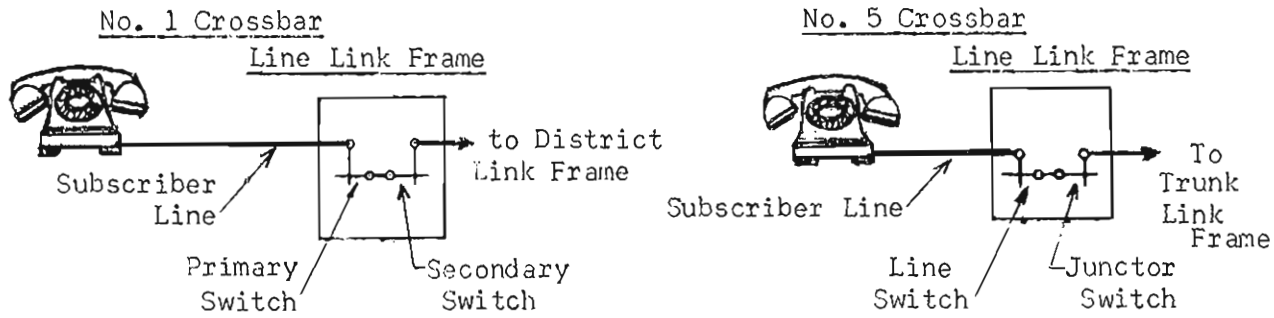
No. 5 Crossbar OUTGOING Call



No. 5 Crossbar INCOMING Call



Subscriber Lines cable to Vertical Units of Crossbar Switches on Line Link Frames.

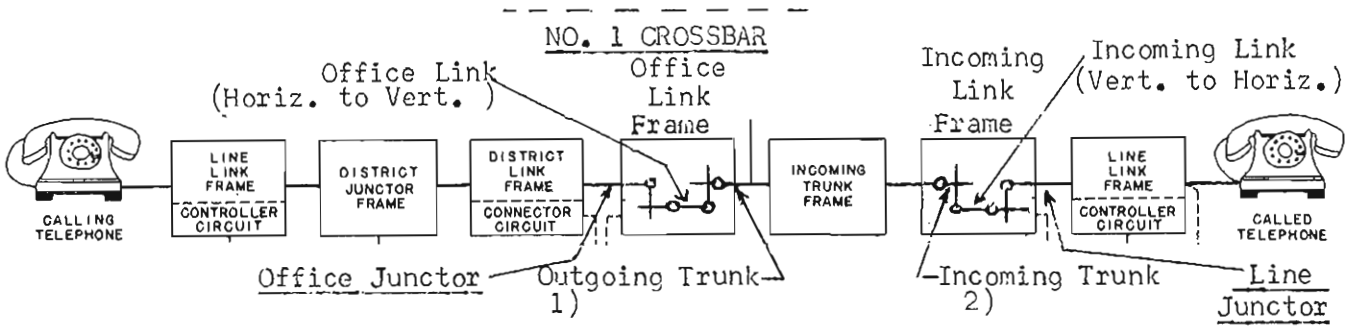


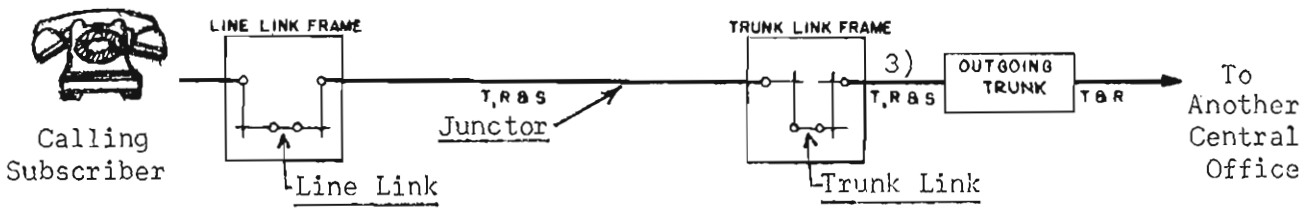
Trunks cable to Horizontals or Levels of:

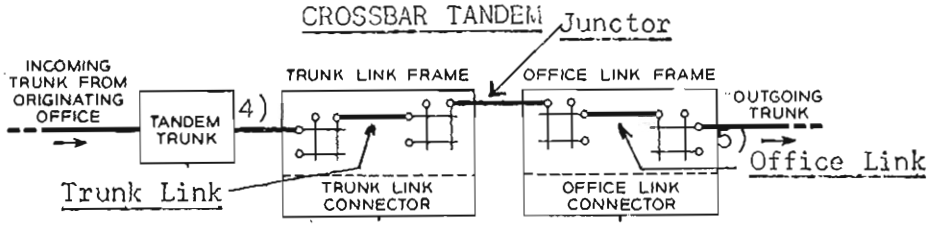
1) Office Link Frames in No. 1 Crossbar.
2) Incoming Link Frames in No. 1 Crossbar.
3) Trunk Link Frames in No. 5 Crossbar.
4) Trunk Link Frames in Crossbar Tandem.
5) Office Link Frames in Crossbar Tandem.
6) Incoming Frames in No. 4A Crossbar Toll.
7) Outgoing Frames in No. 4A Crossbar Toll.

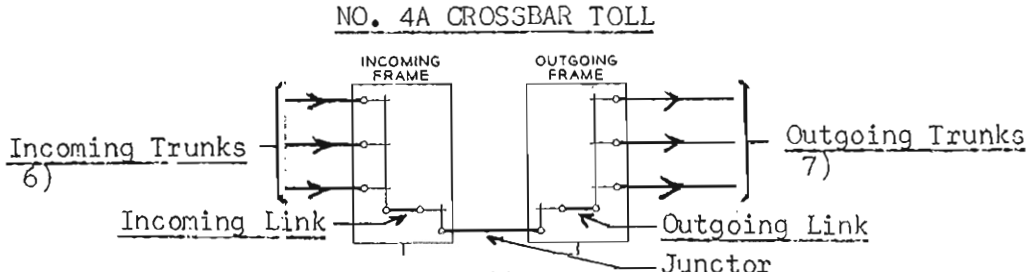
Links are paths between Crossbar Switches on the same Frame.

Junctors are paths between Crossbar Switches on different Frames.





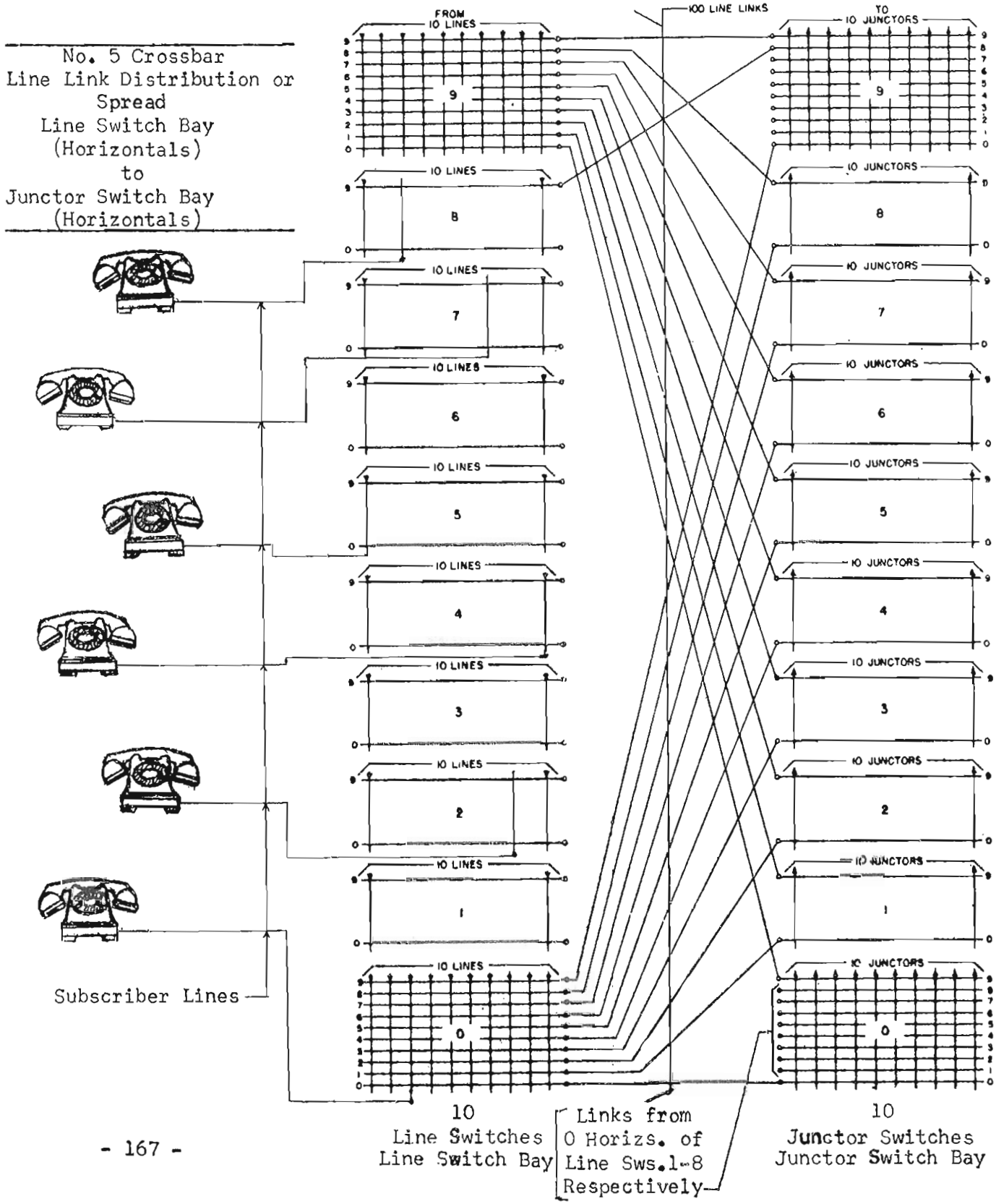




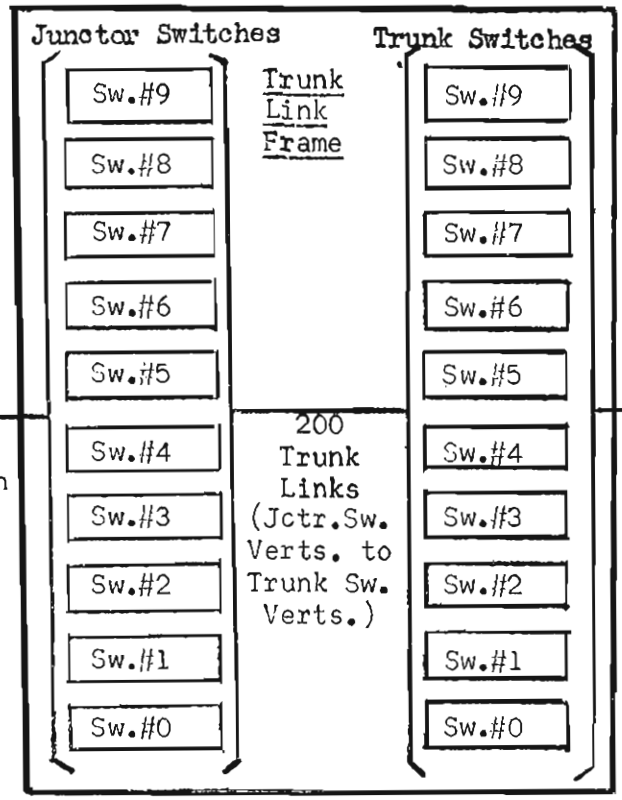
Crossbar Switches are used in "Tandem" (one following the other) in building up a Talking Path through the Switching Frames. For example, in Crossbar System Line Link Frames:

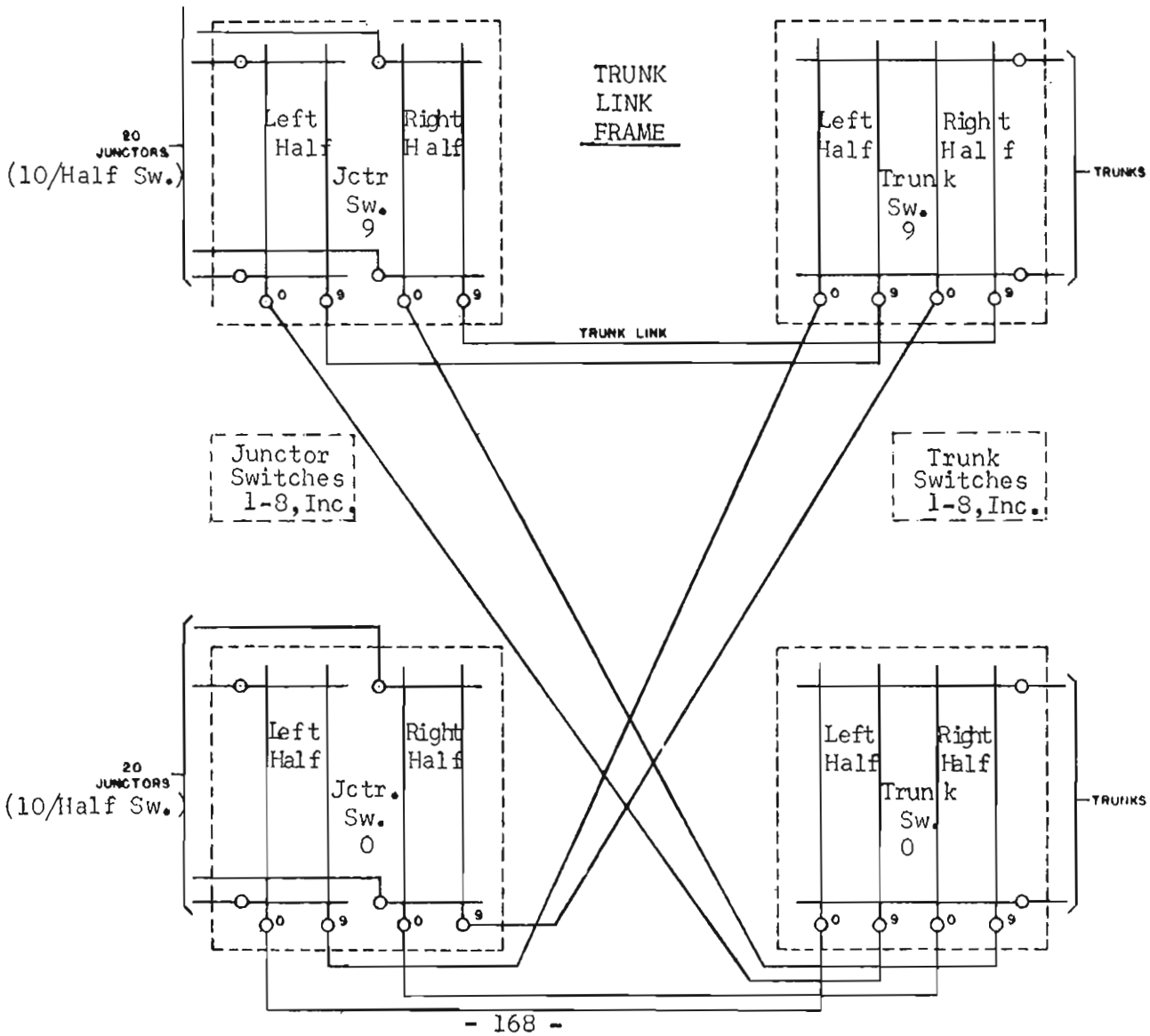
10 Switches mount, one above the other, in a Bay (the space between two Vertical Uprights) - No. 1 Crossbar Primary Bay,
No. 5 Crossbar Line Switch Bay.

10 Other Switches mount, one above the other, in a second Bay, alongside the first Bay - No. 1 Crossbar Secondary Bay,
No. 5 Crossbar Junctor Switch Bay.

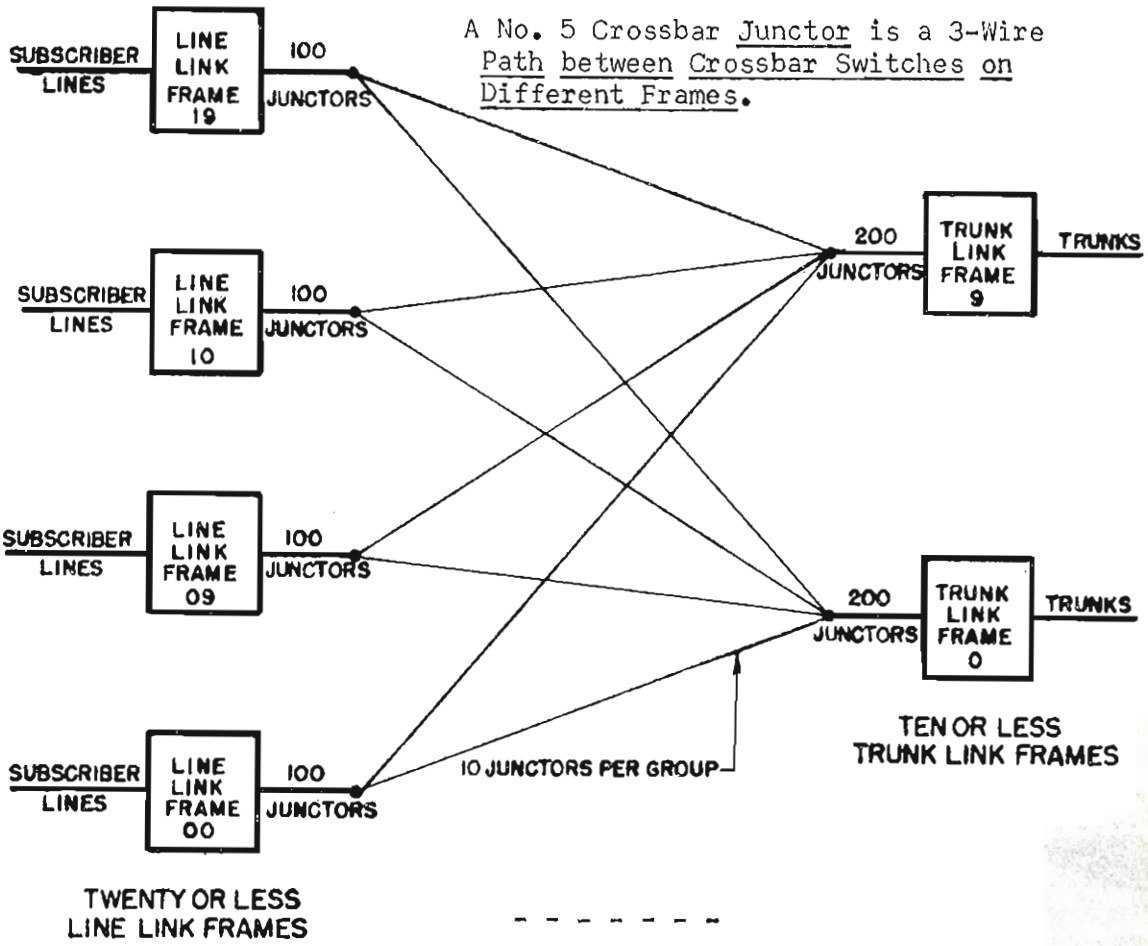


No. 5 Crossbar
Trunk Link Distribution or Spread
Junctor Switch Bay (Verticals)
to
Trunk Switch Bay (Verticals)





No. 5 Crossbar - Typical Junctor Distribution Pattern



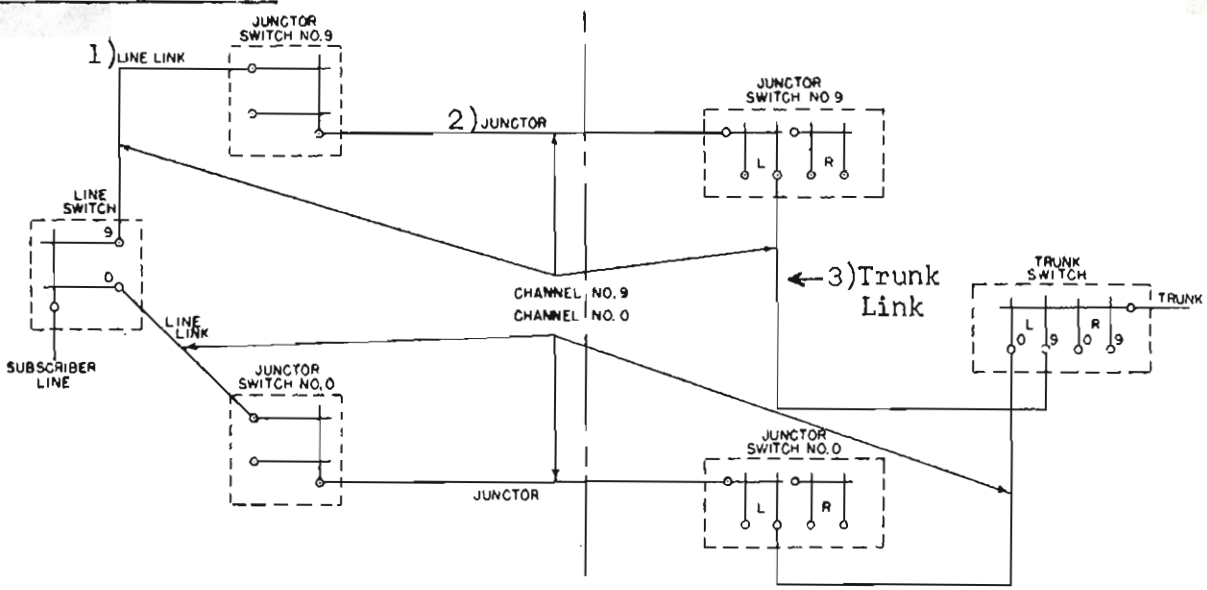
NO. 5 Crossbar CHANNELS

A Channel is a combination of 1) a Line Link, 2) a Junctor, and 3) a Trunk Link, selected by the Common Control Equipment, and "tied" together, end-to-end, by Crossbar Switch Crosspoint Closures, to interconnect a Subscriber Line and a Trunk or Register.

Dialing Channel - Connects a Calling Subscriber Line to an Originating Register.

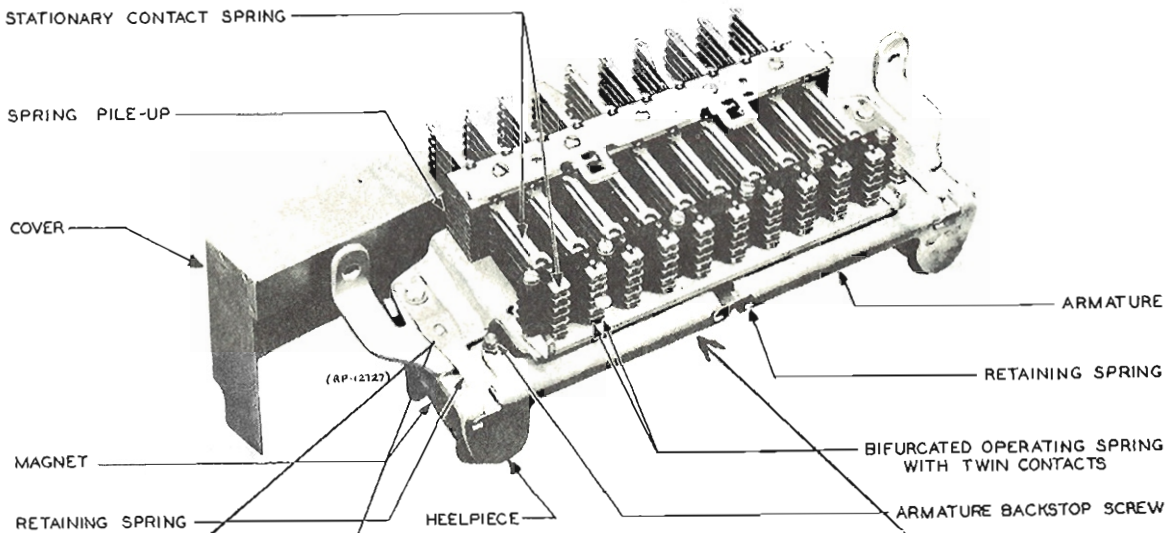
Originating Channel- Connects a Subscriber Line to a Trunk.

Terminating Channel- Connects a Trunk to a Subscriber Line.

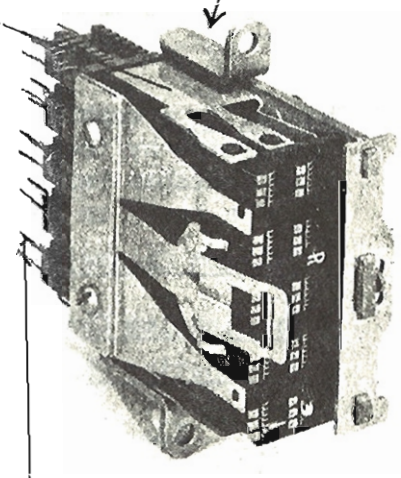


MULTICONTACT RELAYS

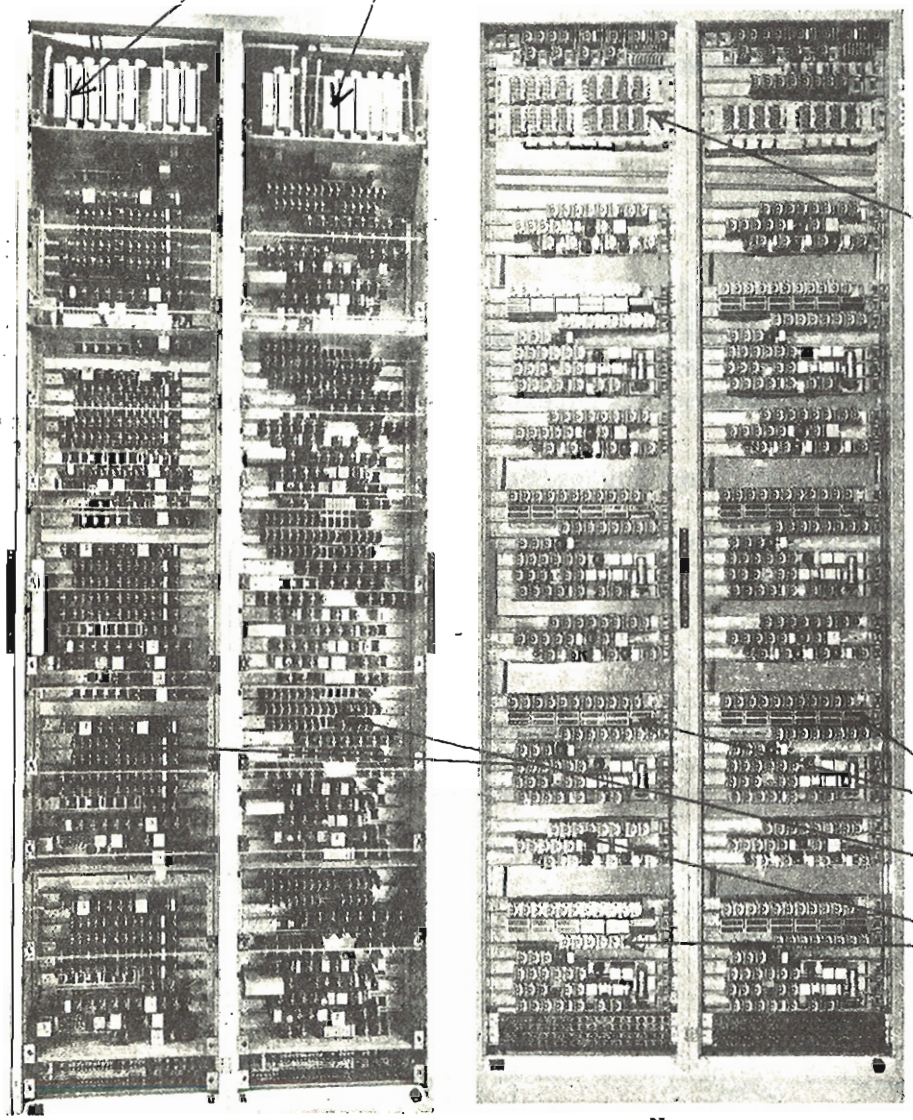
Multicontact Relays are used to cut through a large number of leads between Frames in Setting up a Call.



263 Type
MultiContact Relay
286 Type



Gun Wrap Terminals



Dry Reed Relays

U-Type Relays

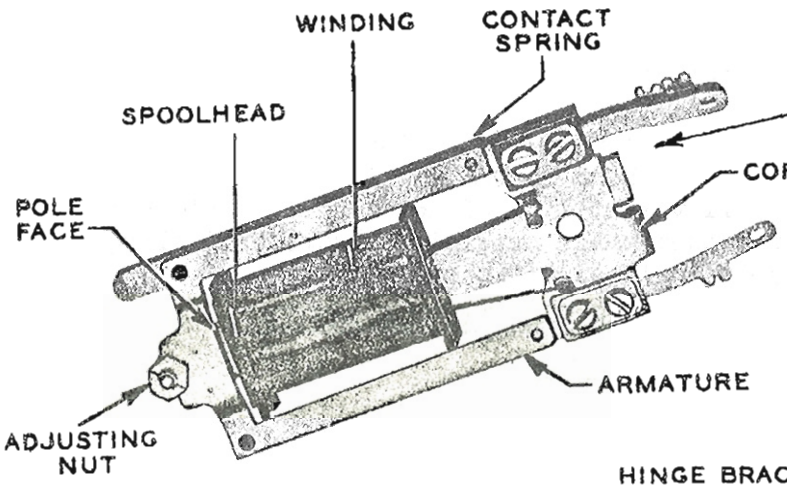
Wire Spring Relays

Old New

Originating Register Frames

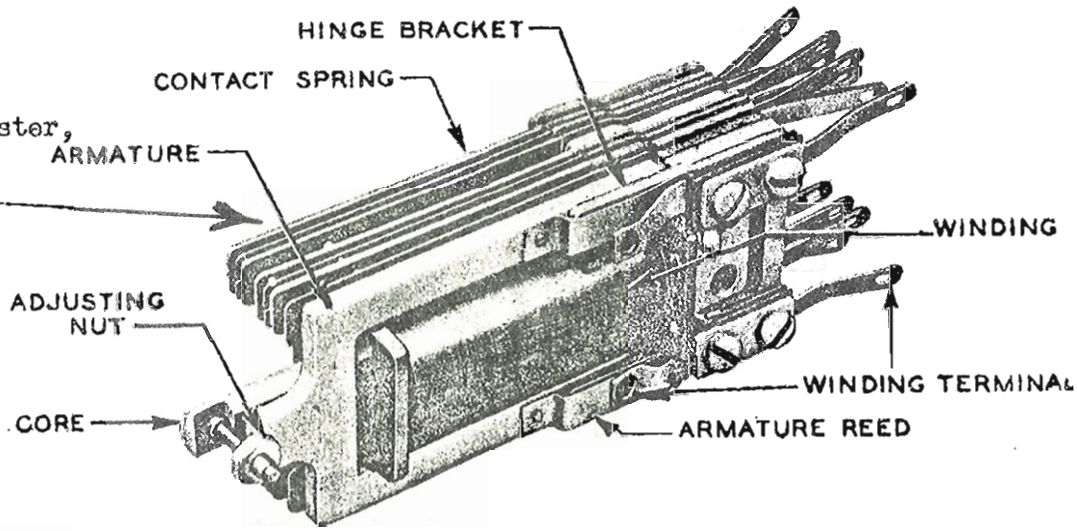
GENERAL PURPOSE RELAYS

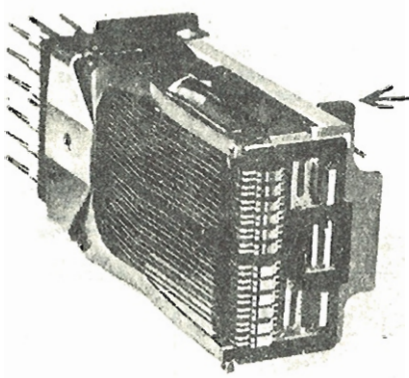
General Purpose Relays are used in Senders, Registers, Marker, Trunks and Control Circuits



FLAT TYPE RELAY - Used as Line Relay on Line Link Frame.

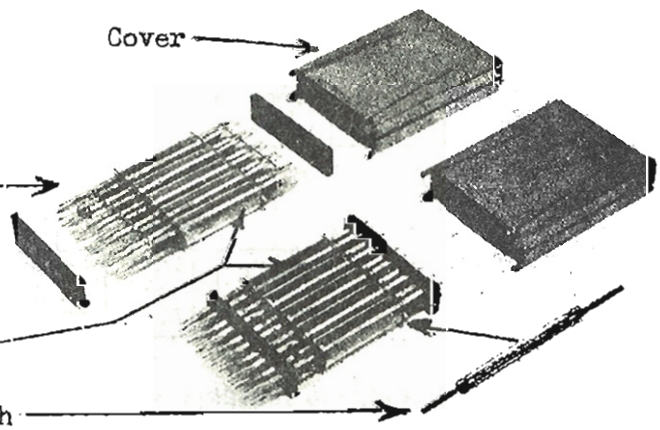
U TYPE RELAY - Used in Counting, Register, Steering, etc., Circuits.





WIRE SPRING RELAY - Replaces U Type in many applications.

DRY REED RELAY - Used in Digit Storage (Register) Circuits.

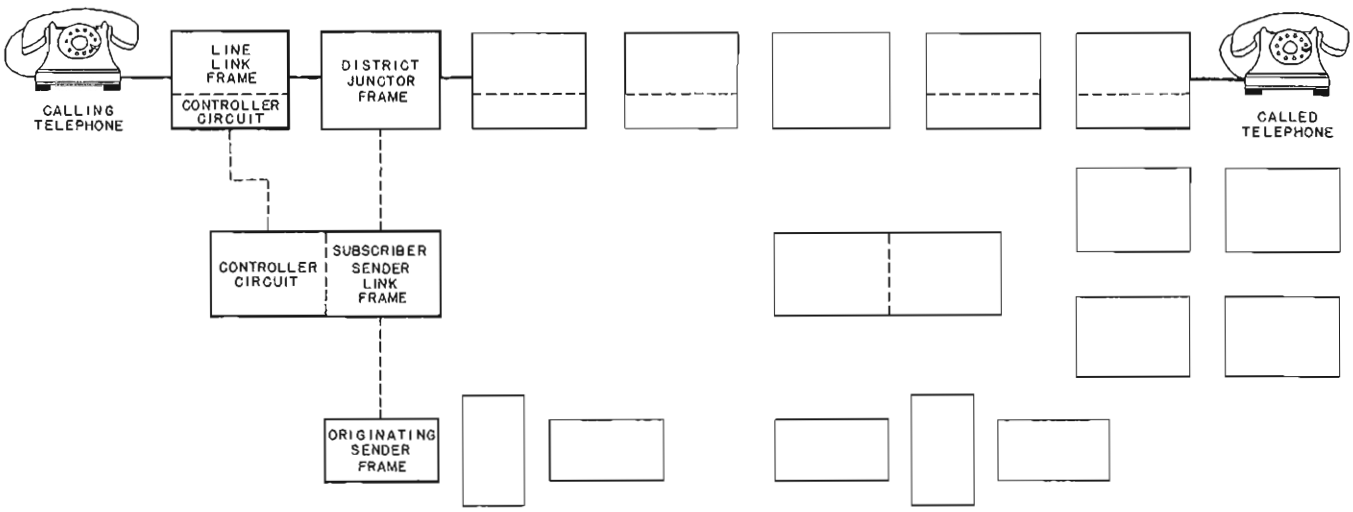


THE CROSSBAR SWITCHING SYSTEMS

1) No. 1 Crossbar - A Common Control Switching System replacing Panel Dial in Large Cities.
2) No. 4 Crossbar - A Common Control Toll or Long Distance Switching System. CAMA Equipment may be provided for No. 4A to record data for billing Calls.
3) No. 5 Crossbar - A versatile Common Control Switching System for Areas on the Outskirts of Large Metropolitan Centers, and for use in Medium to Large Offices, with Tandem and Toll Features, as well as facilities for Local Traffic.
4) Crossbar Tandem - A Common Control Switching System for Traffic Between Local Dial Offices, and a Toll Switching System for Intertoll Traffic, where the large capacity and full versatility of No. 4A Toll would not be economical. CAMA on Crossbar Tandem makes possible Subscriber Dialing of Calls where AMA is not available in Local Offices.

METHODS OF COMPLETING CALLS THROUGH THE CROSSBAR SYSTEMS

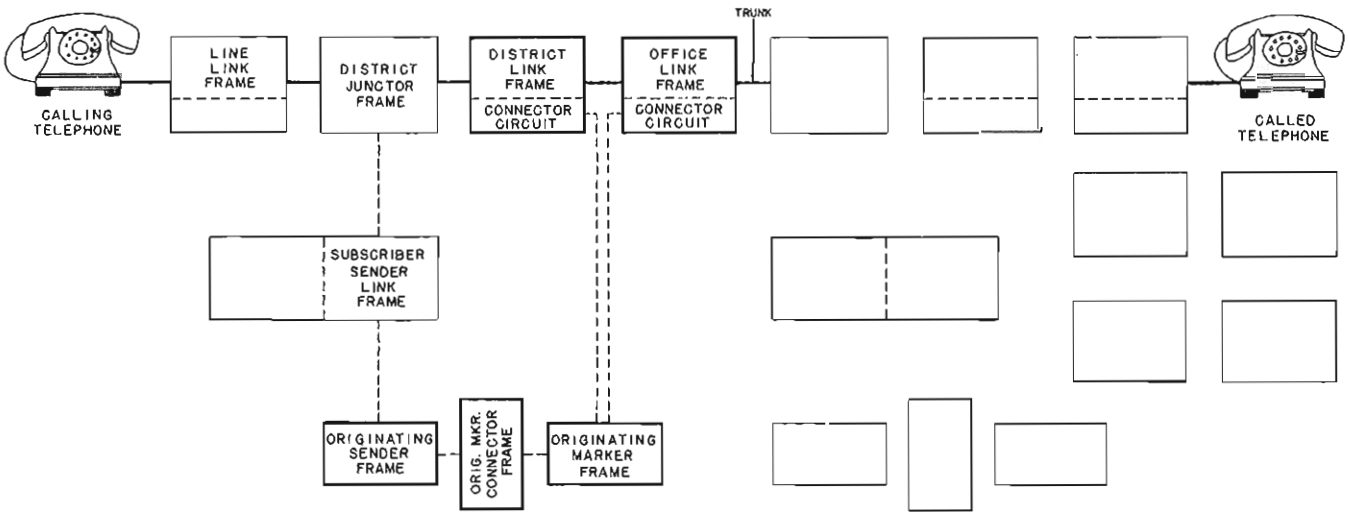
No. 1 Crossbar System



SK. 1

CALLING SUBSCRIBER REMOVES HANDSET

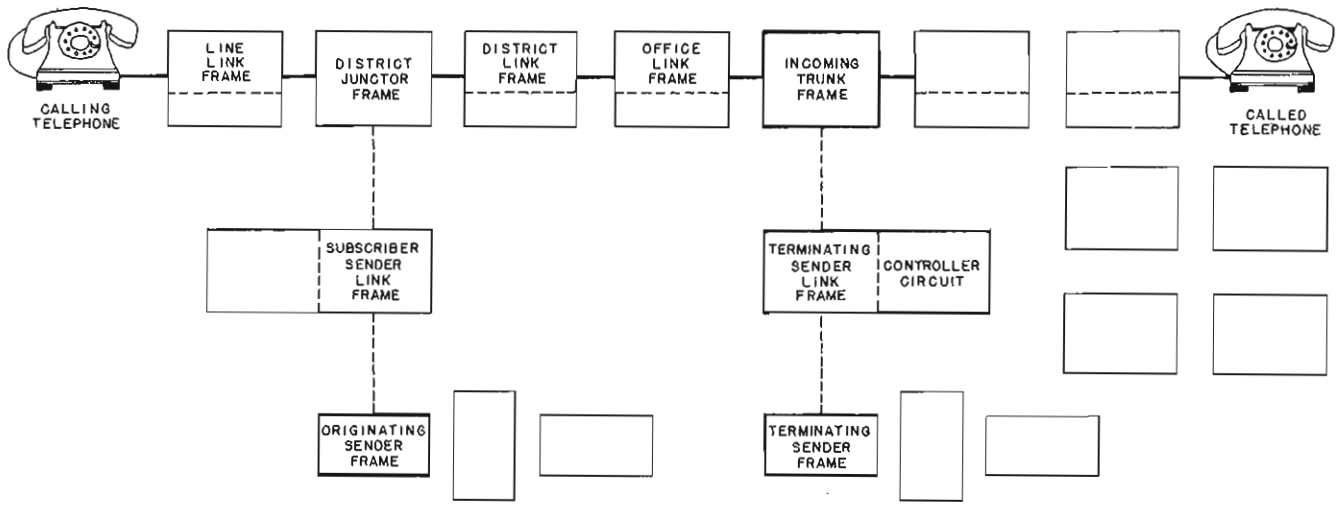
ON THE REMOVAL OF THE HANDSET BY THE CALLING SUBSCRIBER, THE LINE LINK FRAME CONTROLLER CIRCUIT FUNCTIONS TO LOCATE THE CALLING LINE AND IN CONJUNCTION WITH THE SUBSCRIBER SENDER LINK CONTROLLER CIRCUIT SELECTS AN IDLE DISTRICT JUNCTOR. THE SUBSCRIBER SENDER LINK CONTROLLER CIRCUIT ALSO SELECTS AN IDLE ORIGINATING SENDER. THE TWO CONTROLLER CIRCUITS EXTEND THE CALLING LINE TO THE SENDER BY SETTING UP IDLE PATHS THROUGH THE LINE LINK AND SUBSCRIBER SENDER LINK FRAME AND THEN RESTORE TO NORMAL. THE SENDER RETURNS DIAL TONE TO THE CALLING LINE AS AN INDICATION THAT DIALING CAN BE STARTED.



SK, 2

CALLING SUBSCRIBER DIALS THE OFFICE CODE-"OA4" FOR OAKLAND 4

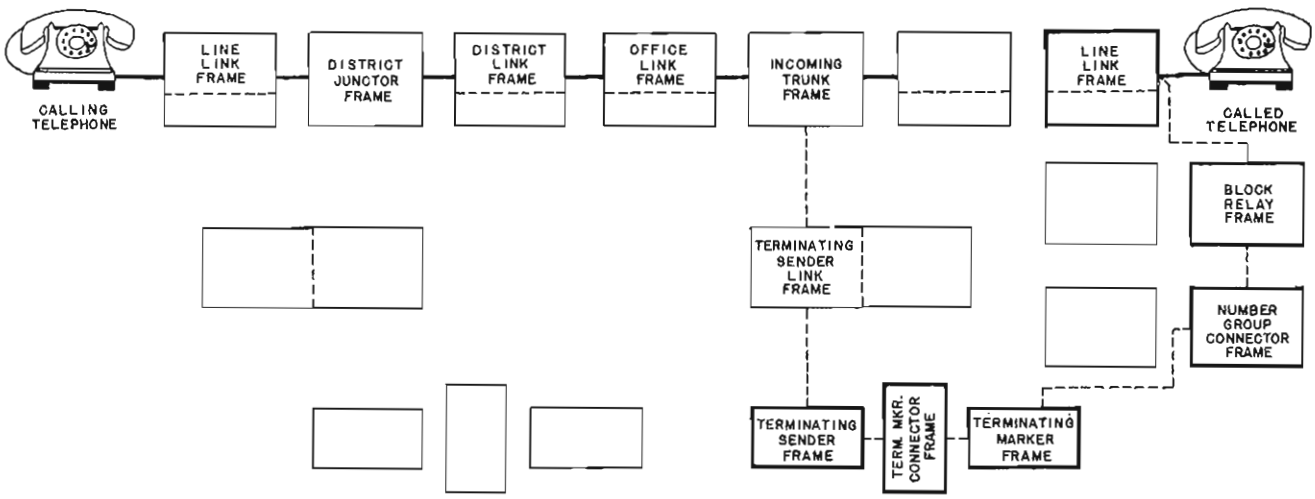
WHEN THE DIAL PULSES FOR THE OFFICE CODE ARE REGISTERED IN THE SENDER, THE SENDER WILL CALL ON AN ORIGINATING MARKER CONNECTOR TO PROVIDE AN IDLE ORIGINATING MARKER. THE SENDER THEN PASSES INFORMATION TO THE ORIGINATING MARKER AS TO THE OFFICE CODE DIALED, CLASS OF SERVICE OF THE CALLING LINE, ETC. THE ORIGINATING MARKER PROCEEDS TO SELECT AN IDLE TRUNK AND THEN SETS UP IDLE PATHS THROUGH AND BETWEEN THE DISTRICT LINK AND OFFICE LINK FRAMES TO CONNECT THE TRUNK TO THE DISTRICT JUNCTOR. THE CONNECTIONS BETWEEN THE ORIGINATING MARKER AND THESE FRAMES ARE THROUGH DISTRICT LINK AND OFFICE LINK CONNECTOR CIRCUITS. THE CONNECTOR CIRCUITS, ORIGINATING MARKER, AND ORIGINATING MARKER CONNECTOR THEN RELEASE.



SK. 3

CALLING SUBSCRIBER DIALS THE NUMERICAL CODE - 1234

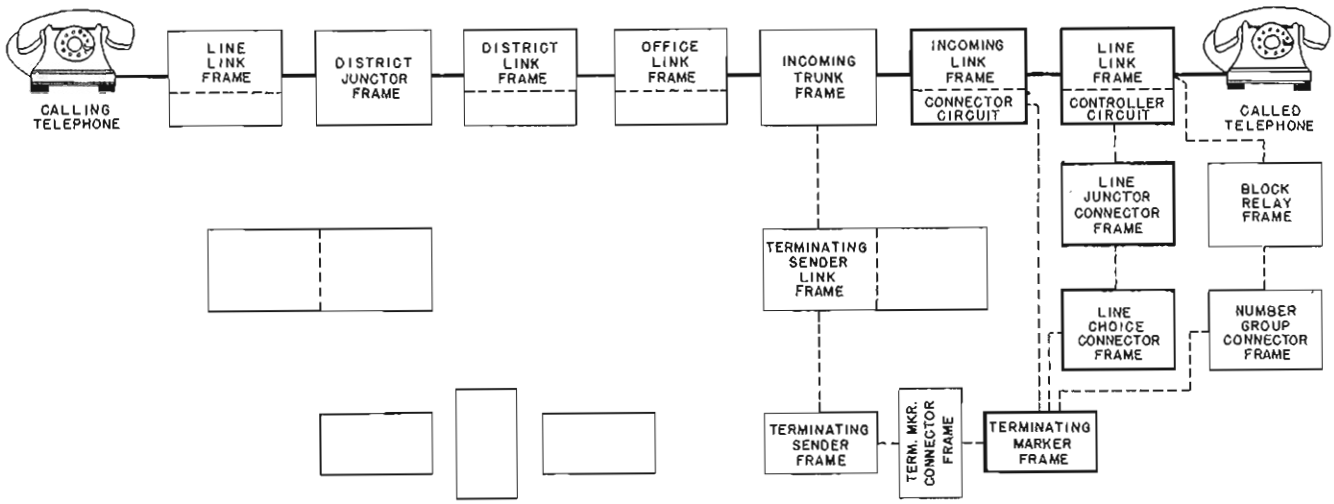
WHEN THE THOUSANDS AND HUNDREDS DIGITS OF THE NUMERICAL CODE HAVE BEEN REGISTERED IN THE ORIGINATING SENDER THE SELECTED TRUNK IS CLOSED THROUGH THE INCOMING TRUNK TO THE TERMINATING SENDER LINK FRAME. THE ASSOCIATED CONTROLLER CIRCUIT SELECTS AN IDLE TERMINATING SENDER AND AN IDLE PATH THROUGH THE TERMINATING SENDER LINK FRAME, CONNECTING THE TERMINATING SENDER TO THE SELECTED TRUNK AND THEN THE CONTROLLER CIRCUIT RELEASES. THE THOUSANDS AND HUNDREDS DIGITS AS REGISTERED IN THE ORIGINATING SENDER ARE NOW TRANSFERRED AND REGISTERED IN THE TERMINATING SENDER. THE TENS AND UNITS DIGITS WHEN DIALED ARE ALSO TRANSFERRED TO THE TERMINATING SENDER. THE ORIGINATING SENDER AND SUBSCRIBER SENDER LINK NOW RELEASE FROM THE CALL.



SK. 4

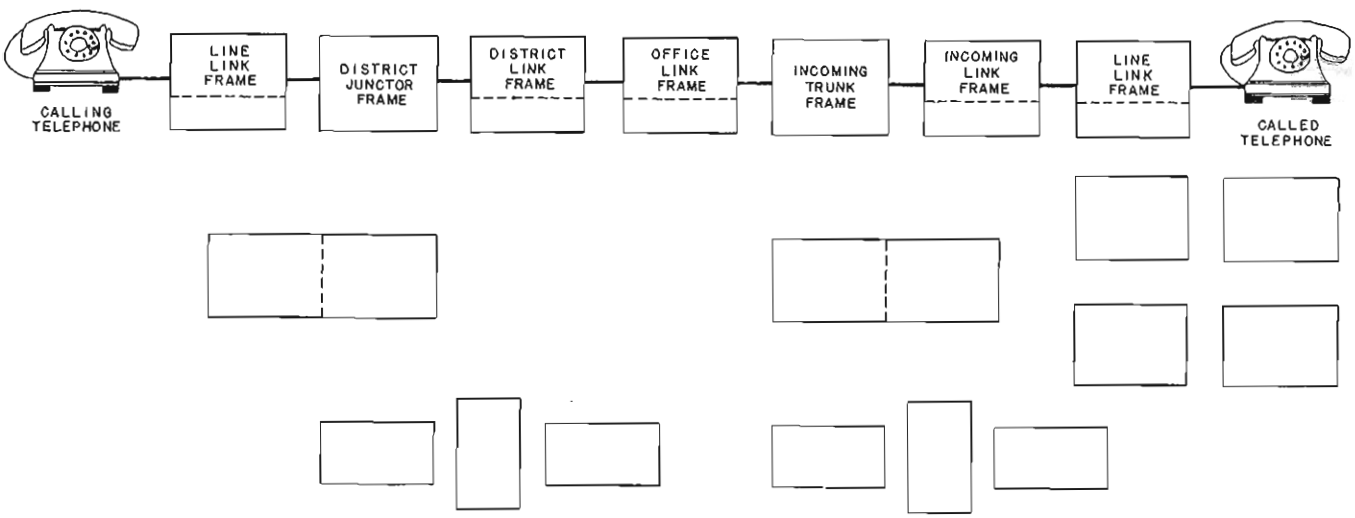
TESTING THE CALLED SUBSCRIBER LINE

AS SOON AS THE NUMERICAL CODE HAS BEEN TRANSFERRED AND REGISTERED IN THE TERMINATING SENDER, THE SENDER CALLS ON A TERMINATING MARKER CONNECTOR TO PROVIDE AN IDLE TERMINATING MARKER. THE TERMINATING SENDER THEN PASSES THE NUMERICAL CODE INFORMATION TO THE TERMINATING MARKER. THE TERMINATING MARKER SELECTS AND CONNECTS TO THE SLEEVE LEAD OF THE CALLED LINE, LOCATED ON A LINE LINK FRAME, THROUGH A NUMBER GROUP CONNECTOR AND BLOCK RELAY FRAME. A TEST IS NOW MADE BY THE TERMINATING MARKER FOR A BUSY OR IDLE CONDITION ON THE LINE. IF THE CALLED LINE IS BUSY THE INCOMING TRUNK IS SET BY THE TERMINATING MARKER TO SEND BUSY TONE TO THE CALLING SUBSCRIBER AND THE TERMINATING SENDER, TERMINATING MARKER CONNECTOR, TERMINATING MARKER, NUMBER GROUP CONNECTOR AND BLOCK RELAY CIRCUITS RESTORE TO NORMAL IMMEDIATELY. LET IT HOWEVER BE ASSUMED THAT THE CALLED LINE IS IDLE.



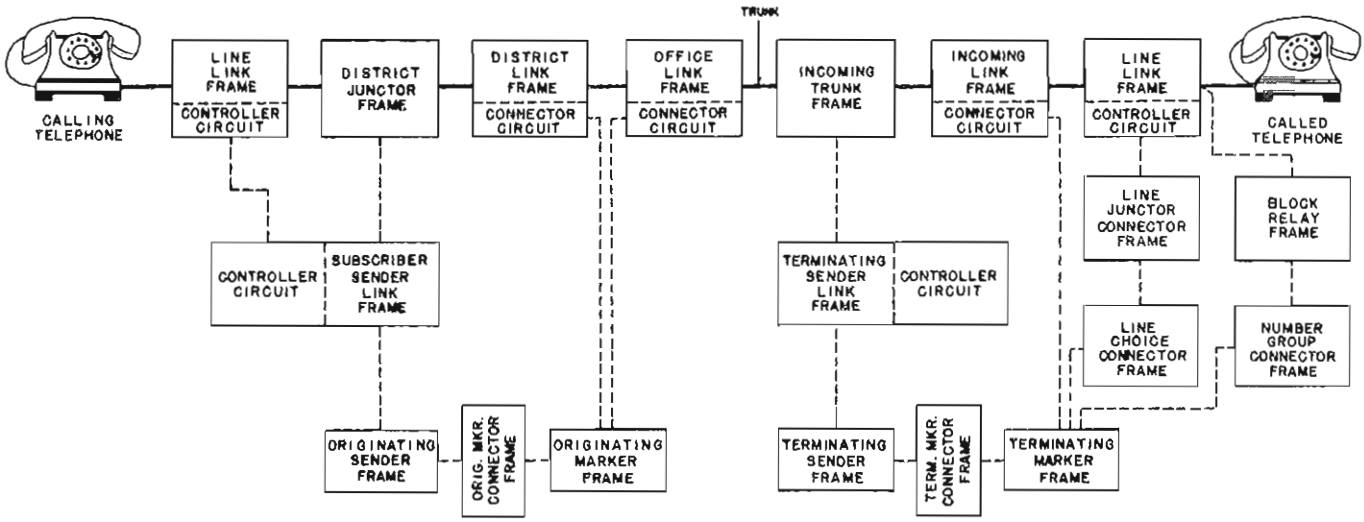
SK. 5
CONNECTING INCOMING TRUNK TO CALLED LINE

THE TERMINATING MARKER ON FINDING THE LINE IDLE SETS UP IDLE PATHS THROUGH AND BETWEEN THE INCOMING LINK AND LINE LINK FRAMES, CONNECTING THE INCOMING TRUNK TO THE CALLED LINE. THE TERMINATING MARKER ACCOMPLISHES THIS WITH THE AID OF THE INCOMING LINK CONNECTOR CIRCUIT, LINE CHOICE CONNECTOR, LINE JUNCTOR CONNECTOR AND LINE LINK CONTROLLER CIRCUIT. THE INCOMING TRUNK PROCEEDS TO RING THE CALLED SUBSCRIBER BELL. THE TERMINATING SENDER LINK, TERMINATING SENDER, TERMINATING MARKER CONNECTOR, TERMINATING MARKER, NUMBER GROUP CONNECTOR, BLOCK RELAY, LINE CHOICE CONNECTOR, LINE JUNCTOR CONNECTOR, LINE LINK CONTROLLER, AND INCOMING LINK CONNECTOR CIRCUITS RESTORE TO NORMAL



SK. 6
SUBSCRIBER TALKING PATH

WHEN THE CALLED SUBSCRIBER ANSWERS, THE TALKING PATH IS COMPLETED BETWEEN THE CALLING AND CALLED LINES. TALKING BATTERY IS FURNISHED TO THE CALLING LINE BY THE DISTRICT JUNCTOR AND TO THE CALLED LINE BY THE INCOMING TRUNK.

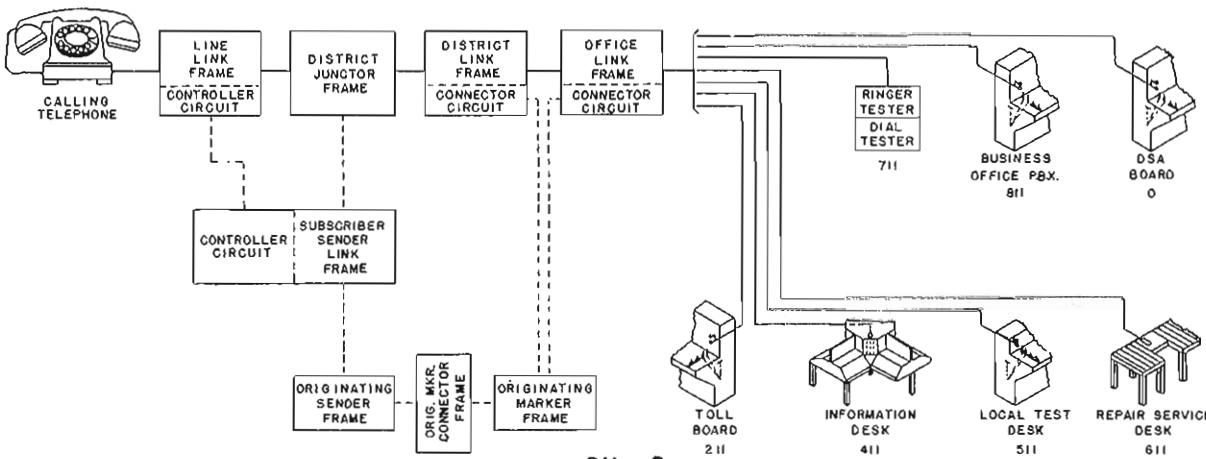


SK. 7

SEQUENCE OF FRAMES INVOLVED IN COMPLETING A CALL BETWEEN TWO SUBSCRIBERS

No. 1 Crossbar System

Calls to Switchboards, Desks and Special Equipment Used In No. 1 Crossbar Offices



SK. 8

SEQUENCE OF FRAMES INVOLVED IN COMPLETING CALLS TO SWITCHBOARDS, DESKS & SPECIAL EQUIPMENT

SKETCH NO. 8 SHOWS THE CROSSBAR FRAMES REQUIRED TO ENABLE THE CALLING SUBSCRIBER TO GAIN ACCESS TO THE DIAL SYSTEM "A" BOARD, TOLL BOARD, INFORMATION DESK, REPAIR SERVICE DESK, AND BUSINESS OFFICE PBX, AND TO GIVE A TELEPHONE REPAIR MAN ACCESS TO THE TEST DESK AND RINGER AND DIAL TESTING EQUIPMENT. CALLS TO THESE POINTS ARE MADE BY DIALING THE NUMBERS AS SHOWN BELOW:

211 PROVIDES A CONNECTION TO THE TOLL OPERATORS AT THE TOLL BOARD, WHO WILL COMPLETE ANY CALL THAT MUST BE HANDLED ON A TOLL CHARGE BASIS.

411 PROVIDES CONNECTION TO THE OPERATORS AT THE INFORMATION DESK WHO WILL FURNISH INFORMATION ON CHANGED SUBSCRIBER NUMBERS OR NEW NUMBERS NOT LISTED IN THE DIRECTORY.

511 PROVIDES A CONNECTION WHEREBY A REPAIR MAN CAN CONNECT TO A TEST MAN AT A LOCAL TEST DESK WHEN REPAIRING TROUBLE ON THE LINE.

611 PROVIDES CONNECTION TO THE REPAIR CLERK AT THE REPAIR SERVICE DESK TO WHOM THE SUBSCRIBER MAY REPORT A TELEPHONE OUT OF ORDER OR MAKE ANY SERVICE COMPLAINTS.

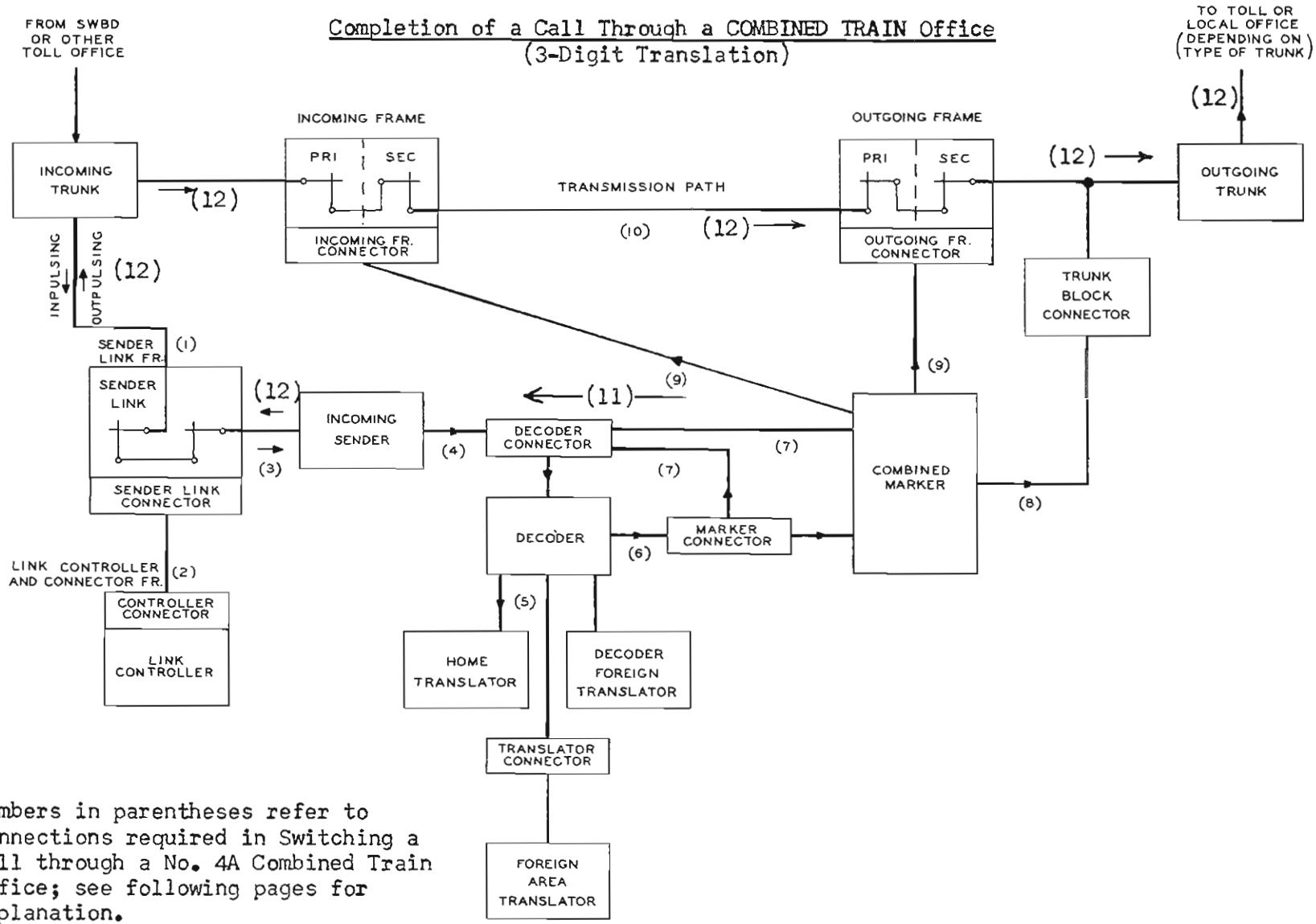
711 PROVIDES A CONNECTION WHEREBY A REPAIR MAN AT A SUBSCRIBER STATION CAN OBTAIN ACCESS TO DIAL AND RINGER TESTING EQUIPMENT.

811 PROVIDES A CONNECTION TO THE BUSINESS OFFICE PBX FOR SERVICE INFORMATION OR COMPLAINTS.

0 PROVIDES A CONNECTION TO THE DSA OPERATOR AT THE DIAL SYSTEM "A" SWITCHBOARD WHO WILL HANDLE SHORT HAUL (AB) TOLL CALLS, EMERGENCY CALLS TO DOCTORS, HOSPITALS, POLICE OR FIRE STATIONS, AND CALLS ON WHICH ASSISTANCE IS NECESSARY DUE TO A SUBSCRIBERS INABILITY TO DIAL.

NO. 4A TOLL SWITCHING SYSTEM

Completion of a Call Through a COMBINED TRAIN Office
(3-Digit Translation)



Note: Numbers in parentheses refer to connections required in Switching a Call through a No. 4A Combined Train Office; see following pages for explanation.

Equipment Arrangements for the No. 4A Toll Switching System

1) COMBINED TRAIN Office - A single Switching Train is provided for Small Offices, handling both Intertoll and Toll Completing Traffic:
   Maximum: 40 Incoming Link or Outgoing Link Frames
   10 Markers
   10 Decoders.

2) SEPARATE TRAIN-COMBINED OPERATION Office - Two Switching Trains are provided for Large Offices; each Train handling both Intertoll and Toll Completing Traffic:
   Maximum: 40 Incoming Link or Outgoing Link Frames per Train
   10 Markers per Train
   18 Common Decoders.

- - - - - -

Completion of a Call Through a COMBINED TRAIN Office No. 4A Toll Switching System (3-Digit Translation)

1) When the Incoming Trunk is seized by an Outward Operator, or a Distant Automatic Toll Office, it signals a Sender Link to connect an Idle Incoming Sender for Registering the Incoming Pulses ("Inpulsing").

2) The Sender Link Controller signals a Controller Connector to seize an Idle Link Controller.

3) The Link Controller tests for, and seizes, an Idle Incoming Sender, closing Crosspoints on the Sender Link Frame to connect the Incoming Sender to the Incoming Trunk.
   Then the Sender Link Controller and the Controller Connector release.

4) The Incoming Sender signals the Outward Operator, or the Outgoing Sender, in the Distant Office to begin Outpulsing.
   When the Incoming Sender has registered three (3) digits, it signals a Decoder Connector to seize an Idle Decoder.

5) The Decoder immediately connects to its Home Translator. The Foreign Area Translator is used on Calls requiring 6-Digit Translation - Area Code + Local Office Code.
   The Incoming Sender transmits the three digits through the Decoder to the Home Translator, causing a Punched Metal Card corresponding to the 3-Digit Area Code to be dropped.
   A light-sensitive photo-transistor system associated with the Metal Card coded by means of perforations, furnishes to the Decoder information on Trunk Selection, Alternate Routing, Code Conversion, Variable Spilling of Digits, etc.

6) The Decoder "reads" the Dropped Card and signals a Marker Connector to seize an Idle Marker.

7) Upon Marker seizure, the Marker Connector signals the Decoder Connector to connect the Incoming Sender to the Selected Marker.

The Incoming Trunk registers its Incoming Frame Appearance in the Marker via the Sender Link, Incoming Sender and Decoder Connector.

8) The Marker obtains the locations of the required Outgoing Trunks from the Decoder and the Dropped Card; see Connection "5)".

The Marker selects an Idle Outgoing Trunk through a Trunk Block Connector.

The Selected Trunk registers its Outgoing Frame Appearance in the Marker.

The Decoder and the Dropped Card inform the Marker:

a) The Type of Outpulsing required,
b) If digits should be outpulsed ("spilled forward") to the next office as received,
c) If digits should be deleted,
d) If digits should be substituted - Code Conversion, or
e) If digits should be prefixed.

Then the Marker signals the Decoder to release.

9) The Marker now sets up the Transmission (Talking) Path from the Incoming Trunk to the Selected Outgoing Trunk.

The Marker gains access to the Incoming Links through the Incoming Frame Connector, and to the Outgoing Links and Junctors through the Outgoing Frame Connector.

10) The Marker tests the: 1) Incoming Links,
2) Outgoing Links, and
3) Junctors, to find an Idle Channel.

Then the Marker closes through that Idle Channel from the Incoming Trunk to the Outgoing Trunk.

11) The Marker passes the Outpulsing information to the Sender, then releases.

12) The Sender Outpulses (Multifrequency (MF) or Dial Pulse (DP)) the digits through the Sender Link, over the Transmission Path, to the Outgoing Trunk, and through to the next office. Then the Incoming Sender and Sender Link release.

Calls outgoing to offices requiring Panel Call Indicator (PCI) Pulsing or Revertive Pulsing (RP) make use of:

a) An Incoming Sender to register the Called Number as "Inpulsed,"
b) And an Outgoing Sender to "Outpulse" the Called Number.

The Incoming Sender pulses into the Selected Outgoing Sender through the Incoming and Outgoing Frames, the Outgoing Trunk, and the Outgoing Sender Link.

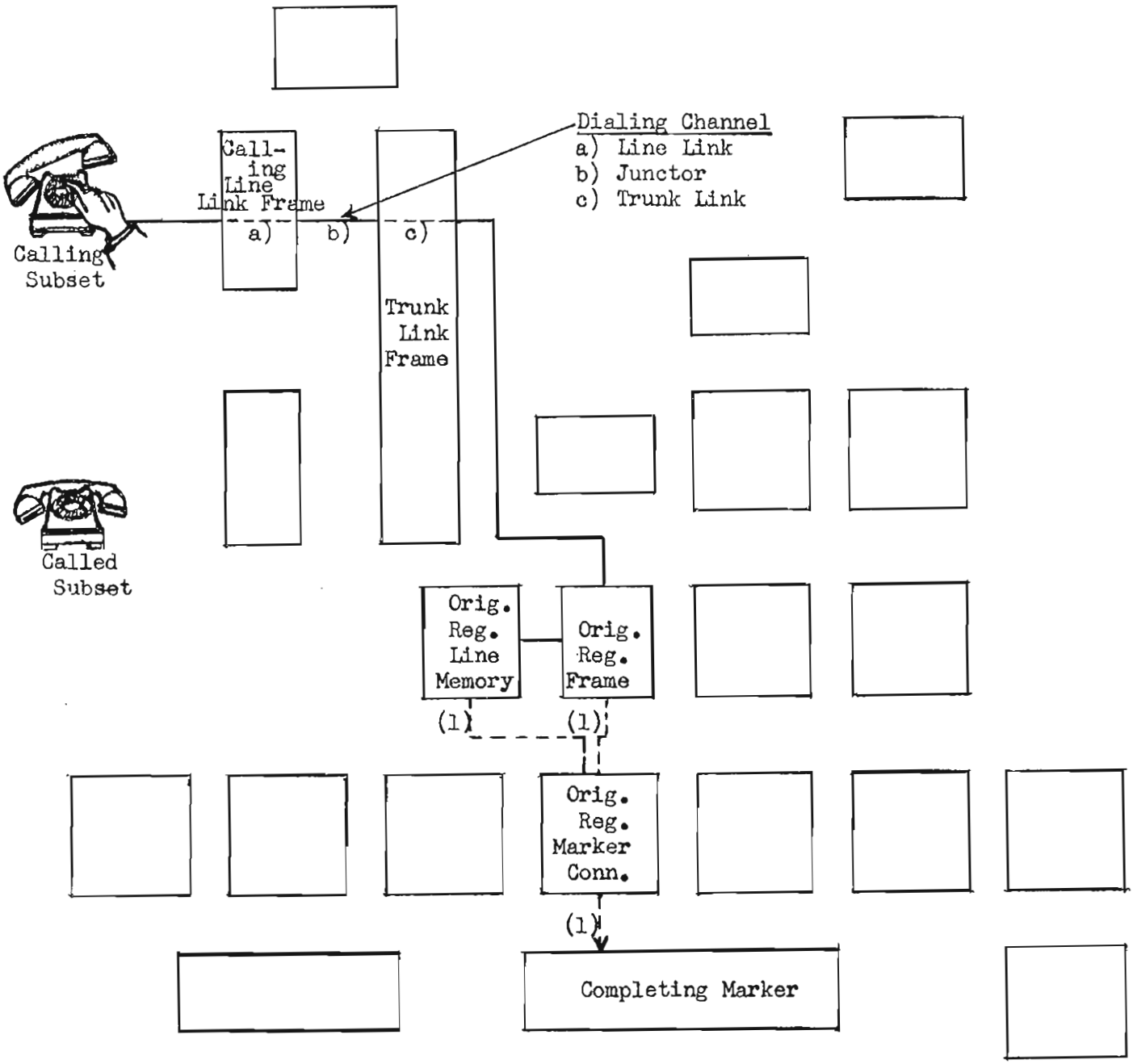
13) Crosspoints in the Transmission Path release when a Disconnect Signal is received.

NO. 5 CROSSBAR SYSTEM

THE INTRAOFFICE CALL

A Call between two Subscribers in the same Office, served by the same Marker Group, but not on the same Subscriber Line, is an Intraoffice Call. The following sketches show the frames involved and the functional steps required subsequent to the Dial Tone Job and registration of the dialed digits.

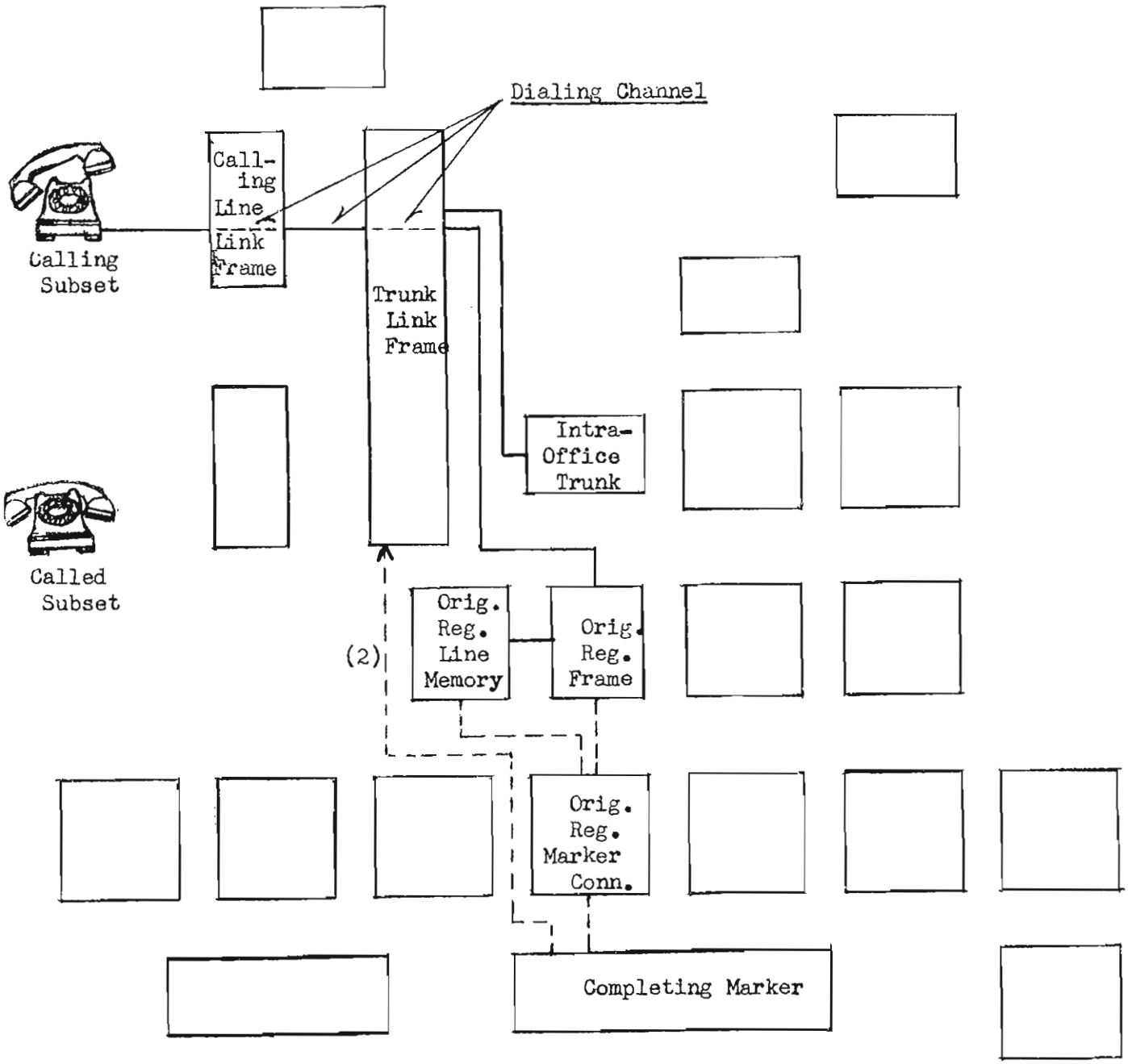
Note: Numbers in parentheses, "(1), (2), (3)," etc., indicate the connection made in that particular sketch.



SKETCH 1

The Originating Register Seizes an Idle Completing Marker

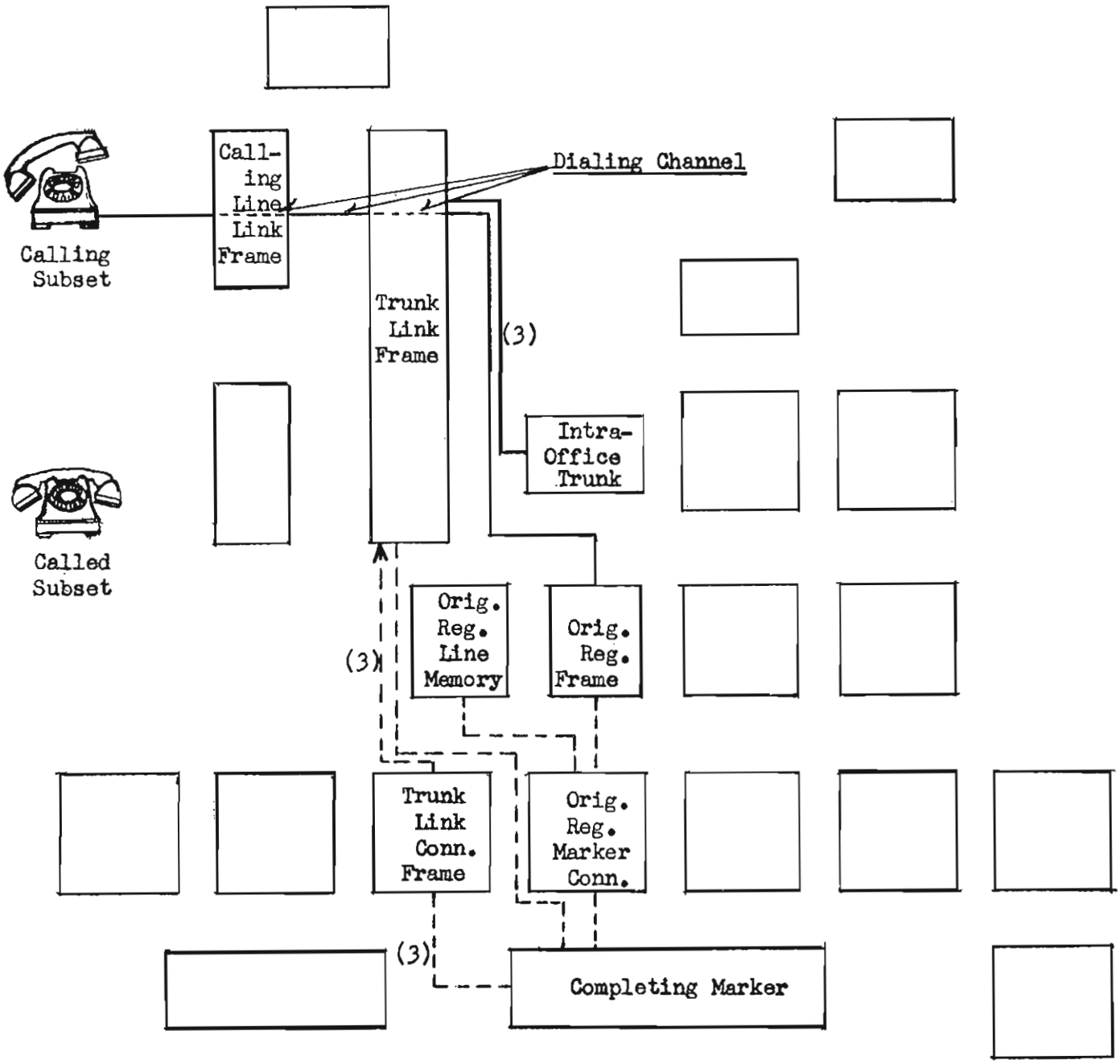
The Calling Subscriber receives Dial Tone from the Originating Register and proceeds to Dial the digits of the Called Telephone Number. The Originating Register stores the digits in the order dialed. Upon completion of Subscriber Dialing, the Originating Register and associated Originating Register Line Memory Frames connect to an idle Completing Marker through the Originating Register Marker Connector Frame. Calling Line location and Class of Service information, as well as the number of the Line Link used in the Dialing Channel, together with the Called Telephone Number are transferred to the Completing Marker.



SKETCH 2

The Completing Marker Checks all Idle Trunk Link Frames for Idle Intraoffice Trunks

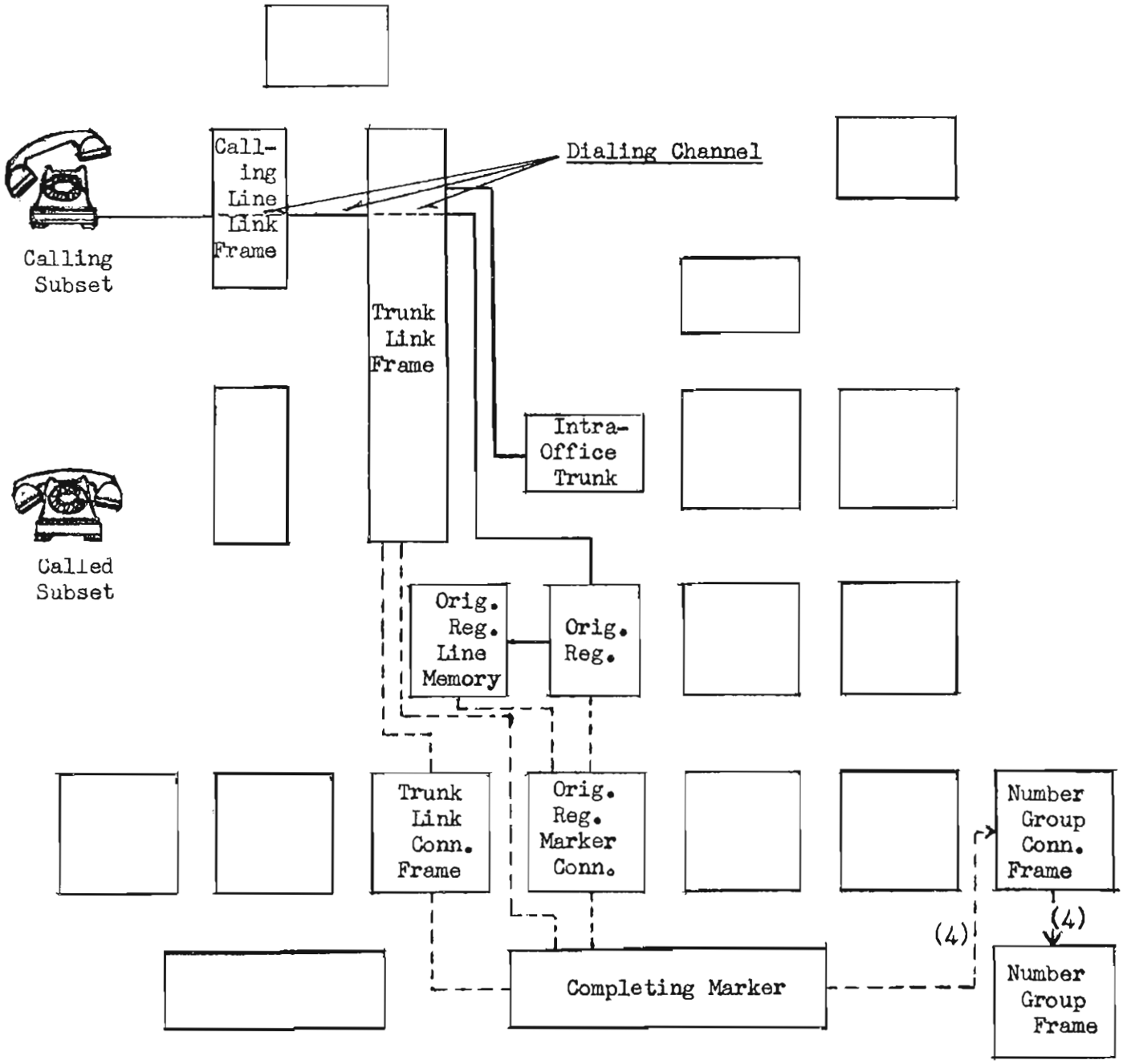
The Completing Marker, recognizing the Dialed Office Code as being associated with its own group of Line Link Frames, checks all Idle Trunk Link Frames for Idle Intraoffice Trunks. An Idle Trunk Link Frame with Idle Intraoffice Trunks is selected.



SKETCH 3

The Completing Marker Seizes the Trunk Link Frame and an Idle Intraoffice Trunk

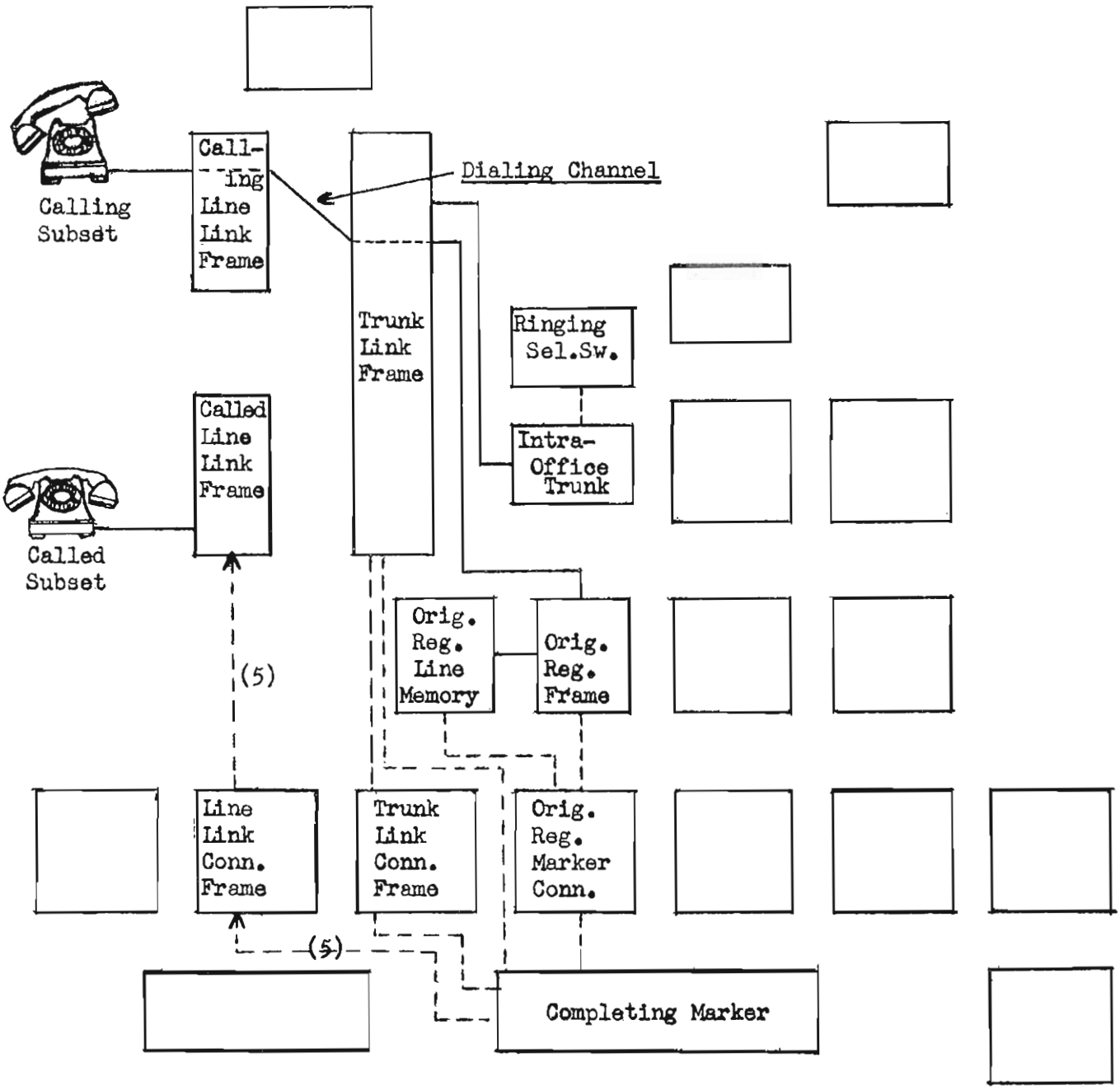
The Completing Marker seizes the selected Trunk Link Frame and connects to it through the Trunk Link Connector Frame. The Completing Marker then selects an Idle Intraoffice Trunk.



SKETCH 4

The Completing Marker Seizes the Called Line Number Group Frame

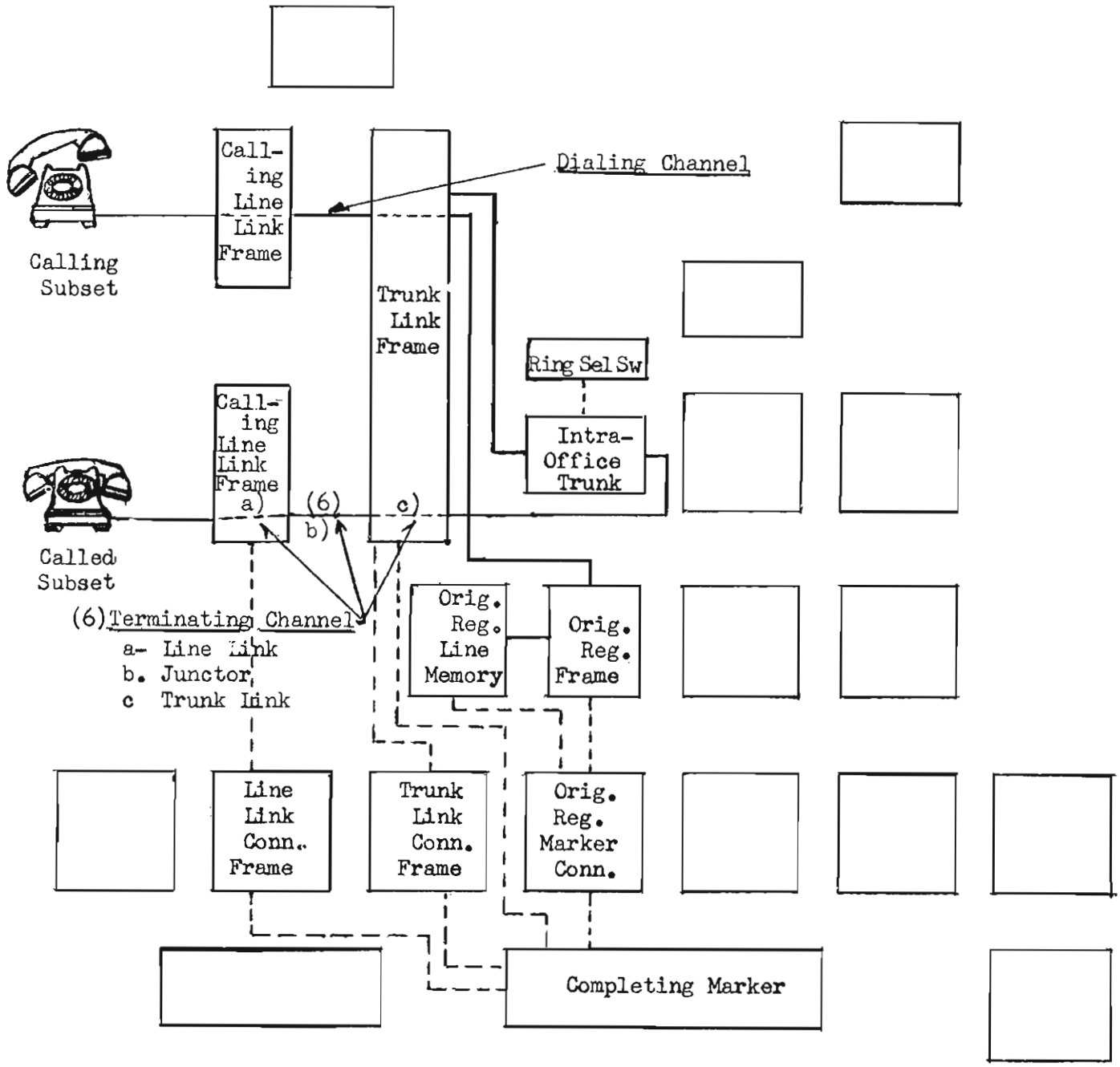
While selecting an Idle Intraoffice Trunk, the Completing Marker, through the Number Group Connector Frame, seizes the Number Group Frame upon which the Called Line Location information appears. The Number Group Frame furnishes the following information to the Completing Marker: 1) The Line Link Frame number, 2) Called Subscriber Line Location on that Frame, and 3) the Ringing Current to be applied. The Completing Marker releases the Number Group and Number Group Connector Frame.



SKETCH 5

The Completing Marker Seizes the Called Line Link Frame

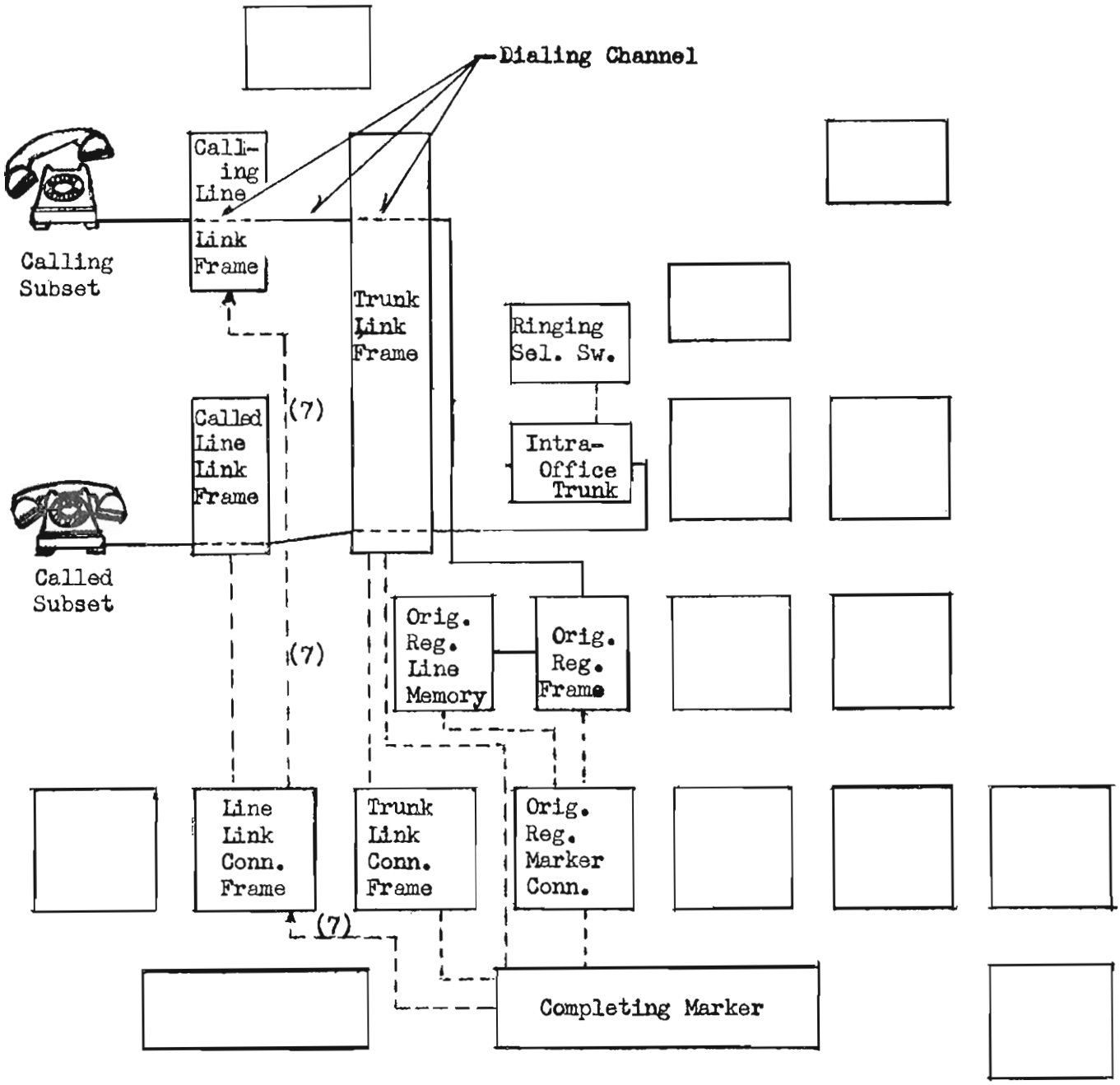
The Completing Marker seizes the Line Link Frame on which the Called Subscriber Line appears, through the Line Link Connector Frame.



SKETCH 6

The Completing Marker Closes Through a Terminating Channel

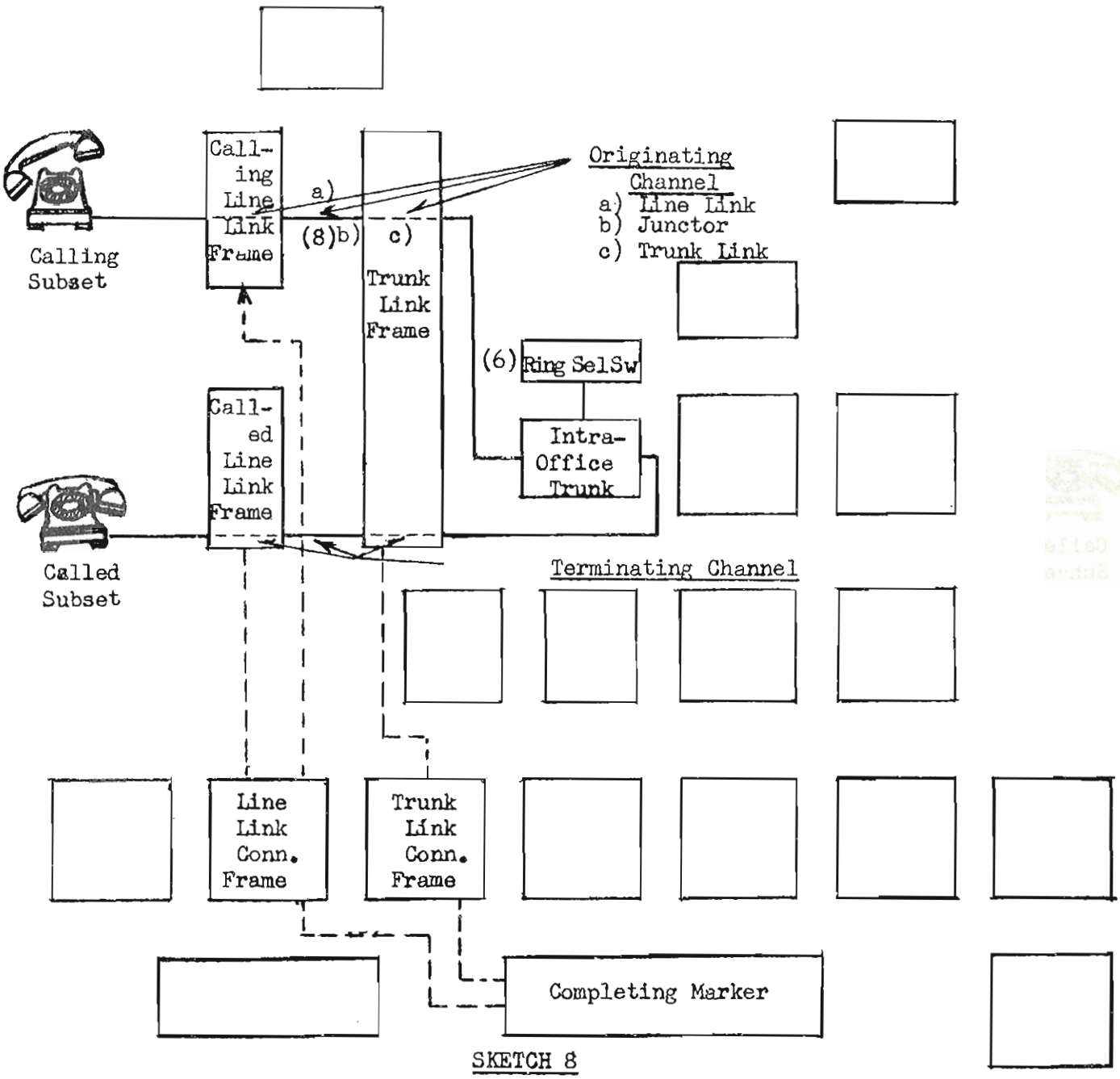
Following seizure of the Called Line Link Frame in Sketch 5, the Completing Marker checks the Called Subscriber Line for a busy condition. If the Called Subscriber Line is Idle, the Completing Marker proceeds to select and close through an Idle Channel from the Intraoffice Trunk to the Called Subscriber Line. At the same time, the Completing Marker connects the Intraoffice Trunk to the Ringing Selection Switch through the Trunk Link Connector Frame. If the Called Subscriber Line checks busy, the Completing Marker releases the Intraoffice Trunk and selects an Idle Tone Trunk, which it links to the Calling Subscriber Line to furnish Busy Tone.



SKETCH 7

The Completing Marker Seizes the Calling Line Link Frame

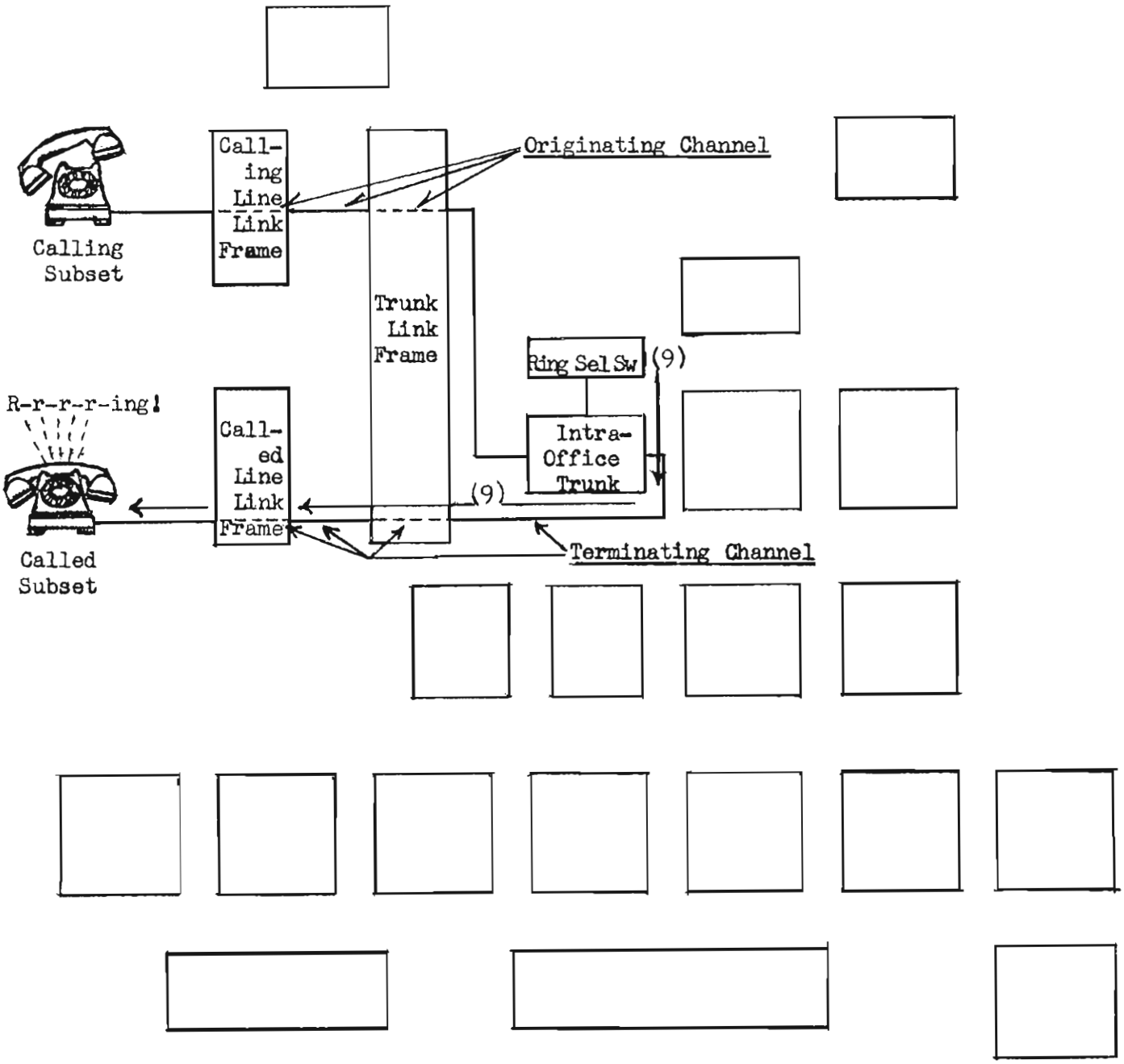
The Completing Marker, having established a Channel from the Intraoffice Trunk to the Called Subscriber Line, now seizes the Calling Line Link Frame through the Line Link Connector Frame and prepares to close through a Channel from the Calling Subscriber Line to the Intraoffice Trunk.



SKETCH 8

The Completing Marker Closes Through an Originating Channel

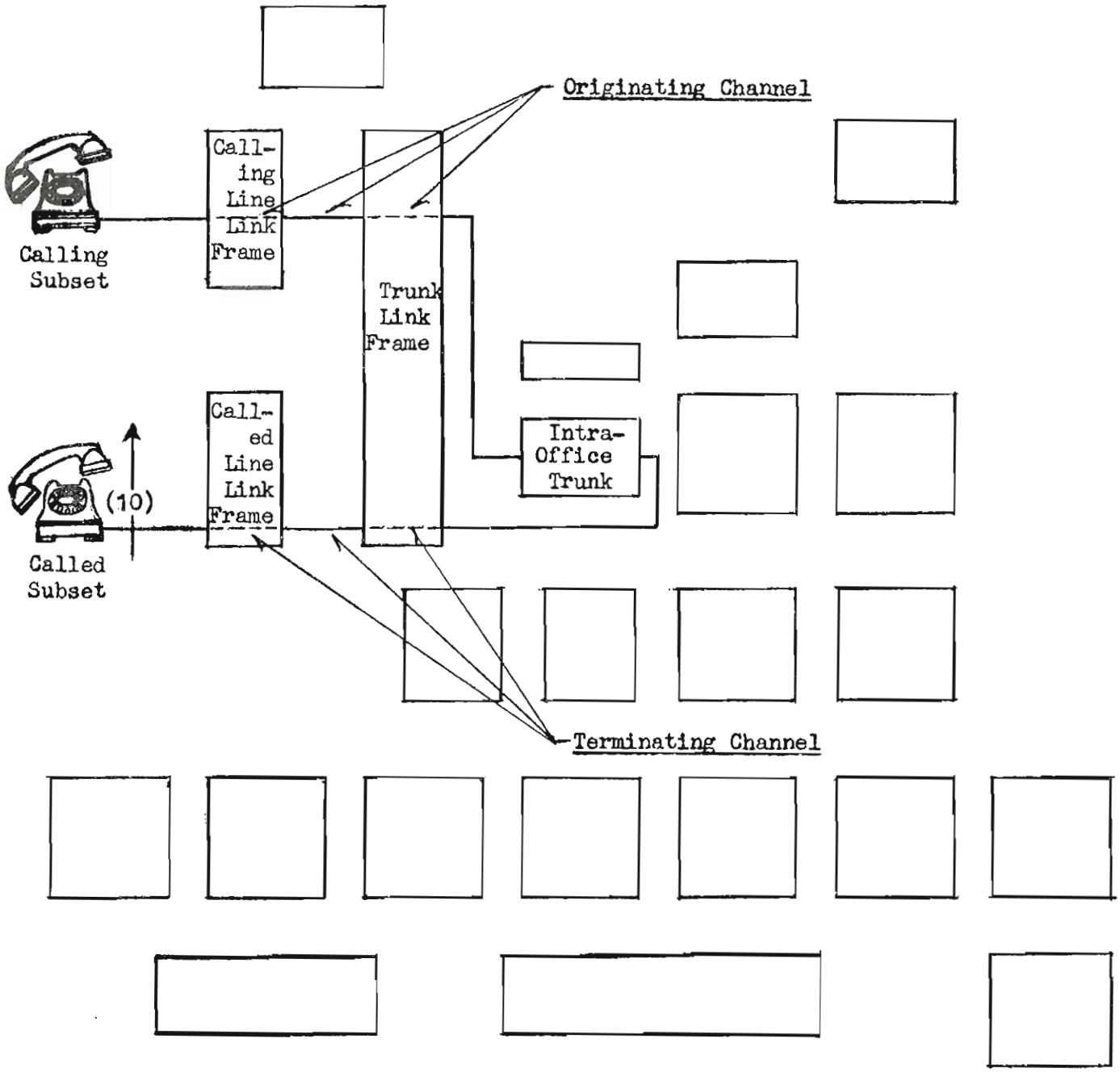
Following seizure of the Calling Line Link Frame through the Line Link Connector Frame, the Completing Marker tests and selects an Originating Channel (Line Link, Junctor and Trunk Link) from the Calling Subscriber Line to the Intraoffice Trunk. The Dialing Channel, Originating Register and Originating Register Line Memory Frames release, and the Completing Marker closes through the Originating Channel. Then the Completing Marker and associated Connectors release.



SKETCH 9

Ringing Current is Applied to the Called Subscriber Line

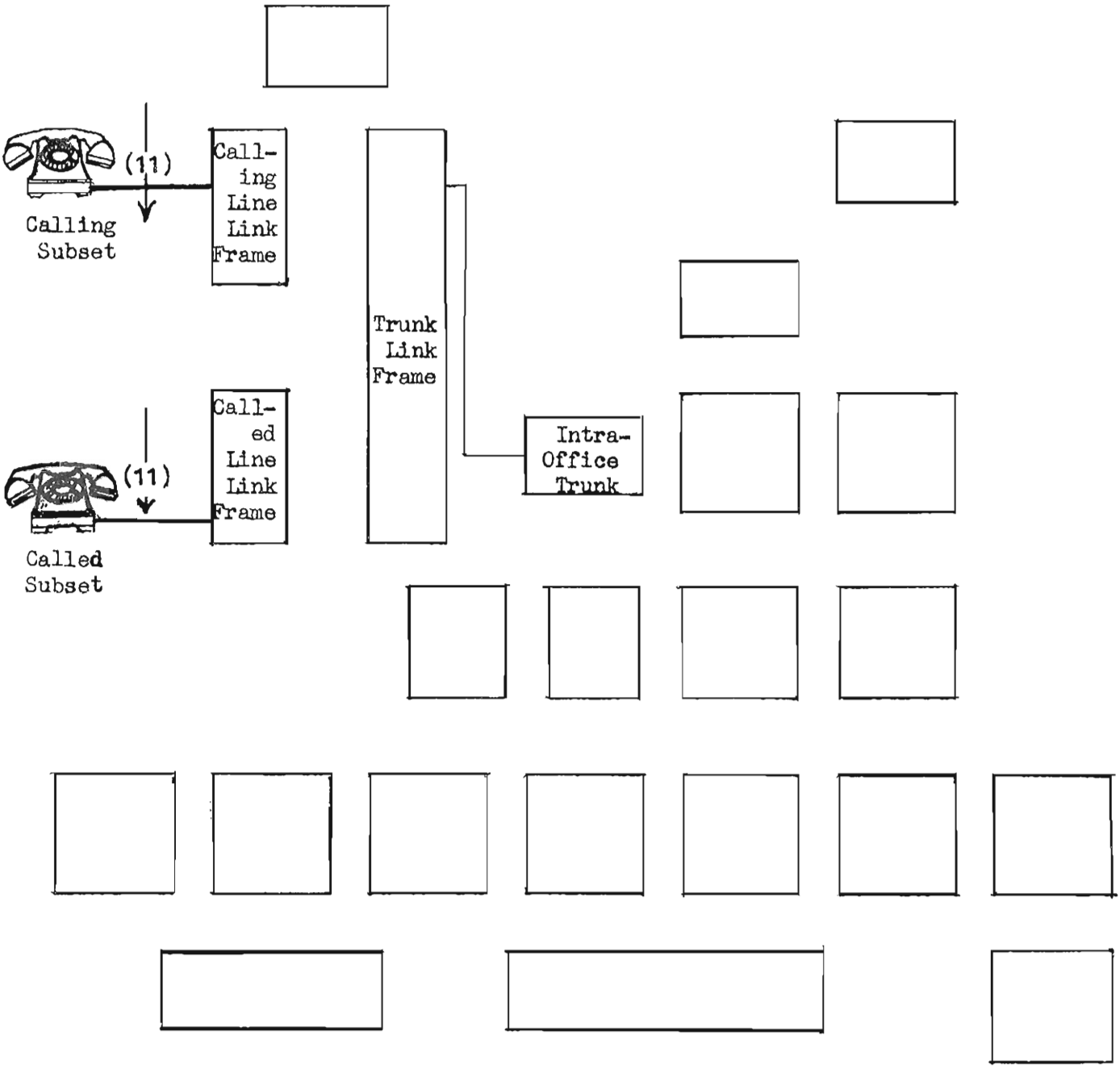
Ringing Current is applied to the Called Subscriber Line through the Intraoffice Trunk, over the Terminating Channel, from the Ringing Selection Switch.



SKETCH 10

The Called Subscriber Answers

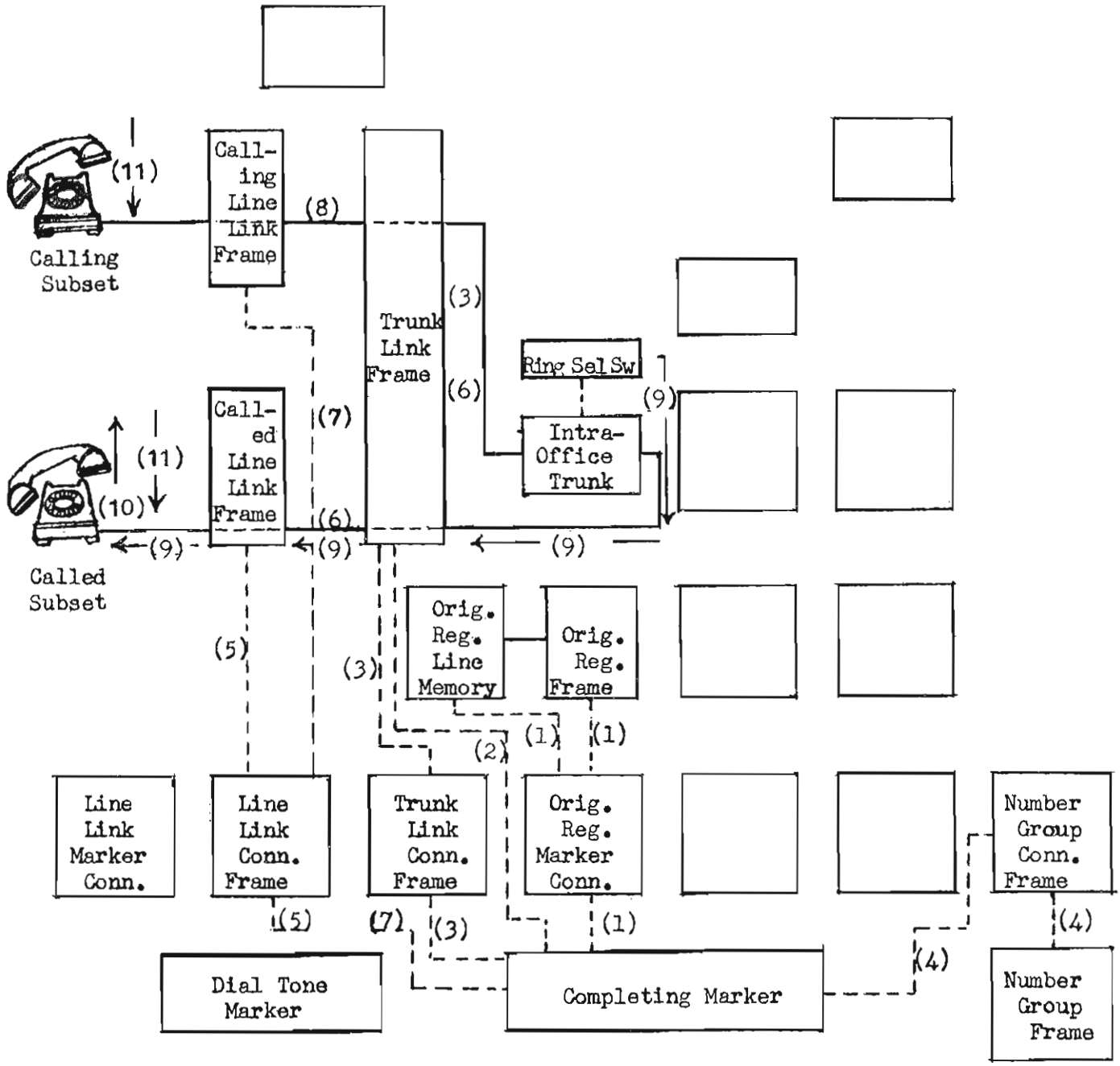
Ringing Current is tripped (cut off) by removal of the Called Subscriber Handset, and the connection from the Intraoffice Trunk to the Ringing Selection Switch released. Talking Battery and Ground are furnished to the Calling and Called Subsets by the Intraoffice Trunk.



SKETCH 11

The Calling and Called Subscribers Replace Their Handsets

The release of all Channel Crosspoints results when the Talking Battery Path to the Calling and Called Subsets is broken by replacement of the Handsets.



SKETCH 12

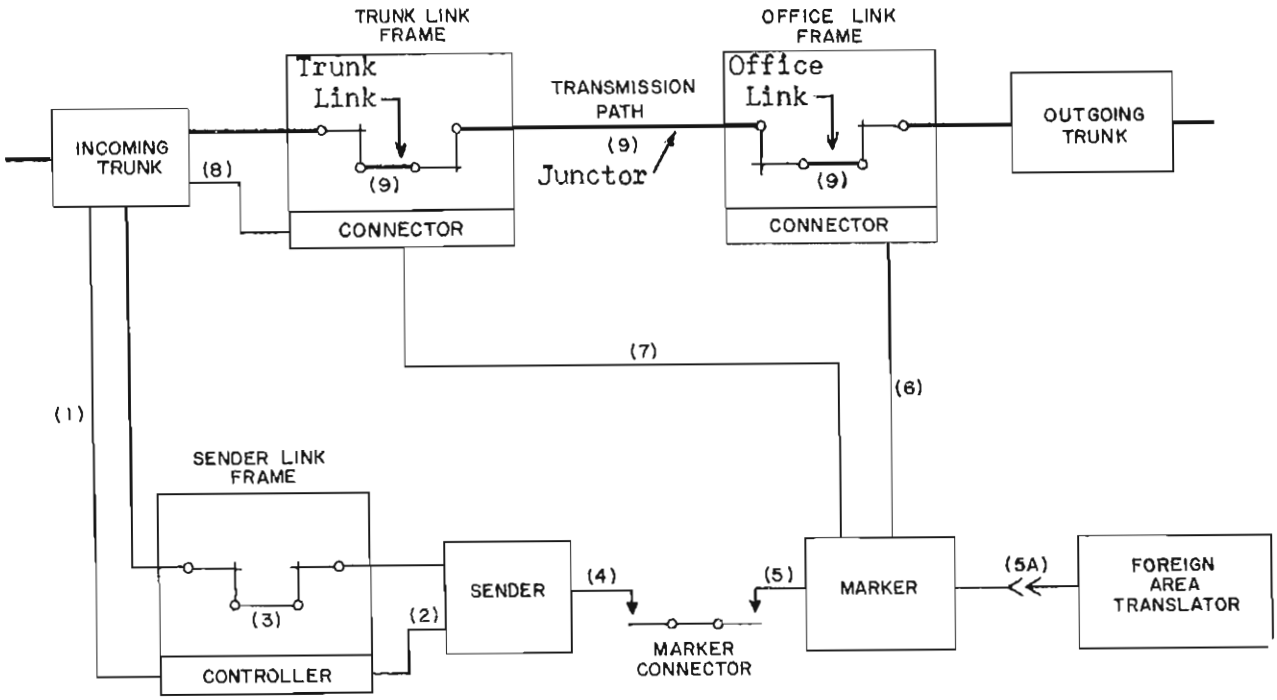
Frames Involved in Completing a Call Between Two Subscribers In the Same No. 5 Crossbar Dial Central Office

The Talking Path is shown in heavy black lines.
Broken Lines indicate temporary connections required between various frames in setting up the Call.

CROSSBAR TANDEM

Completion of a Call Requiring 3-Digit Translation

The Crossbar Tandem Switching System handles traffic between Local Dial Offices in the same Metropolitan Area, as well as Intertoll Traffic.



1) When the Incoming Trunk is seized at the Originating End, it signals a Sender Link Controller to select an Idle Sender for registering the Incoming Pulses ("Inpulsing").

2) The Sender Link Controller tests for and selects an Idle Sender.

3) The Sender Link Controller operates Crossbar Switches on the Sender Link Frame to connect the Sender to the Incoming Trunk.
   Then the Sender Link Controller releases.
   The Number of the Trunk Link Frame on which the Incoming Trunk appears is stored in the Sender.

4) The Sender signals the Originating Operator or Sender in the preceding office to start Outpulsing.
   When three digits have been registered, the Sender signals the Marker Connector to select an Idle Marker.

5) The Marker Connector seizes an Idle Marker.
   The Sender "spills" the first three digits into the Marker, along with the Number of the Trunk Link Frame on which the Incoming Trunk appears - "3)."
   The Marker:
   a) Decodes the information received from the Sender.
   b) Operates a Route Relay from which it determines routing information for the Call.
   c) Passes Outpulsing instructions to the Sender.

5A) 6-Digit Translation permits two or more Routes from the Switching Center to or towards the Foreign Area.

When the first three digits are XOX/X1X, the Sender waits for six digits before seizing a Marker.

The Marker decodes the first three digits (Area Code) and operates an Area Relay.

Operation of the Area Relay causes seizure of a Foreign Area Translator.

Digits 4, 5 and 6 are transmitted to the Foreign Area Translator.

The Foreign Area Translator passes one of 60 Route Indications to the Marker, then releases.

The Marker handles the Call as in the case of 3-Digit Translation.

6) The Marker seizes the Office Link Connector serving the Office Link Frame on which the Outgoing Trunks appear, and tests for an Idle Outgoing Trunk.

The Marker signals the Sender to release the Marker Connector.

The Marker Connector releases the Marker.

7) The Marker seizes the Trunk Link Connector serving the Trunk Link Frame on which the Incoming Trunk appears.

8) The Marker directs the Incoming Trunk, through the Sender, to connect to the Trunk Link Connector.

The Trunk Link Connector cuts through to the Marker test leads for the Trunk Links serving the Switch on which the Incoming Trunk appears.

The Marker maintains a path to the Sender through the Trunk Link Connector, the Incoming Trunk and the Sender Link.

The Marker informs the Trunk Link Frame to cut through the test leads for the Junctors to the Office Link Frame on which the Outgoing Trunk appears.

9) The Marker tests for and closes through an Idle Channel (Trunk Link, Junctor and Office Link) from the Incoming Trunk to the Outgoing Trunk.

The Marker informs the Sender the Channel has been closed through, then the Marker releases.

10) Upon receipt of a "Go" Signal from the next office, the Sender Outpulses.

After completion of Outpulsing, the Talking Path is cut through.

The Sender passes supervision of the Call to the Incoming Trunk.

Then the Sender and Sender Link Frames release.

11) When a Disconnect Signal is received from the Calling End, all Crosspoints on the Trunk Link and Office Link Frames release, restoring the Equipment to normal.

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Some Features of DDD (Direct Distance Dialing).

1) Numbering Plan Areas and Codes
2) Switching Plan for DDD
3) Switching Features:
   a) Alternate Routing
   b) Storing and Spilling Forward Digits as Required
   c) Code Conversion
   d) Prefixing
   e) 6-Digit Translation

1) NUMBERING PLAN AREAS AND CODES

312-WH3-2700

To make possible DDD, each Telephone has a Distinctive Directory Number - 10 or 11 Digits:

312-WH3-2700

1) AREA CODE - 3 Digits - XOX and X1X
2) CENTRAL OFFICE CODE - 3 Digits - ABX
3) NUMERICALS - 4 Digits - 5th Digit - W,J,R, or M, Party Letter

To reach the above Telephone from any point within Area 312, Dial WH3-2700.
To reach the above Telephone from any point outside Area 312, Dial 312-WH3-2700.

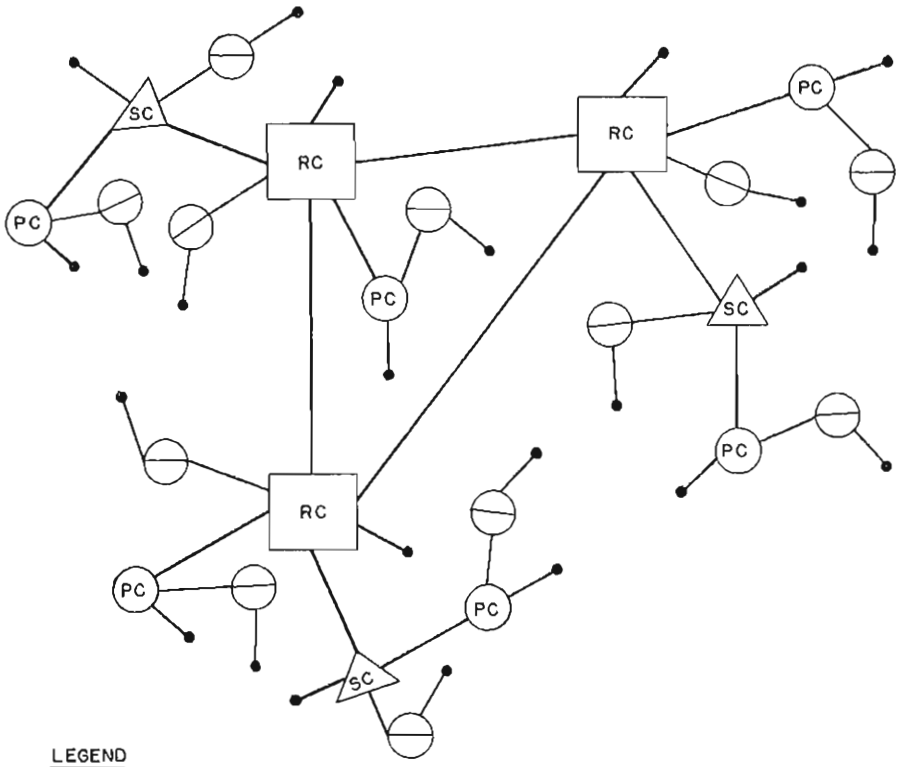
2) SWITCHING PLAN FOR DDD

The Switching Plan employs Alternate Routing of Toll Calls, using Intertoll Trunks at very high efficiency, and minimizing delay of a Call due to ATB (All Trunks Busy).

CSP's - Control Switching Points - More Important Toll Offices:

A) Distribute Traffic over High Usage and Final Trunk Groups.

B) Types of CSP's:
   1) RC - Regional Center - Class 1 Office
   2) SC - Sectional Center - Class 2 Office
   3) PC - Primary Center - Class 3 Office



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

C) CSP Switching Systems:
   1) No. 4A or *4M Toll Crossbar
   2) Crossbar Tandem
   3) No. 5 Crossbar
   4) Step by Step Dial.

   *4M - No. 4 Toll Crossbar converted to have full CSP features of 4A.

D) Each TC (Toll Center) has a Final Group to a particular HOME CSP - a PC, SC or RC.

E) Each PC "HOMES" on an SC or RC

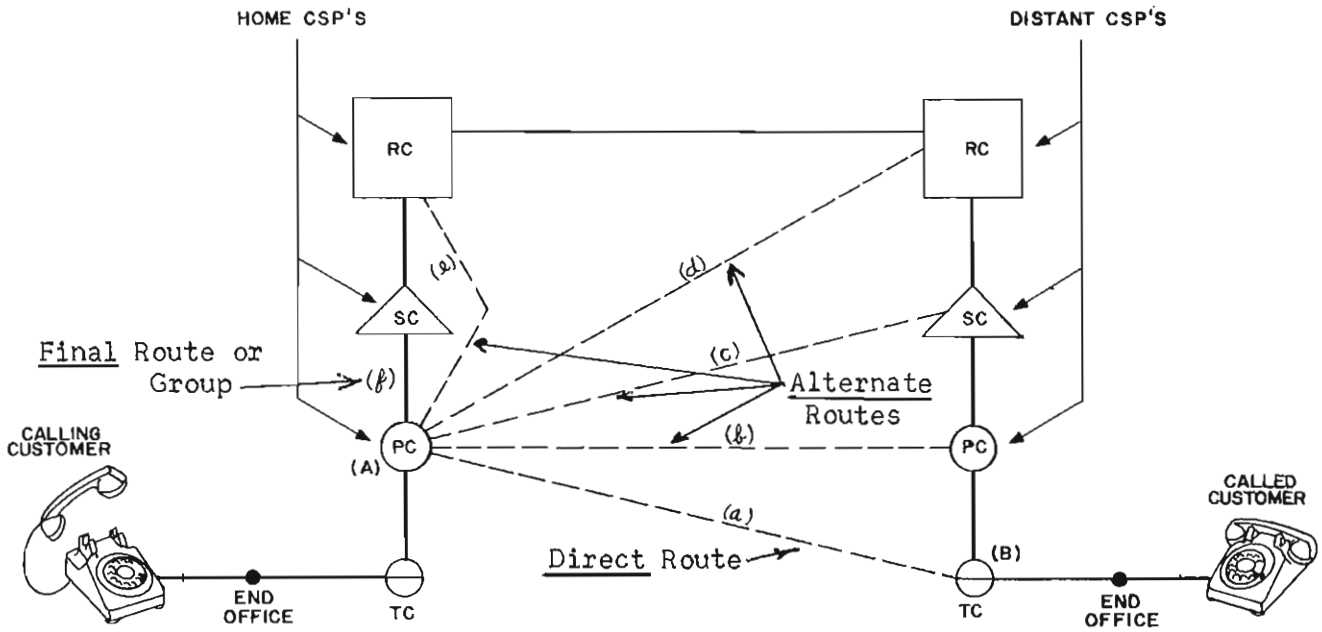
F) Each SC "HOMES" on an RC

G) All RC's interconnected with Final Trunk Groups - Backbone Network between any two (2) TC's.

H) High Usage Trunk Groups provided between any two Offices where Traffic warrants, regardless of Class - TC, PC, SC or RC.

Intertoll Trunk Groups - High Usage Groups handle only part of the Busy Hour Traffic, with the excess Calls overflowing to successive Trunk Groups.

A) Direct Route - First Choice.
B) Alternate Routes - Second, Third, etc., Choice.
   1) No. 4A - Max. 6 Alternate Routes.
   2) Crossbar Tandem - Max. 3 Alternate Routes.
C) Final Trunk Groups - Last Choice - Backbone Routes.
D) A Call is routed (advanced), in a predetermined order, from one CSP to the next in the chain, in search of an Idle Trunk.



Possible ROUTES from PC (A) to Reach TC (B)

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Six (6) Possible Routes from PC (A) to Reach TC (B) - See Diagram Above.

Five (5) High Usage Trunk Groups, tested in order "from far to near."

(a) Direct Route - PC (A) to TC (B).
(b) First Alternate Route - PC (A) to Distant PC)
(c) Second Alternate Route - PC (A) to Distant SC) - (If no Idle Trunk, Call switched over (f) Final Trunk Group to Home SC.
(d) Third Alternate Route - PC (A) to Distant RC)
(e) Fourth Alternate Route - PC (A) to Home RC)

One (1) Final Trunk Group:

(f) PC (A) to Home SC.

- - - - - -

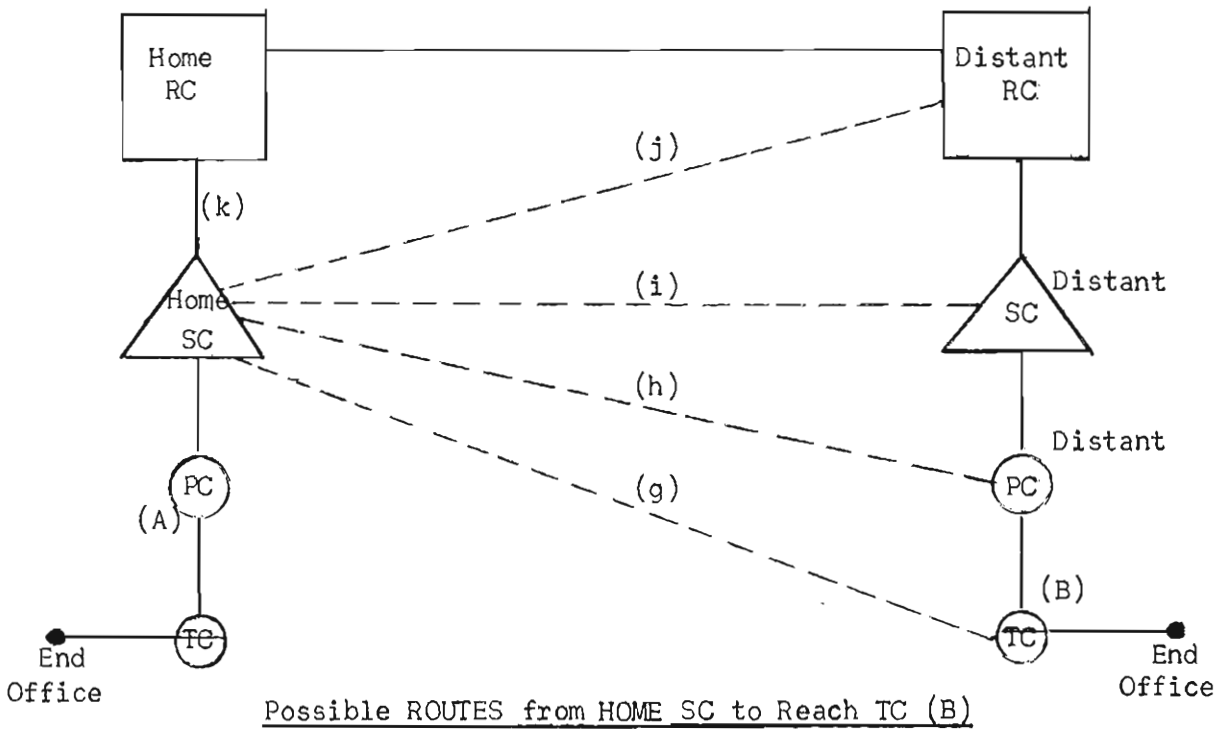
Five (5) Possible Routes from Home SC to Reach TC (B) - See Diagram next page:

Four (4) High Usage Trunk Groups, tested in order "from far to near."

(g) Home SC to TC (B)
(h) Home SC to Distant PC)
(i) Home SC to Distant SC) - If no Idle Trunk, Call switched over (k) Final Trunk Group to Home RC.
(j) Home SC to Distant RC)

One (1) Final Trunk Group:

(k) Home SC to Home RC.



Possible ROUTES from HOME SC to Reach TC (B)

- - - - - -

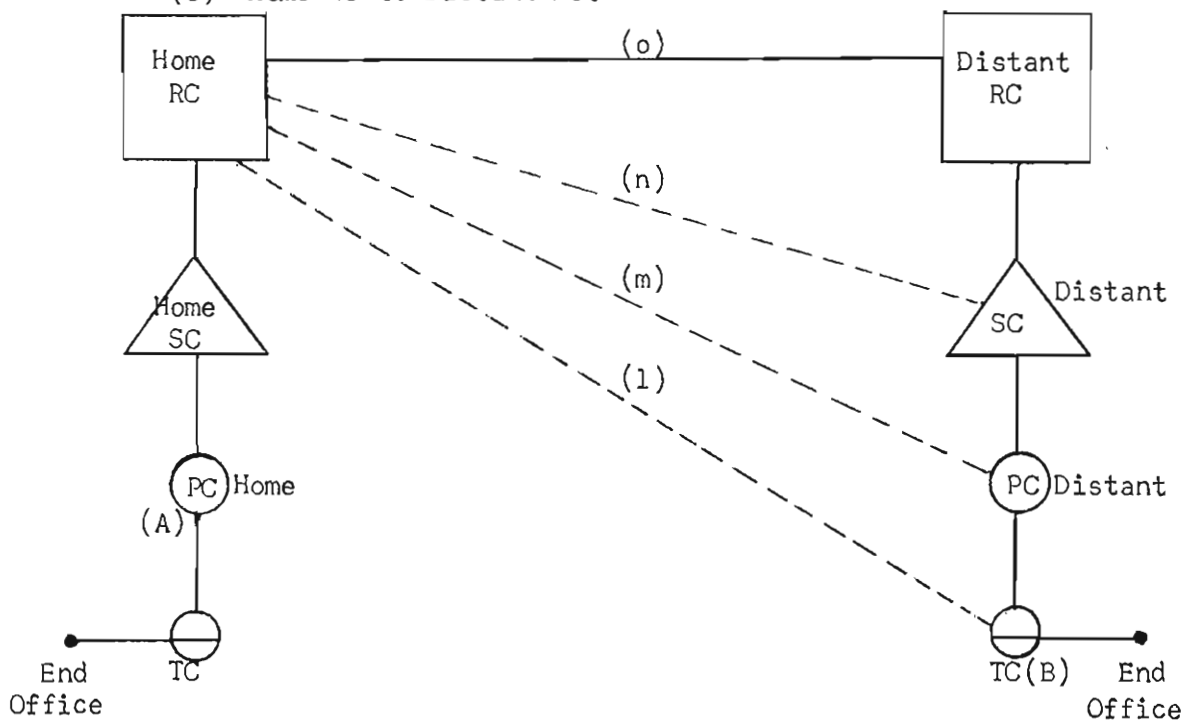
Four (4) Possible Routes from Home RC to Reach TC (B) - See Diagram Below:

Three (3) High Usage Trunk Groups, tested in order "from far to near."

(l) Home RC to TC (B)
(m) Home RC to Distant PC) - If no Idle Trunk, Call switched over (o)
(n) Home RC to Distant SC) Final Trunk Group to Distant RC.

One (1) Final Trunk Group:

(o) Home RC to Distant RC.



Possible ROUTES from HOME RC to Reach TC (B)

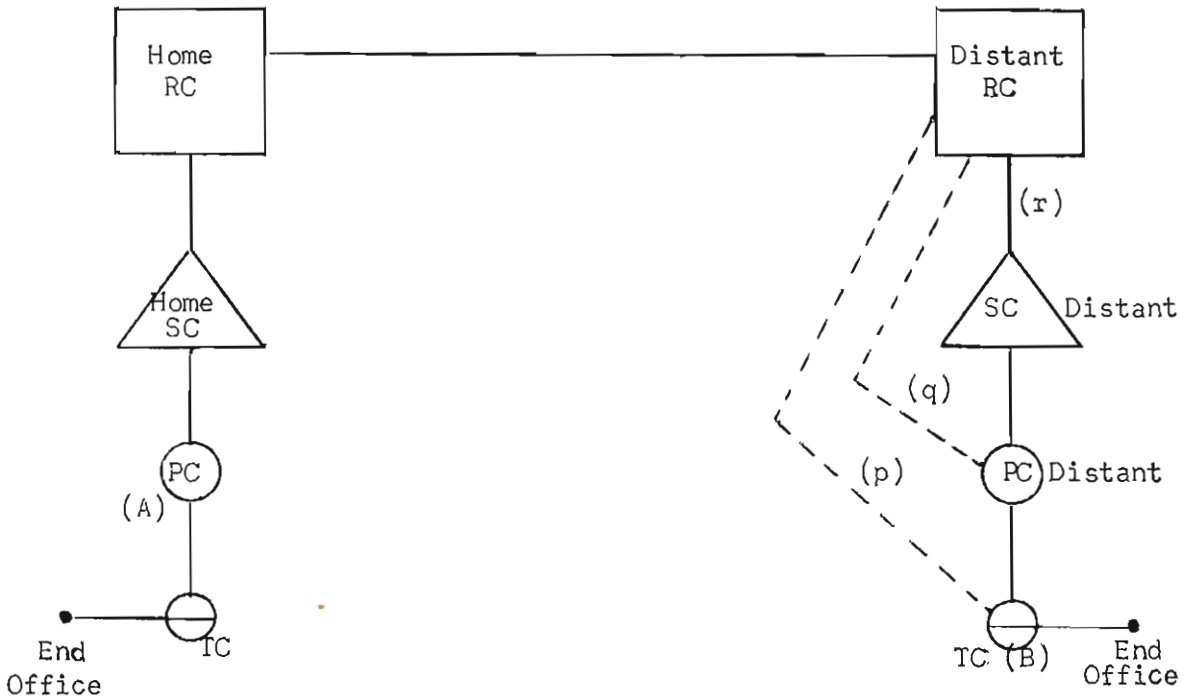
Three (3) Possible Routes from Distant RC to Reach TC (B) - See Diagram Below:

Two (2) High Usage Trunk Groups, tested in order "from far to near."

(p) Distant RC to TC (B)
(q) Distant RC to Distant PC) - If no Idle Trunk, Call switched over (r) Final Trunk Group to Distant SC.

One (1) Final Trunk Group:

(r) Distant RC to Distant SC.



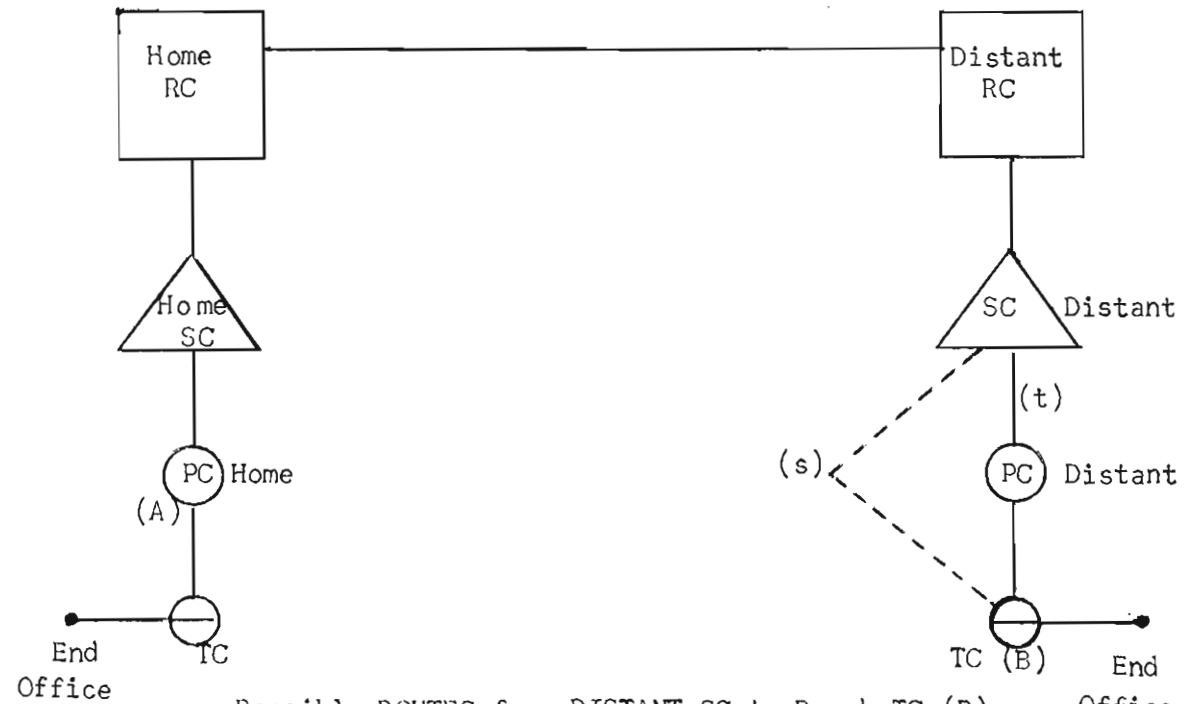
Possible ROUTES from DISTANT RC to Reach TC (B)

- - - - - -

Two (2) Possible Routes from Distant SC to Reach TC (B) - See Diagram Below:

(s) High Usage Trunk Group - If no Idle Trunk Call switched over (t) Final Trunk Group to Distant PC.

(t) Final Trunk Group - Distant SC to Distant PC.

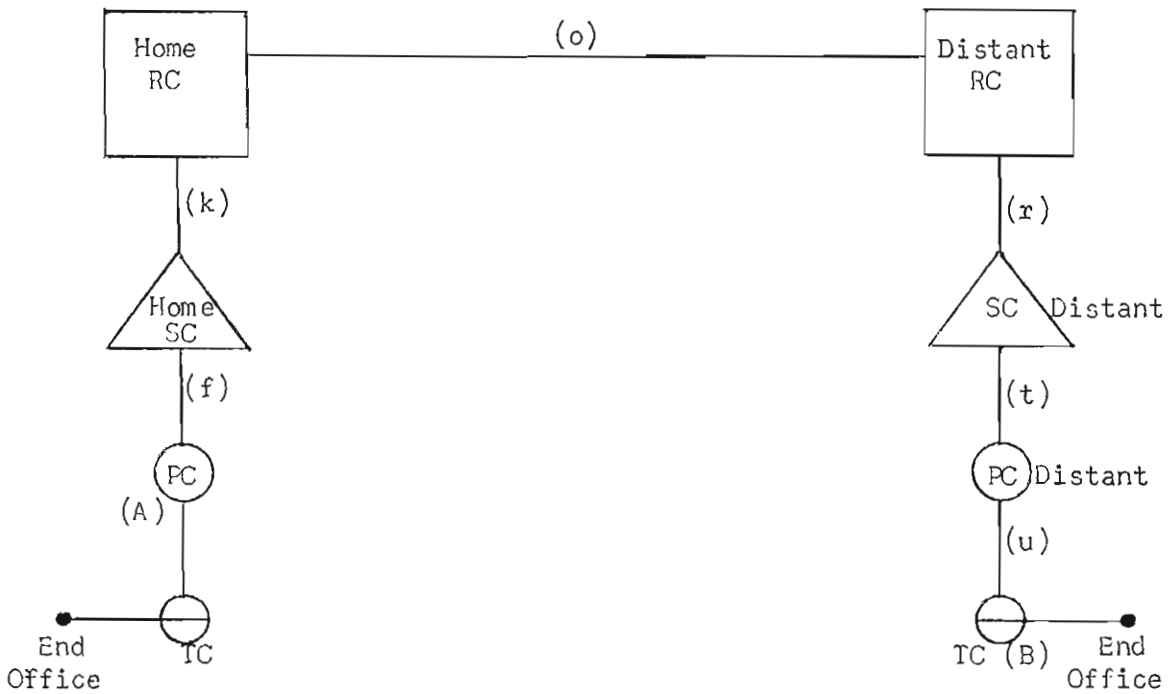


Possible ROUTES from DISTANT SC to Reach TC (B)

Backbone Routes - Call Routed entirely over Final Trunk Groups (Very Unlikely) - See Diagram Below:

(f) PC (A) to Home SC
(k) Home SC to Home RC
(o) Home RC to Distant RC
(r) Distant RC to Distant SC
(t) Distant SC to Distant PC
(u) Distant PC to TC (B)

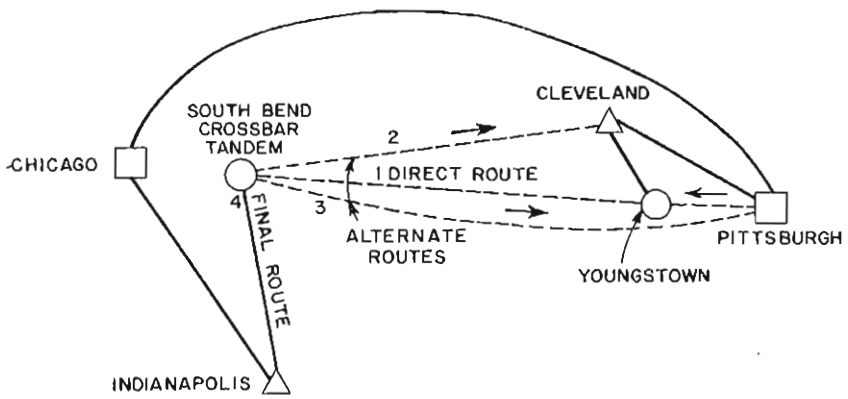
Note: Checking available Routes requires about one second at each Office.



BACKBONE ROUTES - PC (A) to TC (B)

- - - - - -

3a) ALTERNATE ROUTING

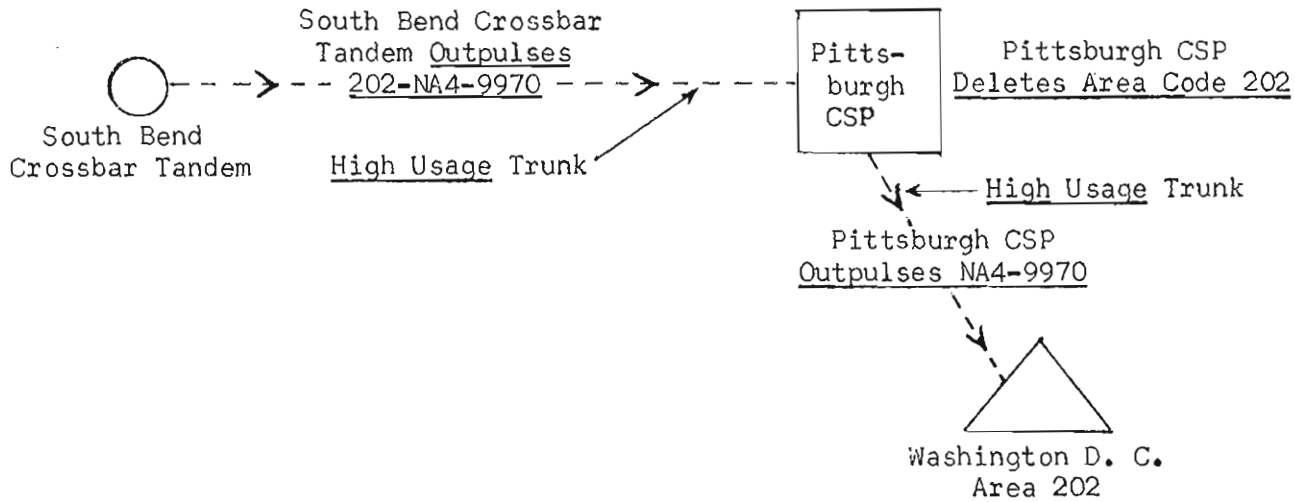


Possible ALTERNATE ROUTING - South Bend to Youngstown

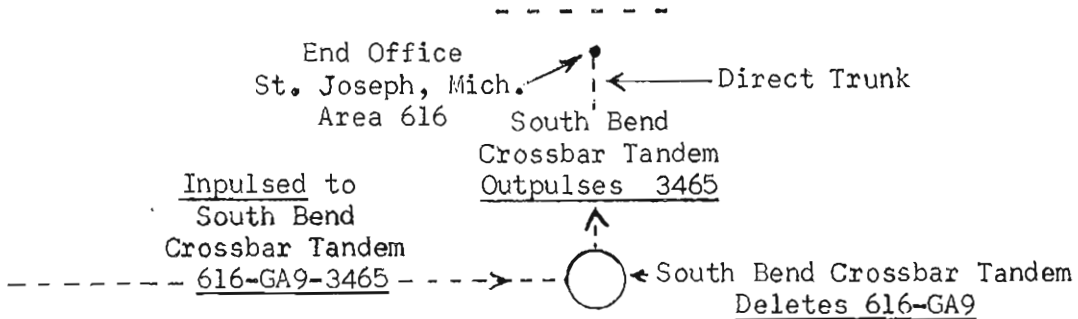
1st Choice - Direct Route - South Bend to Youngstown.
2nd Choice - First Alternate Route - South Bend via Cleveland to Youngstown.
3rd Choice - Second Alternate Route - South Bend via Pittsburgh to Youngstown.
4th Choice - Final Route - South Bend via Indianapolis, Chicago, Pittsburgh and Cleveland to Youngstown - Backbone Route.

3b) STORING and "SPILLING FORWARD" (Outpulsing) Required Digits

CSP Switching Equipment: 1) Stores all Digits received.
2) "Spills Forward" (Outpulses) only those Digits required to complete the Call.

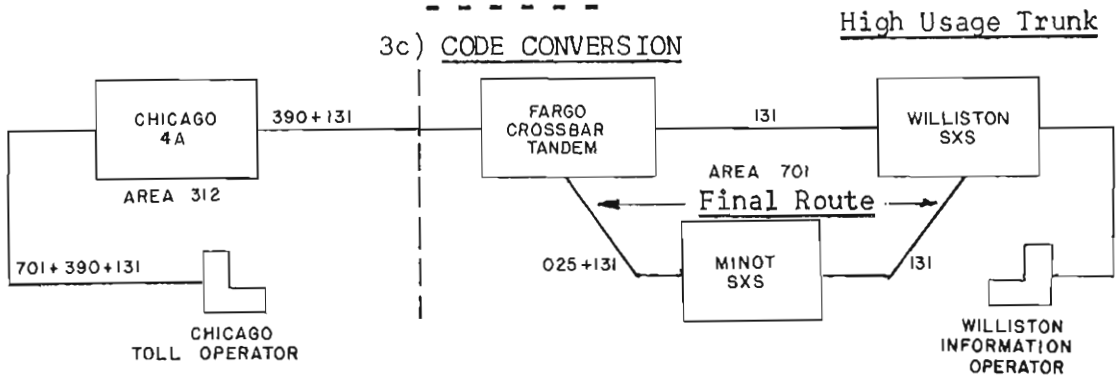


DELETION OF 3-DIGITS - South Bend to Washington, D. C. Call



DELETION OF 6-DIGITS

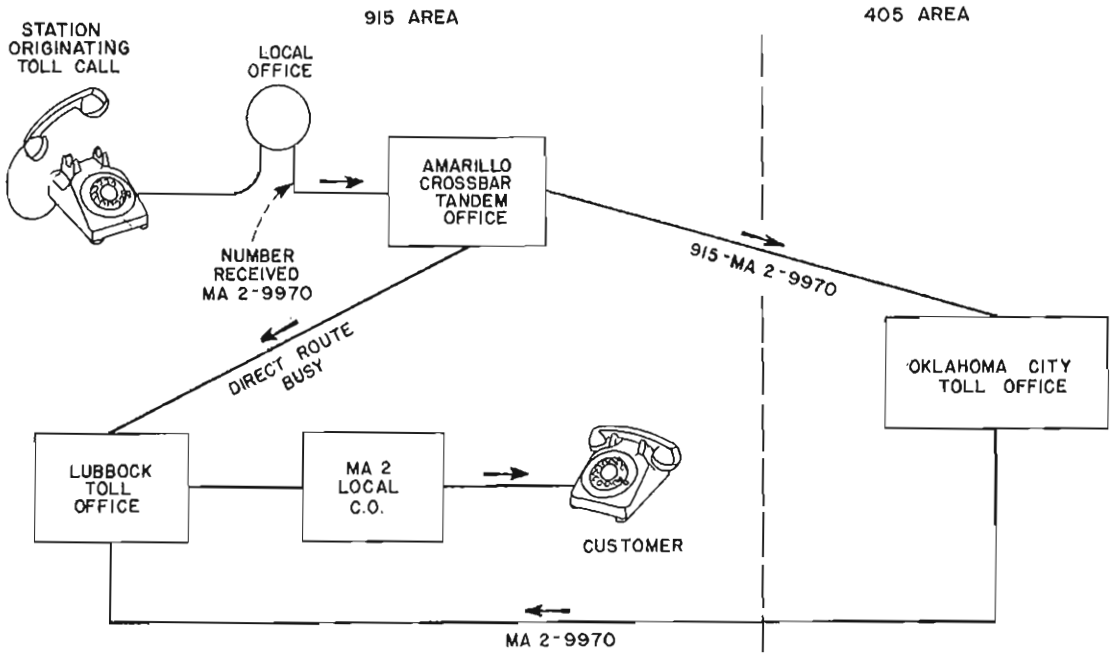
3c) CODE CONVERSION



Chicago Toll Operator Keys "701-390-131" into No. 4A Toll to reach Williston, N.D., Toll Information Operator.
Chicago 4A Toll seizes a Direct Trunk to Fargo, N.D., and Outpulses "390-131," Deleting the Area Code "701."
Fargo Crossbar Tandem checks All Trunks Busy in the High Usage Group to Williston.
Fargo Crossbar Tandem CONVERTS "390" to "025" to operate Step by Step Switches in the Minot Office, routing the Call via the Final Trunk Group.
Fargo Crossbar Tandem then Outpulses "131" into Williston Step by Step Equipment to reach the Williston Toll Information Operator.

3d) PREFIXING

A Call may be Routed from one Area to another and back to the Originating Area for Completion.



PREFIXING - Routing Through a Foreign Area

On a Call from Amarillo to Lubbock, Texas, within the Same Area:

1) All Direct Trunks to Lubbock are Busy.
2) Amarillo Crossbar Tandem PREFIXES Area Code "915" and Outpulses "915-MA2-9970," routing the Call via Oklahoma City in Area 405.

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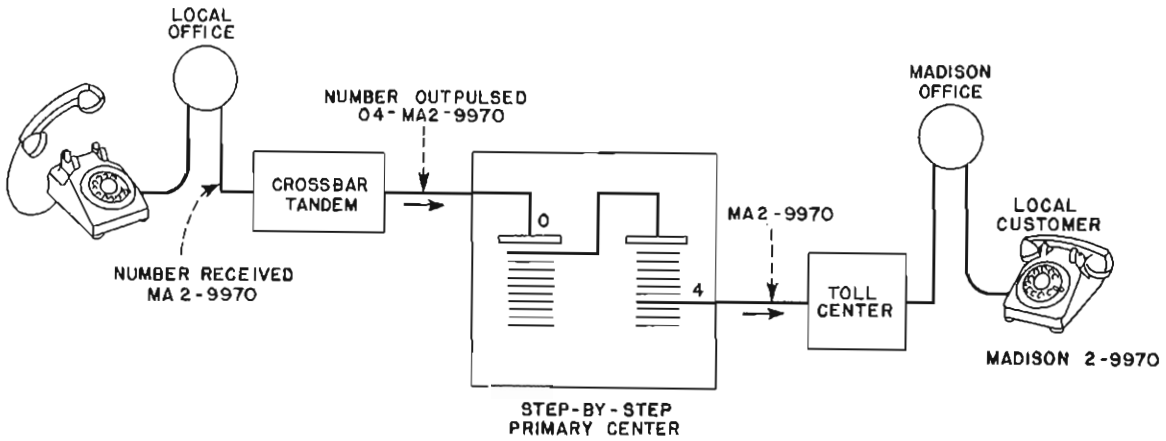
Prefixing Digits may be required to Route a Call Through a Step by Step Primary Center.



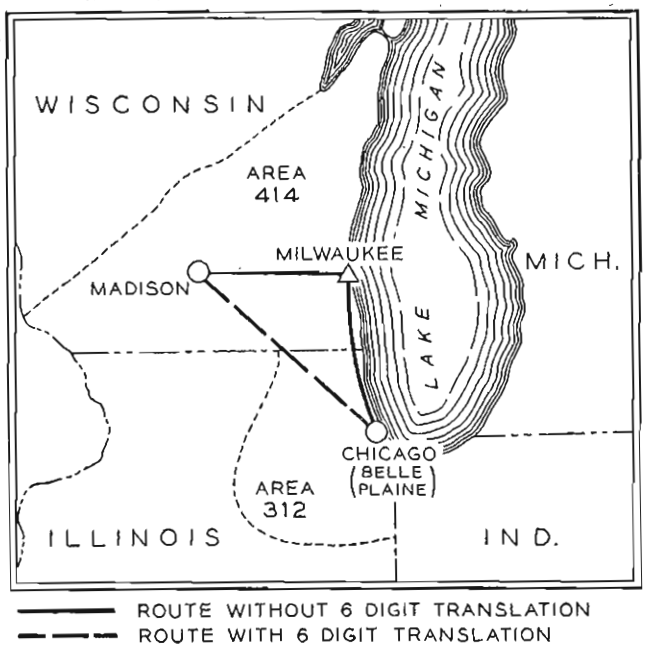
1) The Crossbar Tandem Office Registers "MA2-9970."
2) To operate the Toll Selectors in the Step by Step Primary Center, the Crossbar Tandem Equipment PREFIXES "04" to "MA2-9970," and Outpulses "04-MA2-9970."
3) The full 7-Digit Number, "MA2-9970," is passed to the Toll Center Switching Equipment.

3e) 6-DIGIT TRANSLATION

3-Digit Translation Routes All Calls to a Foreign Area over a Single Route.

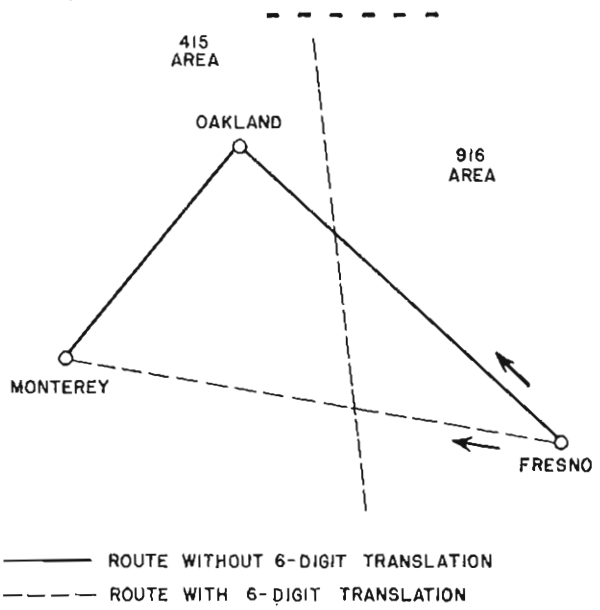
6-Digit Translation, using a Foreign Area Translator, Routes Calls over Two or more Routes, to or towards the Foreign Area involved.

1) The Crossbar Tandem Marker, for example, Translates the Area Code.
2) Then the Marker Calls in the Foreign Area Translator to Translate the Central Office Code.



6-DIGIT TRANSLATION
Chicago Belle Plain Crossbar Tandem to Madison, Wis.

3-Digit Translation would Route All Calls via Milwaukee, involving extra Trunk Mileage and an additional Switching Point.
With 6-Digit Translation, High Usage Trunks direct to Madison are tested first.



3-Digit Translation - All Calls from Fresno to Monterey would be routed via Oakland.
6-Digit Translation - The Direct Trunks to Monterey would be tested first.

6-DIGIT TRANSLATION
Fresno to Monterey, California