SECTION 5

INTRAOFFICE CALL

DETAILED CIRCUIT OPERATION

WIRE-SPRING-RELAY TYPE

INTRAOFFICE CALLS

NO. 5 CROSSBAR OFFICES

CONTENTS

		PAGE
A.	INTRODUCTION	4
B.	ESTABLISHING THE TERMINATING CONNECTION - CALL-FORWARD LINKAGE	5
1.	General	5
2.	Originating Register Selects an Idle Marker	5
	Originating Register Marker Connector - Register Part	5
	Originating Register Marker Connector - Marker Part	5
	Originating Register Marker Connector - Preference Control	6
	Originating Register Connects to a Marker	6
3.	Class of Service and Screening Relay Functions	8
4.	Code Translation and Grounding Code Points	11
5.	Operating the Route and Route Series Relays	14
6.	Recording the Calling Line Identity in the Marker	16
7.	Recording the Called Line Numericals in the Marker	17
8.	Trunk Link Frame Selection, Preference and Seizure	18
	General	18
	Testing for a Trunk Link Frame With Idle Intraoffice Trunks	18
	Testing for an Idle Trunk Link Frame	18
	Testing for an Idle Intraoffice Trunk	19
	Trunk Link Frame Preference	19
	Trunk Link Frame Seizure	20
	Recycle of Frame Memory Preference	21
9.	Number Group Selection, Seizure and Translation	21
	Number Group Selection	21
	Number Series Selection	21
	Operation of Number Series Relay	22
	Number Group Seizure	22
	Number Group Translation	23
10.	Called Line Information Transferred to the Marker	26
11.	Trunk Selection	27
	Trunk Blocks and Trunk Groups	27
	BT Leads	28
	Testing and Seizure of Idle Intraoffice Trunk	28
	Test for an Idle Trunk	29
	Trunk Selection	29
	Preference Lockout Circuit	29
12.	Release of the Number Group	30
13.	Selecting the Line Link Frame - Call-Forward Linkage	30
14.	Operation of the Called Line Identification Relays	31
15.	Selection and Application of the Ringing Combinations	32
16.	Class Information and Class Check	34
	General	34
	Flat Rate Call	35
	Coin Charge Call	35
	Message Rate Call	36

CONTENTS

		PAGE
17.	Channel Test and Selection	37
	General	37
	Junctor Distribution	37
	Junctor Subgroup Selection	38
	Selection of the Group of Line Links	39
	Selection of a Group of Trunk Links	39
	Test Check	40
	Channel Test	40
	Channel Selection	41
	Channel Preference	41
18.	Select and Hold Magnet Operation	42
	Select Magnet Operation	42
	Hold Magnet Operation	42
	General	42
	Idle Check of Channel Links Before Operating Hold Magnets	43
	Hold Magnet Timing and Control	44
	Hold Magnet Operation - Light Traffic	45
	Operation of Trunk Switch and Junctor Switch Hold Magnets - Trunk Link Frame	45
	Operation of Junctor Switch Hold Magnet - Line Link Frame	45
	Operation of Line Hold Magnet - Line Link Frame	45
	Hold Magnet Operation - Heavy Traffic	46
	Dual Voltage Operation	46
	Operation of Trunk Switch and Junctor Switch Hold Magnets - Trunk Link Frame	46
	Operation of Line Hold Magnet - Line Link Frame	47
	Sleeve Crosspoint Check After Operating Hold Magnets	47
	Trunk Switch Crosspoint Check - Trunk Link Frame	47
	Junctor Switch Crosspoint Check - Trunk Link Frame	47
	Junctor Switch Crosspoint Check - Line Link Frame	48
	Junctor Switch and Line Switch Crosspoint Check - Line Link Frame	48
19.	False Cross-Ground Test	48
20.	Continuity Test	49
	Operation of the CON Tube and CON and CONA Relays	50
	Operation of the RCTA and RCTB Relays	51
21.	Ground, Loop, and Receiver-off-Hook Tests	52
	General	52
	GT1 Relay	52
	GT Relay	53
	Ground Test	53
	Loop Test	53
	Receiver-off-Hook Test	53
22.	Double Connection Test	54
23.	Release of the Select Magnets	54
24.	Linkage Check Circuit	54
C.	ESTABLISHING THE ORIGINATING CONNECTION - CALL-BACK LINKAGE	55
1.	General	55
2.	Release of Certain Relays Used in the Terminating Connection - Call-Forward Linkage	55
3.	Start of the Call-Back Linkage	56

CONTENTS

		PAGE
4.	Selecting the Connecting Path to the Calling Line	56
	General	56
	Selecting the Line Link Frame	56
	Selecting the Vertical Group	57
	Selecting the Horizontal Group	57
	Selecting the Line Hold Magnet	57
	Selecting the Line Link Test Leads	57
	Selecting the Junctor Subgroup	58
	Selecting the Group of Trunk Links	58
	Test Check and Channel Selection	58
5.	Release of the Dialing Connection	58
6.	Dial Tone Lockout	58
7.	Select and Hold Magnet Operation	59
8.	Continuity Test	59
9.	Double Connection Test	59
10.	Transfer of Connecting Path Supervision to the Intraoffice Trunk	59
11.	Marker Release	60
12.	Originating Register and Originating Register Marker Connector Release	60
13.	Ringing the Called Customer	60
14.	Disconnect at the End of the Call	61
	Called Customer Disconnects First	61
	Calling Customer Disconnects First	61

A. INTRODUCTION

1.01 This is one of a group of sections that describes the detailed circuit operation for the various types of calls and is associated with wire spring relay type circuits of the No. 5 crossbar system.

1.02 Intraoffice calls are calls between two customers in the same office or between two customers in different offices that are served by the same marker group. They are described in six stages:

(1) Establishing the dialing connection.

(2) Dialing the called number.

(3) Establishing the call-forward linkage or terminating connection.

(4) Establishing the call-back linkage or originating connection.

(5) Ringing the called customer.

(6) Disconnect.

Fig. 1 shows the circuits engaged in completing the above stages.

1.03 Stage 1 above is contained in the section that describes the circuit operation for establishing the dialing connection. During this stage, an originating register is selected and connected to the calling line by a dial tone marker.

1.04 In stage 2 the complete called line directory number is dialed into the originating register. When dialing is completed, the originating register seizes a completing marker.

1.05 In stage 3 above, the marker selects an intraoffice trunk and connects it to the called line. By connecting to the called line before connecting to the calling line, the marker is able to make an early test to determine if the called line is busy. If it is busy, the calling line is immediately connected to a tone trunk. Making the busy test early in the call saves needless marker operations on calls to busy lines, thereby reducing average marker holding time.

1.06 In stage 4 above, the marker connects the intraoffice trunk to the calling line. At the end of this stage, the marker and the originating register are released.

1.07 The connection for ringing the called customer is set up by the marker at the end of stage 3. The actual ringing, however, is delayed until the end of stage 4. This prevents premature ringing if a delay is encountered in establishing the originating connection.

1.08 When the called line is one of a group of lines comprising a PBX group, it is possible for the call to be completed to any idle line in the group. The selection of an idle line in a PBX group is called PBX terminal hunting.

B. ESTABLISHING THE TERMINATING CONNECTION - CALL-FORWARD LINKAGE

1. General

1.01 Establishing the terminating connection consists of the selection of an intraoffice trunk and the connection of this trunk to the called line.

1.02 When the calling customer has finished dialing, the originating register seizes a completing marker. The register then transfers to the marker the class of service of the calling line and the dialed digits of the called number. The marker uses this information in the following ways:

(a) From the class of service of the calling line, it determines what type of trunk is needed for charging purposes (for example, flat rate, message rate, coin, etc.).

(b) From the office code of the called line number, it determines that the call is intraoffice.

(c) From the numericals of the called line number and from the number group circuit, it determines the equipment location of the line and the type of ringing that is required.

1.03 The marker then selects and seizes an intraoffice trunk for the required class of service by connecting to a trunk link frame. The terminating connection is then established from the B appearance of the trunk to the called line.

2. Originating Register Selects an Idle Marker

Originating Register Marker Connector

2.01 An originating register requiring the services of a marker to complete its call gains access to a marker through the originating register marker connector, register part, thence through an originating register marker connector, marker part, and thence through to the marker.

2.02 Register Part of Connector: One originating register marker connector, register part, is paired with one originating register marker connector, marker part. The register part is provided with one group of wire spring multicontact relays and one preference relay per register. The passage of information from the originating register to the originating register marker connector, marker part, and then to the marker are provided by these multicontact relays. One preference relay per register is provided to establish a preference for registers competing for the same connector.

2.03 Marker Part of Connector: One originating register marker connector, register part, is paired with one originating register marker connector, marker part. The marker part is provided with one group of wire spring multicontact relays per marker. The passage of information from the register part of the connector to the marker are provided by these multicontact relays. The connection through the originating register marker connector, register and marker part, is held as long as the connected register requires the marker, and during this time the other registers associated with this connector may not gain access to a marker.

2.04 Originating Register Marker Connector Preference Control Circuit: In each marker connector there is a preference control circuit consisting of a marker start relay MS and marker busy relay CB for each marker. It is the purpose of these relays to give each connector access to the first idle marker depending on the connectors preference position and to make the marker busy to all other connectors, to operate connector relays which will close all the necessary leads between the marker and the originating register, and by means of cross-connections in the markers to vary the order of preference of connectors for markers.

2.05 Originating Register Marker Connector Control Circuit: Each connector also has a control circuit which in connection with the master traffic control circuit and the frame traffic control serves to equalize the service given to the several connectors in a group. This is done by gating the connectors (holding the start leads open) after they are once used if other connectors are being served at the same time. Therefore a connector will not be served a second time until other connectors calling for markers have been served once.

2.06 This type of connector is called a double-ended connector because one of several circuits of one type on one end of the connector seeks one of several markers on the other end. Refer to Fig. 2 for a typical multiple arrangement of the originating register and the originating register marker connector frames.

2.07 A number of originating registers share one marker connector. Therefore, any originating register that attempts to seize its connector must compete with the other originating registers served by this same marker connector. If the originating register marker connector is busy, the originating register waits until it is idle before it proceeds. This is necessary because no alternate originating register marker connector is provided.

Originating Register Connects to a Marker

2.08 The first operation in stage 3 is marker seizure by the originating register. This is controlled by the register preference start feature in the connector.

2.09 There is one RS (register start) relay per register in the register part of a marker connector. The circuit is arranged so that if one or more RS relays operate, only one set of register connector multicontact relays operates at one time. These RS relays are wired in a preference chain in which contacts and wiring are multipled to insure against open circuits which might put the entire marker connector out of service. The winding of the RS relay for the register, which is assigned last preference, is connected directly to ground (FS-1, FS-2, FS-3, SD-26024) (OS 701-2).

2.10 When a register is ready to seize a marker, its MST (marker start) relay operates. This operates the RS relay which operates the associated multicontact relays RA through RE. If other registers call for a marker while their connector is busy, their RS relays may also operate. However, the operating path for the multicontact relays of these registers is opened by the operated RS relay of the engaged register.

2.11 The RS relay for the last preference register is connected directly to ground and it may operate at any time. When it does, operating ground for all the other RS relays is removed. However, if some less preferred RS relay is operated, its locking ground is extended toward the more preferred relays. This provides operating ground for these relays. If the first preferred RS relay is the first one operated, it is possible for all the other RS relays in the chain to operate. As each RS relay operates, it locks and waits its turn for the preference chain ground to operate its multicontact relays. The ground circuit starts at the first preferred RS relay and progresses toward the last preferred relay.

2.12 After the RC relay operates, battery is connected to start leads STA and STB and extended through the preference control circuit to the MSA or MSB punching (FS-1, SD-26029) (OS 701-2). The two relays of the W and Z combination in the marker connector control circuit determine which one of the two start leads is closed through the marker connector control CB- (chain busy) relay (FS-2, SD-26029) (OS 701-2). Over this particular lead an MS- (marker start) relay associated with a marker is operated. The operation of the W and Z relay combination and the CB- and MS- relay chain circuits described in the dial tone job also applies here, except for the following differences:

(a) W and Z Relay Combination: Ground is applied to the W relay through the MC (marker connector) relay. When the marker is ready to disconnect, it causes the operation of the MRL (marker release) or BT (busy tone) relay in the originating register (FS-2, SD-26023, FS-4, SD-26024, FS-5, SD-26040). This removes battery from the ST lead, which releases the MS- relay. Relay MS- causes the release of the MA through ME relays (FS-1, SD-26023). Relay MC removes the ground, shunting relay Z (FS-4, SD-26029).

(b) MS- (Marker Start) Relay Chain Circuit (OS 701-2): Both originating register marker connectors and incoming register marker connectors are competing for completing markers through the same MS- relay chains. An MS- cross-connection punching is provided per CB- relay. Punchings MSA and MSB for each connector are cross-connected to two of these MS- punchings. A marker associated with an MS- punching connected to an MSA or MSB punching is a first choice marker for the originating register and incoming register marker connector from which the start lead originates. Since there are two start leads, each frame has two first choice markers. The start lead that is connected through the marker connector control circuit determines which of these two markers is the first choice on a particular usage. The arrangement of the cross connection is such that each marker is first choice for about the same number of connectors.

(c) CB- (Chain Busy) Relay Circuit (OS 701-2): A particular start lead that is connected through the marker connector control circuit applies resistance battery to the punching to which it is connected. If the marker associated with this punching is busy serving another connector, relay CB- is operated. Resistance battery is then passed to the next CB- relay in the chain. Assume that the resistance battery is finally connected to a released CB- relay associated with an idle marker. This battery then operates and locks the MS- relay (in preference control circuit) associated with the idle marker. The CB- relay locking ground is provided by the operated RC relay in the originating register marker connector, register part (FS-4, SD-26024, FS-3, SD-26029).

2.13 The operation of relay MS- operates multicontact relays MA through ME (marker connector), thereby seizing the marker. The operation of relay MA shunts relay CB- in the seizing preference control circuit associated with the seized marker. Relay MD operates relays MCB- (marker connector busy) in the marker. These relays apply ground to all of the CB- relays associated with the seized marker in all preference control circuits, operating all but the shunted one in the seizing connector. Relay MS- in operating also releases the marker connector check relays, MAK, MCK, and MSK in the marker. The release of any one of these relays operates relay TM, which starts marker timing. A check for the marker seizure is indicated by the operation of the marker CKG1 and CKG2 relays. These relays provide battery, ground, and the interconnections necessary for the marker to operate.

2.14 The connector is prevented from reverting to a more preferred marker by locking operated those CB- relays in the connector corresponding to busy markers at the time a seizure is attempted. The locking ground is provided immediately by relay TM (timing), and later by relay RC (marker connector). It is connected in such a way that at least one CB- relay must be normal to enable the ground to lock those that are operated. This is necessary to prevent a call from blocking itself if a temporary all-markers-busy condition is encountered.

2.15 There is a time interval between the operation of relay MS- in the seizing preference control circuit and the operation of relays CB- in all of the other preference control circuits. During this interval other connectors may also operate MS- relays associated with the same marker. These MS- relays, however, would be in less preferred connectors than the first connector to succeed in operating its MS- relay. Because of the arrangement of the chain circuits controlling the operation of the MA relay, the highest preference connector, with relay MS- operated, always succeeds in seizing the marker. The subsequent operation of CB- relays in other connectors transfers their start leads to other markers, releasing their MS- relays associated with this marker.

2.16 On an attempt by two connectors to seize the same marker, the one with a faster operating MS- relay always succeeds. In order to prevent a particular connector from being served repeatedly while others are forced to wait, a system of traffic control is provided. Traffic control is described in CD-26029-01.

2.17 After the marker is seized, the calling line class of service, the called line office code and numericals, and the calling line identification are passed from the originating register to the marker.

3. Class of Service and Screening Relay Functions

3.01 When a marker is trying to do a job (intraoffice call for instance) one of the several things it must consider is the calling subscriber's class of service. Obviously, if the subscriber is using a coin telephone, the marker has to choose a trunk with coin charging features. If the subscriber happens to be a message rate subscriber, it must pick the right kind of intraoffice trunk for this service.

3.02 During the dial tone job, the dial tone marker determined the class of service of the calling subscriber and then passed it to the originating register. After dialing was completed, the originating register connected to the completing marker and passed the subscriber's class of service to the marker. On SD-26002, FS-10 we see the details of this transfer. The tens digit of the class of service operates one of the CTO, 1 or 2 relays. The operated CT- operates a CTAO, 1 or 2 and if provided, a CTBO, 1 or 2. The units information is passed to the CUA- and the CUB- relays if they are provided, two out of five CUA's and two out of five CUB's operate for the class of service units. There are two sets of class of service relays. One set handles thirty classes in the A group, the other thirty classes in the B group. The marker is equipped with the A group and an option will add the B group relays. With this option we can have sixty classes of service in a marker group. Because any class of service operates tens and units relay in the A group and also tens and units relays in the B group, a control or separator is provided. The control which separates a class of service in one group from a class in the other is the CGA and CGB relays shown on FS-10. The CGA relay indicates one of thirty classes of service in the "A" group and the CGB indicates one of thirty classes of service in the "B" group. Each class of service in either "A" or "B" group is represented by a punching SWC-. There are thirty SWC's numbered 0-29 in each group. These punchings are connected to the windings of screening relays according to assignments for class of service. The reason for providing so many classes of service is that in large marker groups which consist of two or three central office designations, classes of service are distinguished, in the various offices, for charging purposes.

3.03 Each completing marker has an assortment of screening relays. They are used to control the marker routing of calls made by the various classes of service. These relays are assigned to the classes of service by cross-connection assignments. On OS 714-1, Sheet 1, there is a sketch which shows how the class of service information passes from the originating register to the completing marker. We can see how each class of service is represented by a punching SWC-. The tens and units relays for each class of service apply ground to one of the thirty SWC punchings. These SWC- punchings are cross-connected to the windings (SW- punchings) of screening relays according to assignments for class of service. On OS 714-1, there is one example (class of service 07) of how each SWC- punching is grounded. Each other class of service punching is grounded in a similar way.

3.04 We can see on OS 714-1 how this ground operates screening relay S07 through the cross connection. Also on the right side of the sheet, a similar circuit shows us that one will operate a second relay S31. We have two screening relays operated for this one class of service. They will provide us with many contact points or paths so that we can "screen" this class of service and give it the proper treatment for our call.

3.05 The assignment of S- relays to classes of service is arbitrary. We have assigned two relays S07 and S31 to class of service 07. If our central office happened to be larger, if it had many more divisions of class of service than we have on OS 714-1, then we would need more than two S- (screening relays) for each class of service. The different classes of service shown on the sketches are typical of those found in many central offices. Because the charges on many routes vary for two similar classes of service in the two

offices, the class of service in Office B (Podunk 6) are assigned different screening relays than their counterparts in Office A (Podunk 5).

3.06 In this series of operational sketches and in the series on route relay operation the material is presented as though it were engineered for an existing central office unit. On OS 714-1, Sheet 1, there is a chart which describes the assignments of the typical classes of service of two central offices, Podunk 5 and Podunk 6. These are two physical central offices in one marker group and represent Office A and Office B. Typical arrangements of assignments and cross connections are presented on these sketches.

3.07 The relays shown on OS 714-1, Sheet 1, are under the heading "Class of Service Grouping - Group A." This means that this arrangement represents a completing marker equipped for either thirty or sixty classes of service, and in either case, this is the "A" group. The group is divided into two sorts. In sort 1, each class of service is assigned an individual screening relay. These relays will be used for the routes where subscribers with different class of service receive different treatment. In sort 2, some classes of service share a screening relay. For example, Podunk 5 subscribers with the service PBXF, IF and 2F all use screening relay S28. This is done to cut down on cross connections. Since for various outgoing routes these classes of service relays get the same treatment, we can cut down considerably on our use of S- relays and cross connections through this arrangement.

3.08 Screening relays S08, S09, S31 and S32 are for trunk classes of service where toll and tandem switching features are provided. These features are discussed in another section of the text under Toll and Tandem Switching features.

3.09 On Sheet 2 of OS 714-1, we have a sketch of two sets of screening relays S00-03 and S116-119. These represent the first four and last four respectively of all the screening relays provided in the completing marker. Screening relays S00, S01, S02 and S03 have their contacts multipled so that they form a unit. Each successive group of four screening relays are wired as a unit in the same way. The table on this page shows at a glance how the relays are divided into groups, four relays to each group.

3.10 The left side of the S relay contacts are multipled and connected to USC punchings. For example, punching USC0 is common to number one contact of S relays 00, 01, 02 and 03. However, the other side of these contacts of the relays appear as twelve separate punchings so that we can make individual connections as they are required. For instance if we connect a circuit to punching USC0, then we have four possible paths we can follow depending on which S- relay is operated. If we assign four classes of service to these four relays, we can give them individual treatment by continuing the paths from S0 punchings of the four relays to the desired points. This arrangement is called "screening." In selecting S- relays for assignment to classes of service, we take as many groups of four S- relays as are required and connect their associated USC- punchings. For instance, in our marker group, we have ten classes of service in Podunk 5 (eight subscriber classes and two trunk classes) and eight classes in Podunk 6. This gives us a total of eighteen classes. Five groups of S- relays (S00 to S07 and S20 to S29 inclusive) have their associated USC- punchings connected.

3.11 Sheet 3 of OS 714-1, is a reproduction of the standard marker cross connection form which is used for class of service discrimination. Most of the items, which appear on the form apply to the route relay sketches, OS 716-1. These are discussed later in this section. However, we can see some of the assignments pertaining to class of service and S- relays on this sheet. For example, at the top of the sheet we have the classes of service appearing as column headings. They are grouped into central office heading PO 5 (Podunk 5) and PO 6 (Podunk 6). Immediately under these, we have the service relay or screening relay numbers assigned to these classes of service. In the middle of the sheet we have a division - "service relay NO." Across the sheet appear the S- relay numbers 28, 29, 30, etc. Relay number 28 is used for classes of service 00, 01 and 02. This agrees with the cross connections and the table on Sheet 1. We can see that the top part of the form pertains to the service (or screening) relays in sort 1 as shown on Sheet 1 of this OS. The bottom half of the form shows those service relays in sort 2. The marker cross-connection form is offered so that the student can become familiar with the method of presenting the assignments for these cross connections. The assignments, as written in this form, apply to our fictitious central offices, Podunk 5 and Podunk 6. The details of these assignments as they appear on this form, will be discussed under route relay cross connections.

3.12 On calls made by a 2-party line, the originating register determines which party is calling. It passes the results of the test to the completing marker. Either the TP relays or RP relays operate on 2-party calls. The marker must determine which party is calling for proper charging of the call. It is possible to give two parties of a line different service. For example, we might allow the ring party to have flat rate service, and the tip party message rate service. This is done by assigning separate S- screening relays to the two parties. On SD-26002, FS-11 there is a group of punchings, SWPO-3. These punchings are cross-connected to the SWC- punchings representing 2-party lines. The other side of the TPA and RPA screening contact field, appears as SWT 0-3 and SWR 0-3 punchings. The SWT 0-3 (on TPA or TPB relay) or SWR 0-3 (on RPA or RPB relay) punchings are cross-connected to the SW- punching according to class of service cross-connection assignments. With this cross-connection arrangement, the two parties have individual S- (screening) relays. We can use the screening relay paths so as to give separate charge conditions for each of the two parties.

4. Code Translation and Grounding Code Points

4.01 When the originating register connected to the completing marker through the marker connector, it passed to the marker all the information about this call. Three pieces of information were the A, B and C digits which the subscriber had dialed. These three digits represent the central office code of the called subscriber. The marker examines these digits one at a time beginning with the "A" digit. It uses these digits to place ground on a punching which represents the dialed central office code. This punching is called a code point. A code point has a number which represents the digits (or letters) for which it stands. The process which the marker performs in trying to ground the proper code point is called code translation. This part of the text describes how the marker performs this operation. An example using one of the intraoffice codes will be followed.

4.02 Let us assume that our calling subscriber dialed a telephone in his own central office. The number, which he dialed, is POdunk 5 1234. The marker is not interested in the telephone number - 1234 at this time; the marker will look at it later. At this time the marker is concerned with the A, B and C digits 765- for Podunk 5. We can use the sketches of OS 715-1 to see what takes place.

4.03 On Sheet 1, we have the AC0 and 7, BC0 and 7, CC0 and 7 digit register relays. They represent the whole complement of AC0, 1, 2, 4, 7, BC0, 1, 2, 4, 7, and CC0, 1, 2, 4, 7 relays which store the central office code. For our call, the dialed code is 765- (Podunk 5). The AC0 and 7, BC2 and 4, CC1 and 4 relays would be operated.

4.04 Also the LT (local translator), OR (originating register call), PK (no partial dial - no permanent signal check) and SCK (no stuck coin check) relays are operated by grounds from the originating register. Since the first digit is a "seven" 765-(P05) the AT-7 ("A" digit translator number seven) relay should operate. We can trace the ground from normal contacts of the XT relay (crossed translator indication) through operated CKG 2 and OR, normal FAC and through two checking circuits. One of these checks for false coin signals from the register, the other for false timing signals (permanent signal time-out, partial dial time-out). Our circuit continues through operated PK, normal SCN, operated OR to the two-out-of-five "A" digit checker. If we have anything other than two AC relays operated, the call is blocked. This prevents translation attempts when "crossed" or "false" "A" digits are received. The path goes on through operated AC0 and AC7, operated LT contacts, through the LTA7 to ATW7 cross connection and winding of AT7 relay. So far we have translated the A digit. The LT (local translator) relay indicates to the marker it must translate three digits A, B and C in order to ground the proper code point C765. Of course at this moment the marker doesn't know which code point it will ground. This is what it's trying to find out in the code translation process.

4.05 On Sheet 2 we find the translation circuit for the "B" digit. Since our "B" digit can be any of the letters on the dial, it follows that it will be one of the numbers 1 through 9. There are three auxiliary translator relays on this sketch. They are B147, which represents the "B" digits 1, 4 and 7, B369 (for "B" digits 3, 6 and 9), and B258 (for "B" digits 2, 5 and 8). Since our "B" digit is a "6" (765,P05), the B369 relay operates. The path is through operated BC2 and BC4 and the two-out-of-five "B" digit checking circuit. This same ground is also connected to the contacts of the BC relays of the translator. We can move this ground through the operated BC2 and BC4, operated AT7, through the AT76 to BT7S cross connection. This will operate "B" digit translator relay BT7S.

4.06 A word about the method of translating the "B" digit before we go on with this call. There are one thousand possible codes if we consider the digits 0 to 9 for A digit, 0 to 9 for B digit and 0 to 9 for the C digit (10 x 10 x 10). Codes which have an "0" in the B digit are used for customer national toll dialing and these are discussed later in this section. There are one hundred of these codes which have a zero in the B digit. The remaining nine hundred codes are translated by thirty multicontact relays which have thirty contacts each (30 x 30 = 900). These relays are named BT- for "B" digit translator. They are numbered according to the "A" digit which they

represent and lettered according to the "B" digits which they translate. The letters used are "R", "S" and "T". "R" stands for the B digits 1, 2 and 3. "S" stands for 4, 5 and 6. "T" stands for 7, 8 and 9. Relay BT4R, for example, represents those codes which have a four in the "A" digit and either a one, two or three in the "B" digit. Relay BT6S represents those codes with a six in the "A" and either a four, five or six in the "B" digit. Relay BT5T represents those codes with a five in the "A" and either seven, eight or nine in the "B" digit. The arrangement used in translating the "B" digit is similar to the translation of the "C" digit in the pretranslator. In translating the "B" digit, the marker divides the nine possible digits (one to nine) into three groups, R, S and T and then divides them again using the auxiliary relays B147, B258 and B369. We can readily see in Table A how this double-division splits the "B" digit so that with two references, namely R, S, or T and one of the three auxiliary relays, we have an exact definition of the "B" digit.

TABLE A

"B" DIGITS

9

8 "T" DIGITS

7

6

5 "S" DIGITS

4

3

2 "R" DIGITS

1

B369 RELAY B258 RELAY B147 RELAY

4.07 We have operated BT7S on this call. This relay stands for all the codes which have a seven for an "A" digit, a four, five or six for a "B" digit and anything from zero to nine for a "C" digit. This arrangement gives us a total of thirty codes (1 x 3 x 10). The codes handled by BT7S are 74-(0-9), 75-(0-9) and 76-(0-9). Our code, 765, falls in this category. Of course, the operated B369 relay has split this division by a third so that we now have narrowed our possible codes to ten, BT76 (0 to 9). Up to this point, we have translated the "A" digit (operated AT7) and have translated the "B" digit (operated BT7S).

4.08 On Sheet 3, we have the translation circuit for the "C" digit. Starting with the ground through the CKG2 contacts, we pass through the "C" digit checking circuit (through CC1 and CC4 operated) through operated contacts of CC1 and CC4 again operated contacts of B369 relay to a multiple of number fifty contact of all thirty BT-- relays. However, only one of these BT7S, is operated. This contact is wired to a punching which is identified as code point C765. This code point represents the ABC digits 765 for PODunk 5.

4.09 The "C" digit translator circuit on Sheet 3 is divided into nine fields of one hundred codes each. The codes in any one of these fields all have the same "B" digit. For instance, our code C765, falls into the top center group or field. These one hundred punchings are indicated as "X6X" codes. This means those codes which have a six in the "B" digit, but various "A" and "C" digits. Relays BTOS to BT9S (ten relays) each has ten contacts in this field (10 x 10 = 100 code points).

4.10 Various other examples are shown on this OS. Some are identified and some are not. Each one can be identified as an exact code punching having a 3-digit number.

4.11 The translation of one and 2-digit code points is discussed in a different section of this text.

5. Operating the Route and Route Series Relays

5.01 So far in the progress of our call, the marker has grounded the code point, C765, which represents the called central office, Podunk 5. We have defined this call as an intraoffice job, however, at this time there is no indication as to what kind of a job it is to perform. It must first operate a route relay; this relay will give the marker information about the kind of call.

5.02 On OS 716-1, Sheet 2, we have a typical sketch of route relay cross connections for intraoffice routes. In the marker group we have been discussing, we have two central offices, Podunk 5 (Office A) and Podunk 6 (Office B). We have been provided with various classes of service which are described on OS 714-1. Also we have been given three different kinds of intraoffice trunk circuits. One of these (SD-26060-01 for instance) is equipped to handle calls by flat rate customers. By this we mean those subscribers who can make an intraoffice call free. Another trunk (SD-26061-01) is equipped to handle message rate subscribers using automatic message charging equipment. These subscribers are those who pay a charge for each time unit of a call, even on intraoffice calls. This trunk is equipped for charging these calls. Another group of trunks for intraoffice traffic are those with coin features. These trunks must be able to time calls and summon the common coin control equipment when coin subscribers make intraoffice calls.

5.03 While there are other arrangements of intraoffice trunks, the choice of separate trunk groups for these three major divisions of class of service was elected in our office. Separate trunk groups for flat rate, message rate and coin subscribers is the arrangement shown on OS 716-1, Sheet 2. This arrangement is typical of most No. 5 crossbar offices.

5.04 On this sheet we can see the code point C765 for Podunk 5, which the marker has just grounded. Since C765 represents Office "A" it is cross-connected to the LPA (local physical "A" central office) relay winding. Likewise, C766 for Podunk 6, is cross-connected to LPB for local physical "B" central office. Actually there are four more relays similar to these two. They have been left off this OS for the sake of simplification. It is possible, ultimately, to divide a marker group into six central office subdivisions. They are Office "A" physical (LPA), Office "A" theoretical (LTA), Office "A" extra-theoretical (LEA), Office "B" physical (LPB), Office "B" theoretical (LTB), and Office "B" extra-theoretical (LEB). All six relays are provided in each completing marker. Only those relays which apply to our particular office need be used. And so, on these sketches since our marker group contains two physical central office units, we only show the LPA and LPB relays.

5.05 When the LPA relay operates, it places a ground on an associated APR punching. This punching is shown cross-connected to an isolated punching SC03. There are ninety-six of these SC- punchings provided in each completing marker. They are used as "tie points" - a means of bringing two terminals together through cross connections when the punchings being connected are not on the same or adjacent terminal strips. The USC- punchings are located on the rear of the S relay unit in the marker frame. They are wired to SC- punchings according to the assignments for class of service screening relays.

5.06 In this sketch we also notice that four groups of S- relays (four S- relays in each group) have their number four contacts multipled through the USC03 to USC03 cross connections. As discussed in the test on screening relays, we assign one or more S- relays to each class of service. Since there is a total of sixteen subscriber classes of service in our two central offices, we bridge sixteen S- relays as shown on this sketch. In fact all the other contacts are bridged in a similar manner. We will run into the remainder of these paths as we study the various marker jobs with their different route relay arrangements. For the present we are concerned only with punching USC03 and its paths through number four contact of the screening relays shown. Actually, there are four more S- relays (S08, 09, 10, 11) connected to this group. Relays S08 and S09 are for trunk classes of service. Relays S10 and S11 are spare. The connection to these relays can be ignored when studying intraoffice routes because there aren't any cross connections on their associated S3 punchings.

5.07 If we assume on this call, that our calling subscriber has the class of service number 01, which is individual flat rate in Podunk 5, then screening relays S01 and S28 would be operated. At the present time we are only concerned with screening relay S01. One set of its contacts provide us with a path for operating our route relay R10. The individual contact of our screening relay appears on a punching S3. This punching is cross-connected to a grouping punching SG00. There are sixty of these grouping punchings SG00 to SG59. They are used as a convenient place for connecting various wires which must all connect to a common point. In this case the ultimate point or punching is RC10, however, it wouldn't be practicable to bunch all eight cross-connections from the eight S3 punchings to one punching RC10. So we use the SG- punchings. The assignment of these SG- punchings is arbitrary. For the purposes of keeping the record straight on these sketches, there is a table on OS 714-1, Sheet 3 which list these assignments.

5.08 Since we have three different groups of intraoffice trunks in our office - flat rate, message rate (AMA) and coin - all those subscribers which have flat rate service of one kind or another, use the R10 flat rate intraoffice route relay. All those subscribers having message rate service use route relay R21 - intraoffice message rate (AMA) trunks, and the coin subscribers use R20 - intraoffice coin trunks. These route relays control the marker's selection of their own group of trunks. This is discussed in detail under trunk selection.

5.09 The path for operating route relay number R10, our example, was through operated contacts of S01 relay, the S3 to SG00 cross connection, the SG00 to RC10 cross connection, winding of R10 to winding of a route series relay NCNC. The purpose of a route series relay is to indicate to the marker something about the charge condition for the call. Relay NCNC means there will be no charge and the calling subscriber is not a coin class of service. However, if we choose a message rate subscriber, such as Podunk 5, 2-party message rate, we have a different condition. The screening relay for this subscriber is S06. The S3 punching is connected to SG01 which in turn is connected to RC21, the intraoffice AMA route relay in series with relay MBS1. The MBS1 relay stands for "message billing index number 1." This is a signal which the marker will pass on to the automatic message accounting equipment later on in the intraoffice call. Of course, if the office is not equipped for AMA then some other charge relay is assigned instead of MBS1. If the subscriber making the intraoffice call happened to be a coin subscriber on Podunk 5, then S07 screening relay would be operated. Its S3 punching is cross-connected to route relay R20 in series with TCNC. Relay TCNC means talking charge but not a coin subscriber. At first this might seem contradictory because, in fact, we said our calling subscriber was coin. However, the trunk we are using, SD-26064-01 is designed for coin traffic only and does not require a "coin" signal.

5.10 On OS 714-1 Sheet 3 - the marker cross-connection form - we can see how the route relay cross connections for the intraoffice routes appear. On the left of the form under "assignment," we can find an item "intraoffice." In the next column under punching, we see the punchings APR and BPR which we used on the intraoffice route relay sketch. APR and BPR are cross-connected to SC03. The individual connections from the S3 punchings of the different class of service S- relays are read across the page. For example, PBXF has its S3 punching cross-connected to SG00. We can verify this by looking at the intraoffice route relay sketch OS 714-1, Sheet 2.

5.11 Now that the marker has operated a route relay assigned to intraoffice trunks, it is prepared to operate the marker class (job) control relays. On OS 716-1, Sheet 2, we see the NSI (no sender intraoffice) relay. The NSI punching for this relay is cross-connected to the OS 10, OS 20 and OS 21 punchings of the intraoffice route relays. On FS-32, we can see that the operation of NSI will operate the marker class relays ITR1 and ITR2. These marker class relays control the marker functions related to the intraoffice call.

6. Recording the Calling Line Identity in the Marker

6.01 The calling line identification must be passed from the originating register to the marker. When relay OR operates (FS-21, SD-26002) after the seizure of the marker, it operates the GTL (ground transmitting leads)

relay (FS-57, SD-26002). This operates relay GTL2. These relays operate all of the line identification relays in the marker with the exception of the CUA-, CUB- (class units), CT- (class tens), and LL- (line link) relays. The CUA-, CUB-, and CT- relays were operated previously on the class-of-service transfer. The LL- relays are operated during the call-back stage of the call. The identification relays supply the following information about the calling line (FS-1, SD-26002):

Marker Relays Operated	Information Transmitted
FT 1/4 and FU 2/5	Line link frame number
VG 2/6	Vertical group number
HG 2/5	Horizontal group number
VF 1/5	Vertical file number

This information, however, is not used until the originating connection is made to the calling line.

7. Recording the Called Line Numericals in the Marker

7.01 The numerical registration of the called line number is obtained from the last four digits (D, E, F, and G) of a 7-digit directory number.

7.02 The numericals of the called directory number are recorded on a two-out-of-five basis on the D-, E-, F-, and G- relays in the originating register. In addition, the register grounds two out of the five leads of each group D, E, F, and G. With the operation of the originating register marker connector relays RB and MB, these grounds are extended into the marker.

7.03 The marker determines which of the digits of the called number are the office code and which are the numericals. To indicate this for a 7-digit called number, the N4 (number translator cut-in) relay operates.

7.04 The operation of one of the relays LPA (local physical A), LPB (local physical B), LTA (local theoretical A), LTB (local theoretical B), LEA (local extheo A), or LEB (local extheo B) with relay LT operated grounds the NSL punching (OS 720-1) (FS-81, SD-26002). This punching, cross-connected to the N4 punching, extends ground to cause the operation of relay N4. This relay closes the path for the TH- (thousands), HN- (hundreds), T- (tens), and U- (units) relays which operate on a two-out-of-five basis to register the numerical digits of the called line. The operation of relay N4 also operates relay NE (number end) (OS 720-1). This relay checks if any of the RIA (regular intercept auxiliary), TBIA (trouble intercept auxiliary), or BNA (blank number auxiliary) relays have operated falsely and caused the operation of relay XN (cross in called number figures) (FS-63, 66, SD-26002).

7.05 If the called number is not a 7-digit number, then the translator cut-in relays (OS 720-1) are cross-connected to operate as follows:

Called Number			
Number of Office Code Digits	Number of Numerical Digits	Cross-Connection Punching	Number Translator Cut-in Relays Operated
None	4	NSL to N1	N1
1	4	NSE to N2	N2
2	4	NSF to N3	N3
3	4	NSF to N4	N4

8. Trunk Link Frame Selection, Preference, and Seizure

General

8.01 When the marker is directed to do an intraoffice trunk job, it tests for an idle trunk link frame that has access to one or more idle intraoffice trunks. Only one marker has access to a particular trunk link frame at one time. Therefore, it is necessary to select an idle trunk that is associated with a frame that is not connected to another marker. When such a frame is found, the marker operates the connector relays to seize it.

8.02 To prevent marker delays, the trunk link frame used for this call is seized before the number group is seized. A delay would occur if a marker was allowed to seize the number group first and then encountered an all-trunks and/or an all-trunk link frame busy condition.

Testing for a Trunk Link Frame With Idle Intraoffice Trunks

8.03 There is one FTC- (frame test common) relay per trunk link frame in the marker. There may be ten if an office contains ten or less trunk link frames or twenty if an office contains ten or more trunk link frames. These FTC- relays are connected to R- (route) relay contacts and are common to all route relays under control of the ground supply relays and terminate on FTC- punchings in the trunk link circuit. The FTC- punching associated with the intraoffice route relay is cross-connected to the FT-- punchings that are associated with intraoffice trunks. If at least one trunk is idle, it grounds its FT lead, thus grounding the FTC- lead operating the associated FTC- relay in the marker. The operated FTC- relay indicates an idle trunk on that particular trunk link frame. If no trunks are idle, the test lead is not grounded and the corresponding FTC- relay remains released. Relay FTCK (frame test check) operates to indicate that one or more FTC- relays are operated (FS-20, SD-26002) (FS-1, SD-26032) (OS 702-2).

Testing for an Idle Trunk Link Frame

8.04 Before the marker can select a trunk link frame having idle trunks it must first check that the trunk link frame is not being used by another marker. The operation of the marker off normal TLC1, trunk link control relay, operates the BC0 and BC10, busy cut-in relays. The BC10 relay is provided when an office has more than ten trunk link frames. Relay BC0 extends the windings

of the frame busy FB0-9 relays to their associated trunk link connectors over the FB0-9 leads and relay BC10 extends the frame busy FB10-19 relays to their associated trunk link connectors over the FB10-19 leads. If the trunk link connector is busy the corresponding test lead is grounded and the associated FB- relay will be operated. Idle trunk link frames are indicated by normal FB- relays (FS-23, SD-26002) (OS 702-2).

Testing for an Idle Intraoffice Trunk

8.05 When looking for an idle trunk, the marker tests a maximum of 20 intraoffice trunk circuits on any one trunk link frame at one time. However, in some offices, two subgroups each consisting of 20 intraoffice trunks may be associated with one trunk link frame. Therefore, the 2-step allotter is provided so that the marker may select one of the two groups for testing.

8.06 When the 2-step allotter is not required the intraoffice route relay operates under control of the grounded code point and class screening relays (OS 716-1).

8.07 When the 2-step allotter is required the code point is cross-connected to an RCL- punching, either directly or through class screening relays. The RL- punching is cross-connected to route series relays, either directly or through class screening relays. The RCL- and RL- punchings are associated with the windings of the allotter relays AL- (FS-40, SD-26002). Therefore, the grounded code point will operate an AL- (allotter) relay. The operated AL- relay will close a ground under control of the AGP (allotter group preference) relay to the contacts of the GZ (group Z) relay. Associated with the break contacts of the GZ are LA- punchings and the make contacts are LB- punchings (FS-55, SD-26002). The LA- punching is cross-connected to an RC- punching associated with the R- (route) relay for one subgroup of trunks and the LB- punching is cross-connected to an RC- punching associated with the R- (route) relay for another subgroup of trunks. Since the GZ relay is operated on every other seizure of the marker, traffic is equally distributed to the intraoffice trunk circuits. The remainder of the test is the same as described in Paragraph 8.03.

Trunk Link Frame Preference

8.08 Since it is undesirable for the same trunk link frame to be first choice for the same marker on each usage, a rotating preference system is used. On the previous marker usage, one of the FM0-4 (frame memory) and FMG- (frame memory group) relays that correspond to the trunk link frame used were operated and held until this marker usage. If none were operated, such as after initial application of power, the FM0 and FMG0 would operate when power was applied (FS-21, SD-26002). The FM0 operates through a chain of break contacts on the other FM- relays and released TFK1 relay. The FMG0 operates through a chain of break contacts on the other FMG- relays and released TFK1 relay.

8.09 On this usage, the operated TLC1 relay together with the held FM- and FMG- relays operate the FMK (frame memory check) relay, this in turn will operate the FMG (frame memory guard) relay. The operation of these two check relays is an indication that an FM- and an FMG- relay is operated.

8.10 The marker will be provided with an FS- (frame selection) relay per trunk link frame. There will be ten FS- relays if the office contains ten or less trunk link frames or twenty FS- relays if the office contains ten or more trunk link frames (OS 702-1) (FS-22, SD-26002).

8.11 The operating ground for the FS- relay is supplied through the operated FTC- relay corresponding to a trunk link frame with an idle intraoffice trunk and the contacts of the operated FM- and FMG- relays associated with the previous trunk link frame usage. If relay FTC- is released, indicating no idle intraoffice trunks, the ground is passed to the second higher numbered FTC- relay. If relay FTC- is operated, indicating idle intraoffice trunks, but relay FB- (frame busy) is operated, indicating a busy frame, the ground is still passed to the second higher numbered FTC- relay. If the FTC- relay is operated and the FB- relay that corresponds to the same trunk link frame is released, the ground is then applied to the FS- relay winding operating it (OS 702-2) (FS-22, SD-26002).

Trunk Link Frame Seizure (FS-1, SD-26033) (FS-2-3-4, SD-26039) (OS 702-2)

8.12 Each trunk link frame has a connector circuit and a preference control and make-busy circuit associated with it.

8.13 The trunk link connector consists of a set of multicontact relays for each marker. These relays provide the necessary leads between the markers and the trunk link frames. One set of multicontact relays operate at a time under control of the frame preference control and make-busy circuit. It also provides the marker with office size and frame arrangement information.

8.14 The preference circuit consists essentially of two chains of relays, one relay in each chain for each marker, and a transfer circuit to make operative one chain or the other. The transfer is brought into play either automatically in case of certain troubles, or manually when this is desired for maintenance purposes. The preference relays operate the multicontact relays in the trunk link connector circuit.

8.15 The control circuit permits only one marker to have access to a particular trunk link connector at a time.

8.16 In each preference control circuit there is one MP- (marker preference, regular) relay per marker in one chain and one E- (marker preference, emergency) relay per marker in another chain. The operation of the FS- relay in the marker connects resistance battery to the start lead "ST" to operate the MP- relay with the TR normal. The MP- relay locks to ground on its own contacts.

8.17 Assuming that an intermediate marker has operated its MP- relay, lower numbered marker MP- relays cannot operate since these are cut off by the contacts of the operated MP relay, but higher numbered markers can operate their MP relays. These relay winding chains and work contact chains prevent more than one marker from seizing the same trunk link connector at a time. When the connected marker releases its MP relay and MP relays for higher numbered markers are operated, the next higher marker will be served.

8.18 The operation of the MP- relay grounds the MC lead to the trunk link connector and causes the operation of the M relay under control of a chain circuit through normal MP- relays in lower preference circuits unless it is the lowest preference circuit. Relay M operates the MA1, MA2, MB1, MB2,

MC1 and MC2 relays. The TFK1 and TFK2 (trunk frame check) relays operate in the marker (FS-24, SD-26002) to indicate the seizure of the trunk link frame.

Recycle of Frame Memory Preference (OS 702-2) (FS-21, 23, SD-26002)

8.19 After the trunk link frame has been seized it will be necessary for the marker to reset the frame memory relays. The operation of relay TFK1 removes the locking ground from relays FM- and FMG- held from the previous usage, thereby allowing them to release. The release of relays FM- and FMG- releases relay FMK which releases relay FMG. The release of relay FMG, together with the operated relay FS- on this usage, operates the FM- relay that corresponds to the trunk link frame being used. Relay FMK reoperates. Because relay TFK1 is operated, relay FML (frame memory lock) operates and relay FMG remains nonoperated. The operation of relay FML releases relays BC0 and BC10, opening the trunk link frame FB- leads and releasing the operated FB- relays.

9. Number Group Selection, Seizure and Translation

Number Group Selection

9.01 When the marker receives the called number, it determines the called line location and the type of ringing required. The number group circuit is used to obtain this information. It translates the numerical digits of a subscriber line into equipment location on a line link frame. The marker determines the TH-, H-, T-, and U- digits of the called line number, selects the proper number group, which in turn translates the number into a line link frame number FT-, FU-, and location on the frame in terms of VG-, HG-, and VF-. The number group also provides the marker with the ringing code that the trunk should use in ringing the called line.

9.02 One number group circuit is assigned to each series of 1000 directory numbers in an office. Thus, a 10,000 number office has ten number group frames. The first frame serves 0000 to 0999, the second, numbers 1000 to 1999, up to the last frame for numbers 9000 to 9999. The marker examines the thousands digit of the called number to determine the particular number group circuit required.

9.03 Any given office may have from 1 to 40 number groups, each being capable of translating 1000 numbers. In order for the marker to select the proper number group, the thousands digit, TH0-9, plus an operated number series, NSS0-5, relay closes battery to one of the sixty punchings ST0-9 associated with the NSS0-5 relays. This punching is cross-connected to one of the ST00-39 punchings associated with the "ST" start lead for the number group connector. This causes the number group to be connected through the number group connector to the marker (FS-83, SD-26002) (OS 721-1).

Number Series Selection

9.04 A "number series" can be defined as a block of 10,000 numbers, 0000 to 9999 and one marker group is capable of handling four number series or a maximum of 40,000 numbers.

9.05 The markers are arranged to handle as many as six office codes, or office divisions. An office division, or code, may use the full 10,000 numbers of a number series. If an office division does not use a full 10,000 numbers, then two or three office codes can use the same number series division providing the hundreds digit within a number group does not conflict, and the office codes are served by the same "A" or "B" number group division.

9.06 The number groups are divided into "A" and "B" subdivisions with physical, theoretical and extra theoretical divisions in each of the "A" and "B" groups. Corresponding indications from the number group translation on PN, TN, or EN leads indicates the office division of the called number. The information is matched against the office division information the marker used in selecting the number group to operate the check relay.

Operation of Number Series Relay

9.07 The number series relay windings are associated with NSS- punchings and the office code group punchings are cross-connected to these punchings to operate the proper number series relay (FS-81, SD-26002).

Number Group Seizure

9.08 Each number group circuit has a preference control and make-busy circuit and a number group connector circuit associated with it.

9.09 The preference circuit consists of two chains of relays, one relay in each chain for each marker, and a transfer circuit to make operative one chain or the other. The transfer is brought into play either automatically in case of certain troubles or manually when it is desired for maintenance purposes. The preference control is used by the marker to gain access to the number group and its purpose is to permit only one marker to have access to a particular number group at a time. The preference relays operate the multicontact relays in the number group connector circuit.

9.10 The control circuit permits only one marker to have access to a particular number group connector at a time.

9.11 The number group connector is a circuit which connects the marker to the number group circuit. The connector consists of a set of five wire spring multicontact relays designated MCA to MCE for each marker circuit. These relays provide the necessary leads between the marker and the number group circuit. Only one set of these relays associated with one marker are operated at one time under control of the preference control circuit.

9.12 In each preference control circuit there is one MP- (regular marker preference) relay per marker in one chain and one E- (emergency marker preference) relay per marker in another chain. These relays are under control of the battery closure to the ST- lead from the associated marker.

9.13 Assuming that an intermediate marker has operated its MP- relay, lower numbered marker MP relays cannot operate since these are cut off by the contacts of the operated MP relay but higher numbered markers can operate their MP relays. These relay winding chains and work contact chains prevent more than one marker from seizing the same number group connector at a time. When the connected marker releases its MP relay and MP relays for higher numbered markers are operated, the next higher numbered marker will be served.

9.14 After the marker seizes a trunk link frame, it seizes the number group. In order to do this, the following six conditions must be established:

Condition	Checked by Relays
Trunk link frame control relays operated in marker	TLC1 and 2, operated (FS-33)
Marker has seized trunk link frame for intraoffice call	TFK1 and 2 operated (FS-24)
Grounds for marker to set up terminating stage provided	FLG operated (FS-33)
Battery for number group provided	SNG1 and 2 operated (FS-85)
Marker steered into proper number group	LPA, LTA, LEA, LPB, LTB, LEB, and associated NSS- (FS-40, 81)
Relays RIA, TBIA & BNA have not operated falsely	SP normal (FS-37, 89)

9.15 The operation of the LPA, LTA, LEA, LPB, LTB or LEB relay operates an NSS- relay (OS 721-1) (FS-81, SD-26002). Two out of the five operated TEO, 1, 2, 4, and 7 relays determine which number group is to be seized. Contacts of these relays extend battery with the aid of the NSS- relay to an STO-9 (start) lead which is cross-connected to one of the number group STOO-39 (start) leads to operate the MP (marker preference) relay in the preference control circuit (OS 721-1).

9.16 The operation of the MP- relay grounds the MC lead to the number group connector and causes the operation of the MCA relay under control of a chain circuit through normal MP- relays in lower preference circuits unless it is the lowest preference circuit. This operates the MCB, MCC, MCD and MCE relays in the connector which closes through the leads necessary for completion of the call between the marker and the number group. The NGK and NGK1 (number group check) relays operate in the marker to indicate the seizure of the number group (FS-1, SD-26035) (FS-85, SD-26002) (OS 721-1).

Number Group Translation

9.17 Each directory number of the 1000 numbers in a number group has three punchings (L, G, and F) assigned to it. One of each of these punchings is located in the three cross-connecting fields. A typical cross-connection

arrangement of the translator fields is shown in Fig. 4. The bottom field serves to identify the line link frame number and is called the LL field. The middle or RF field identifies the ringing combinations and vertical file. The top or VHG field identifies the vertical and horizontal groups.

9.18 In order to simplify the description of locating a called line, let us assume that the number ME 3-2909 was dialed. The office code registration and the number group selection by the thousands digit is described in previous paragraphs. Therefore, we are only concerned at this time with the last three digits (909).

9.19 Since the hundreds digit is 9, the tens digit is 0, and the units digit is 9, relays HN2 and HN7, T4 and T7, and U2 and U7 in the marker are operated. The operation of these relays connects 48-volt battery to the following number group leads (OS 722-1).

(a) The HB9 lead to operate relay HB9 (hundreds block).

(b) The TB0 lead under control of the PN (physical number), PTN (physical and/or theoretical number), TN (theoretical number), or EN (extheo number) relay to operate relay TB90 (tens block) (FS-92, SD-26002).

(c) The U9 lead under control of relay UC (units cut-in) to operate relay U9 (units).

9.20 The operation of an HB- and a U- relay causes the following relays to operate (OS 722-1):

(a) The HB- relay operates relay PN, PTN, TN, or EN.

(b) The HB- relay also operates relay TBW (tens block wetting) in series with a TB- relay.

(c) The U- relay operates relay UK (units check). When relays UK and TBW operate, relay HTUK (hundreds, tens, units check) operates, allowing the call to be completed in the normal manner.

9.21 When relay NGK1 in the marker operates and relays HB9, TB90, and U9 in the number group operate, 48-volt battery is connected to the directory number punchings L909, G909, and F909. The battery path is over the WL, WG, and WF leads (FS-96, SD-26002). The L, G, and F punchings associated with each directory number are cross-connected to LL, VHG, and RF punchings in the translator fields, in accordance with the locations of the line hold magnet on the line link frame. In the assumption under discussion, these three punchings are cross-connected to the translator field punchings in the following manner, L909 to LL39, G909 to VHG11-9, and F909 to RF15-4. From this information, it is seen that the directory number ME 3-2909 is located on line link frame 39, in vertical group 11, in horizontal group 9, in vertical file 4, and that it uses ringing combination 15.

9.22 The frame number is indicated to the marker over two sets of leads. A set of four FT leads indicates the tens digit of the frame number, and a set of ten FU leads indicates the units digit. Thus, for the line link frame number, it is necessary to convey two pieces of information. From

this it may seem that two cross connections are required, one for each piece of data. By the use of a resistor network, however, it is possible to provide these two pieces of data with only one jumper connection.

9.23 Each of the line link frame number terminations to which the directory numbers are cross-connected is associated with the frame tens and units leads to the marker through a pair of resistors. Thus, when battery is applied to punching LL39, a current flows through the FT resistor to the FT3 lead into the marker, where it is recognized as a frame in the thirties; current also flows through the FU resistor to the FU9 lead into the marker, where it is recognized as a frame with a 9 units digit. The resistor networks are described more fully later under Called Line Information Transfer to the Marker.

9.24 A similar arrangement is used for combining the vertical and horizontal group information and also for combining the vertical file and ringing combination information.

9.25 As stated before, the directory numbers in some offices are divided into groups. All of the numbers within the same hundreds block can be assigned to only one of the groups. It may be desirable to provide some of the directory numbers with nonrestricted service; these numbers are known as nondiscriminating numbers. When the numbers in an office are not divided into groups, all numbers are assumed to be physical, and relays TN, EN, and PTN are not provided.

9.26 Each HB- relay in the number group has a contact wired to a PT (physical-theoretical) punching. This punching is cross-connected to a PN, PN1, TN, TN1, EN, EN1, PTN, or PTN1 punching (FS-14, SD-26034). When one of these punchings is grounded by the operation of the HB- relay, the associated relay operates, provided that the physical, theoretical, or extheo indication received from the office code dialed agrees with the physical, theoretical, or extheo indication received from the number group. If the indications agree, the call is completed; if they do not agree, the call is routed to a no-such-number tone trunk or to an operator.

9.27 Under certain conditions, parts of two different thousands series of numbers are placed in one number group. For example, official and coin lines are usually placed in the 9000 series. In offices having less than 9000 numbers, these lines will have to be placed in another number group. When the number group serves a single thousands series of numbers, the PT terminal is cross-connected to the PN, TN, EN, or PTN punching, depending on whether the hundreds block contains physical, theoretical, extheo, or nondiscriminating numbers. When the number group serves two different thousands series of numbers, the numbers in the original series of the partly used thousands series are cross-connected as above. In the added thousands series, the PT punching is cross-connected to the PN1, TN1, EN1, or PTN1 punching.

9.28 Ground on a PN, TN, EN, or PTN punching in the number group operates a similarly designated relay in the marker. Ground on a PN1, TN1, EN1, or PTN1 punching operates the corresponding PN, TN, EN, or PTN relay, provided that relay AST (A series start) is operated.

9.29 If the office code dialed is a local physical number in Office A, relay LPA is operated. If the dialed numericals also represent a physical number, the number group indicates this fact to the marker by operating relay PN. Since

the office code and the numericals match, the ground from a contact of relay LPA through a contact of relay PN operates the PTK (physical and theoretical check) relay. This permits the call to proceed.

9.30 If, through error or in order to avoid paying an extra charge, the office code dialed is a local physical number in Office A and the numericals dialed represent a theoretical number in the same office, a blank number is indicated. The office code dialed causes the operation of relay LPA. Since the numericals dialed represent a number assigned for theoretical numbers, relay HB- operates relay TN. Relays LPA and TN together operate the BN (blank number) relay. Now the call is routed to a no-such-number tone trunk or to an operator. This same matching operation also applies to relays LPB, LTA, LTB, LEA, and LEB.

9.31 If the office code dialed is a local physical number in Office A, relay LPA is operated. If the dialed numericals also represent a physical number in an added thousands series, relay AST is operated (FS-61, SD-26002). The number group grounds the PN1 punching and operates relay PN in the marker. Since the office code and numericals match, the marker operates relay PTK and permits the call to proceed. If relay AST were not operated, the ground on punching PN1 operates relay BNTH to route the call to a no-such-number tone trunk or to an operator.

9.32 If the called line is connected as a nondiscriminating number in the number group, the call is completed regardless of whether the physical or theoretical office code is dialed. For this condition, relay PTN is operated and ground is connected directly to relay PTK, which permits the call to proceed.

9.33 Different treatment of directory numbers can be given by the omission of one or more of the cross connections between the L, G, and F and the LL, VHG, and RF punchings. Numbers can also be blanked out by cross-connecting the PT punching to the BNK punching (FS-14, SD-26034). In this manner, groups of 100 to 1000 numbers can be omitted. Blank, permanently busy, intercepted, and free numbers are treated in this manner.

9.34 There is another function that the number group performs for the marker, that is, indicating when terminal hunting is required. Some of the lines of any number group may be PBX trunks. For those lines, cross connections for PBX and terminal hunting groups are made in the marker in order to gain access to the sleeve leads that are required for terminal hunting.

10. Called Line Information Transferred to the Marker

10.01 When 48-volt battery is connected to the L909, G909, and F909 punchings as previously described, the following relays in the marker operate (OS 722-1):

FUN9 (frame units number 9)
FTN3 (frame tens number 3)
HGN9 (horizontal group number 9)
VGN11 (vertical group number 11)
VFN4 (vertical file number 4)
RCN15 (ringing combination number 15)

These relays are connected through the resistor networks to the translator fields. Although there is a multiplicity of parallel paths in these translator fields, the current through any relay can be calculated from the information shown in Fig. 5. About nine-tenths of the current flows through the relays, which should operate, and about one-tenth of the current flows through each of the remaining relays in parallel, which should not operate. The FUN-, FTN-, HGN-, VGN-, RCN-, and VFN- relays have a high nonoperate adjustment. They are sensitive enough to permit two of them to operate in parallel if a cross develops between two of the information leads to the marker. This is necessary in order to give a trouble indication and to prevent the selection of a wrong number.

11. Trunk Selection

Trunk Blocks and Trunk Groups

11.01 The trunks connect to horizontals or levels on trunk switches on the trunk link frame. There are two trunk appearances per level for levels 2 to 9 on the 10 trunk switches. The two appearances per level are obtained by using a 6-wire switch and operating a T0 or T1 select magnet (Position 0 or 1 respectively) in addition to the T select magnet associated with the level on which the trunk appears. The T0 or T1 select magnet controls crosspoints which connect the link to one or the other of two vertical multiples each consisting of a tip ring and sleeve (OS 709-1). The trunk select magnet T controls crosspoints which connect two horizontal tip, ring and sleeve multiples (corresponding to two trunk appearances) to the two vertical multiples, but, as was just explained, only one vertical multiple is connected to a link. In this manner we have effectively obtained 16 trunk appearances per switch or 160 trunk appearances per frame. The trunks that have their connection to the marker predetermined are assigned to 40 of these appearances. For example, an incoming trunk from another office, when used on a call, is identified to the marker, and the marker must connect to this particular trunk to assist the call. The remaining appearances (120) are assigned to originating registers and those trunks which the marker may select. For example, the marker may use any idle intraoffice trunk of the proper type or any idle outgoing trunk of the proper type (AMA, flat rate, coin, etc.) that connects to the desired completing office.

11.02 Appearances connected by a T0 select magnet are called A appearances and those by a T1 select magnet, B appearances.

11.03 Associated with each A appearance is an FA relay and with each B appearance an FB relay. These relays are effectively trunk connector relays and are operated by the F relay in the trunk. Intraoffice trunks require two appearances on the same trunk link frame and on the same level but on different switches. The calling end is on an A appearance and the called end is on a B appearance. The B appearance is on a switch one higher in number than the one containing the A appearance. Incoming trunks and other trunks requiring ringing are on B appearances. Registers, outgoing trunks and other trunks handling outgoing calls may be on either A or B appearances.

11.04 Trunks requiring ringing have a hold magnet on a ringing selection switch. The proper ringing combination is set by operating select magnets on this switch.

11.05 Access to these magnets is obtained through the trunk link frame connector and level connector relays. The 10 verticals of a ringing switch are associated with one level on the 10-trunk switches of one trunk link frame.

11.06 The 120 appearances or outlets are assigned to trunk blocks (TB0-5) which consist of twenty trunks and/or registers each. In addition to the originating registers, one or more types of trunks may be assigned to this same trunk block. In order to differentiate these from each other, and from registers, a further subdivision of twenty test groups (TG0-19) is provided. Originating registers and each trunk of a group, within one trunk block, are assigned to different test groups, therefore, a particular route may be considered as identified by the combination of TB number (corresponding to TB relay number) and TG number (corresponding to TG lead number) associated with it.

11.07 In the trunk link circuit there is an F punching associated with the F lead of each trunk and a TG punching associated with the TG lead from the marker. All of the F punchings associated with the same trunk group are connected to the same TG punching (OS 718-1) (FS-1, SD-26032).

11.08 The F relays for intraoffice trunks are connected to the TB4 or TB5 relays and are always associated with levels 6, 7, 8 or 9.

BT Leads

11.09 In the trunk each F lead is connected through an F relay winding, through contacts, which are open while the circuit is busy, and then to a BT punching. These BT punchings are connected to contacts of the TB relay associated with the level on which the trunks appear. The BT punchings of intraoffice trunks are always connected to the TB4 or TB5 relay (OS 718-1).

11.10 Although an intraoffice trunk has both an A and a B appearance, the selection of the trunk is determined by the condition on the BT lead associated with the A appearance.

Testing and Seizure of Idle Intraoffice Trunk

11.11 Before selecting the trunk link frame the marker has determined that one or more intraoffice trunks are available for use.

11.12 Following seizure of the trunk link frame, the marker determines which intraoffice trunks are idle, and then selects one that is idle.

11.13 Battery from the marker operates the TB4 or TB5 relay in the trunk link circuit when the connector cut-through relays operate. The operation of the TB- relay is checked by relay TBK (trunk block check) in the marker (FS-27, SD-26002).

11.14 When the TLC1 relay operated in the marker it permitted the marker to determine that none of the TS0-9 (trunk select) relays were operated by the operation of the TSE1-2 (trunk select end) relays. This check insures that the marker will first test for and then select an idle trunk. The operated TSE1-2 relays provide battery for testing and selecting an idle trunk.

Test for an Idle Trunk (OS 718-1) (FS-27, SD-26002)

11.15 When the TB4 or TB5 relay has operated the BT leads are extended to the marker to permit testing for an idle intraoffice trunk. Ground is extended from the marker TGP or TGS relay (controlled by an even or odd numbered TG relay) through the TG- relay to the TG- punching in the trunk link circuit. This punching is cross-connected to the F punchings associated with all the intraoffice trunks on the selected trunk link frame. Idle trunks will extend ground back into the marker over the "BT00-19" leads to operate the associated TT0-9 (trunk test) relays.

11.16 The TT0-9 relays are double wound with each of the windings being associated with one of the "BT" leads. An idle trunk is indicated by the operation of a TT relay.

11.17 Due to the use of the double wound TT relays it should be understood that the operation of a TT relay does not alone indicate the particular trunk that is idle. The marker must determine which one of the two "BT-" leads is grounded with an odd and even preference scheme.

Trunk Selection (FS-28, SD-26002)

11.18 When the TSE1, TBK, and MAK1 relays have operated, ground is extended through the operated or unoperated SQ0 (sequence) relay through an operated JSQ0-5 (junctor sequence) relay to the TT0-9 relay operated to operate a TS (trunk select) relay. The operated TS relay locks under control of the TLC1 relay, releases the TSE1-2 relays which in turn release the TT0-9 relays.

11.19 The JSQ0-5 relay circuit tends to distribute the traffic handled by the marker among the trunks.

11.20 With the operation of the TS relay, marker selection of a trunk is directed to one of the two trunks that may be associated with these two "BT-" leads which appear on a particular TT relay. These leads which indicate idle trunk circuits when grounded are extended to an OTS (odd trunk selection) and an ETS (even trunk selection) relay to permit selection of one of the two leads. If at this time only one of the two leads is grounded the operated or unoperated condition of the TZ (trunk sequence) relay has no significance. Therefore, if the odd BT- lead is grounded the OTS relay operates, and if the even BT- lead is grounded the ETS relay operates. If however the BT- leads are both grounded, then the operated or unoperated condition of the TZ will determine the selection of either the OTS relay or the ETS relay.

Preference Lockout Circuit (OS 718-1) (FS-27, SD-26002)

11.21 The ETS and OTS are double winding relays in which the current through the primary 10-ohm winding is in a direction to operate the relay, and the current through the secondary 200-ohm winding tends to nonoperate the relay. When both windings are energized the current through the 200 ohm or biasing winding is of sufficient magnitude to hold the relay released. If the TZ relay is nonoperated the bias winding of the ETS is opened. Therefore, with ground on both the odd and even BT- leads the ETS relay would operate and the OTS relay would be biased to nonoperate.

11.22 However, if the TZ relay was operated, the OTS biasing winding is opened and the OTS relay would be preferred.

11.23 Operation of either an OTS or ETS relay opens the operating circuit of the other relay.

11.24 For trouble recording purposes an OT (odd trunk) relay would operate on odd trunk selection. The operated or unoperated condition of the OT relay and the selected trunk TS- relay will give an indication of which trunk was selected.

11.25 The busy tests were made with high resistance marker relays which would not operate the 16-ohm frame cut-through relay of the trunk.

11.26 The operation of the OTS or ETS relay changes the high resistance to low resistance which locks the OTS or ETS operated and operates the frame F- cut-through relay of the trunk.

12. Release of the Number Group

12.01 The number group translates the numerical registration of the directory number and transfers it to the marker. This operates one of each of the FUN-, FTN-, HGN, VGN-, VFN-, and RCN- marker relays (OS 722-1). These relays operate their corresponding test relays FUT- (frame units test), FTT- (frame tens test), HGT- (horizontal group test), VGT- (vertical group test), VFT- (vertical file test), and RCT- (ringing combination test) (OS 724-1). Each of the test relays operates one of the locking relays FUL, FTL, HGL, VGL, VFL and RCL which lock under control of relay LLI (line lock identification). This relay later releases the test relays so that they can be used in the originating stage of this call.

12.02 After the called line location is recorded in the marker, the number group is released. This is done when the line identification locking relays in the marker cause the operation of the RNG (release number group) relay (OS 724-1). Relay RNG operates relay NR (number release), which releases relay NSS- and relay N- (FS-81, SD-26002). The operation of relay RNG also releases relays SNG1 and SNG2 (OS 721-1). Relay SNG2 releases the MP- relay in the preference control circuit, thereby releasing the number group connector and number group circuit.

13. Selecting the Line Link Frame - Call-Forward Linkage

13.01 After the location of the called line is identified, the marker connects to the line link frame and tests the called line for a busy condition. If the called line is idle, the marker assists in the connection from the selected intraoffice trunk to the called line. The called line information received from the number group is used to direct the marker to seize the line link frame that contains the called line.

13.02 Each line link frame has a preference control and make-busy circuit and a line link connector circuit associated with it.

13.03 The preference circuit consists of two chains of relays, one relay in each chain for each marker, and a transfer circuit to make operative one chain or the other. The transfer is brought into play either automatically in case of certain troubles or manually when it is desired for maintainance purposes. The preference control is used by the marker to gain access to the line link frame and its purpose is to permit only one marker to have access to a particular line link frame at a time. The preference relays operate the multicontact relays in the line link connector circuit.

13.04 The control circuit permits only one marker to have access to a particular line link connector at a time.

13.05 The line link connector is a circuit which connects the marker to the line link frame. The connector consists of four wire spring multicontact relays designated MA1, MA2, MB1 and MB2 for each marker. These relays provide the necessary leads between the marker and the line link frame. Only one set of these relays associated with one marker are operated at one time under control of the preference control circuit.

13.06 In each preference control circuit there is one MP- (regular marker preference) relay per marker in one chain and one E- (emergency marker preference) relay per marker in another chain. These relays are under control of the battery closure to the ST- lead from the associated marker.

13.07 Assuming an intermediate marker has operated its MP- relay, lower numbered marker MP- relays cannot operate since these are cut off by the contacts of the operated MP- relay, but higher numbered markers can operate their MP- relays. These relay winding chains and work contact chains prevent more than one marker from seizing the same line link connector at a time. When the connected marker releases its MP- relay and MP relays for higher numbered markers are operated, the next higher marker will be served.

13.08 Previously, it was assumed that the called line is located on line link frame 39. Therefore, with relays PTK, RCL (ringing control lock), FTT3, and FUT9 operated, 48-volt battery is connected to the ST-39 (start) lead (FS-5, SD-26002). This lead is wired to the preference control circuit associated with the line link connector for line link frame 39 to operate the MP- relay associated with the marker.

13.09 The operation of the MP- relay grounds the MC lead to the line link connector and causes the operation of the MA1 relay under control of a chain circuit through normal MP- relays in lower preference circuits unless it is the lowest preference circuit. This causes the operation of the MA2, MB1 and MB2 relays in the connector which closes through the leads necessary for completion of the call between the marker and the line link frame. The LFK (line frame check) relay operates in the marker to indicate the seizure of the line link frame (FS-1, SD-26031) (FS-5, SD-26002).

14. Operation of the Called Line Identification Relays

14.01 The operation of the HGT- relay in the marker operates an HGA- and HGB- (horizontal group) relay in the line link and marker connector control circuit (FS-2, SD-26030). These horizontal group relays cause the operation of the HGK (horizontal group check) relay in the marker.

14.02 The operation of the VGT- relay in the marker operates a VGB- (vertical group auxiliary) relay in the line link and marker connector control circuit (FS-2, SD-26030). The VGB- relay operates from direct ground if the marker group is arranged for a maximum of 30 classes of service, or from ground in series with a CGA or CGB relay in the marker, if the marker group is arranged for 60 classes of service.

14.03 With the HGA-, HGB- and VGB- relays operated a path is closed from the line group relay LG- to the "BS" lead. However, the "BS" lead does not have battery connected to it by the marker until the marker HGK relay has operated (OS 705-1). After the HGK relay operates then the LG- relay in the line link and marker connector control circuit operates (OS 705-1).

14.04 With the LG- relay and the VFT- relay in the marker circuit operated a partial path is closed to the L- hold magnet. The completion of this path is described under Select and Hold Magnet operation.

14.05 The operation of relays FTK1, HTK1, and VTK1 in the marker checks that only one of each of the VFT-, HGT-, and VGT- relays, respectively is operated (FS-6, 7, 8, SD-26002).

14.06 The foregoing description shows how the hold magnet associated with the directory number ME 3-2909 is found to be in vertical file 4, horizontal group 9, and vertical group 11 of line link frame 39.

15. Selection and Application of the Ringing Combinations

15.01 In providing telephone service, it is often necessary to connect more than one customer to a single line (party lines). This makes it necessary to supply different types of ringing codes in order to identify the party called. A party who has full selective ringing hears ringing only when his station is being called. A party who has semiselective ringing hears ringing for his own and one other station. On individual, 2-party, and 4-party full selective lines, therefore, each party hears only his own ringing, while on 4-party and 8-party semiselective lines, he hears also the ringing for one other party. However, on 10-party lines, he hears the ringing for four others.

15.02 On party lines, one half of the stations are arranged to be rung over the ring conductor and one half over the tip conductor. Ringing current is 20-cycle current superimposed on a negative dc component to permit the tripping relay to operate when the party answers. However, on 8-party semi-selective lines and 4-party full selective lines, a further limitation in the ringing a party hears is made possible by superimposing the interrupted 20-cycle ringing current on either negative or positive direct current. To specify a ringing code completely, it is therefore necessary to state the side of the line to which ringing is applied, whether it is negative or positive superimposed, and the particular code to be used. These various ringing selections and ringing combinations are shown in the tables on (OS 725-1).

15.03 Crossbar switches are used to apply ringing current to the trunks. One 10-vertical crossbar switch is used for each ten trunks per trunk link frame, per level, which requires ringing. Each trunk circuit is connected to a switch vertical through which any one of the required types of ringing is selected.

15.04 The number group selects the ringing combination for a particular line and passes it to the marker. This was previously described with the assumption that the RCN15 relay operated. The marker sets up the ringing condition on the selection switch and then transfers the control of the ringing to the intraoffice trunk.

15.05 Levels 0 and 1 on the crossbar switch are used to apply ringing to either the tip or ring conductors of the line and ground to the other conductor. Levels 2 to 8 select the types of ringing supplied by the ringing power plant. Level 9 is used to indicate busy and overflow conditions. Each ringing selection requires that two out of ten of the select magnets are operated.

15.06 When an RCT- relay in the marker operates to select the ringing combination, it operates two of the RS- (ringing select magnet) relays (OS 725-1). Each of these relays operates one of the select magnets on the ringing selection switch through the previously operated LV- (level connector) relays. Battery is connected either to the SM0 or SM1 select magnets to determine whether the ringing is to be placed on the tip or ring of the trunk. Similarly, battery is also connected to one of the RS2 to RS8 leads to operate one of the select magnets that determines the ringing code.

15.07 As a check that one of the ringing selection switch select magnets has operated, relay RSK (ringing switch select magnet check) in the marker is operated (OS 725-1). Only one operated select magnet is necessary to operate relay RSK. The operation of relay RS0 or RS1 and the associated select magnet, or the operation of one of the relays RS2 through RS9 and the associated select magnet, is delayed until after the operation of relay RSK.

15.08 The operation of relay RSK operates relay SRK (start ringing check), which in turn operates relay LI (line idle). When relay LI operates, it extends resistance ground from the marker to the selected intraoffice trunk to operate its RC (ringing control) relay.

15.09 Relay RCK1 (ringing switch check) checks the closure of the ringing selection switch crosspoints (OS 725-1). When relay CKG6 operates at the beginning of the call, 210-ohm battery is connected to the negative punching of the primary winding of relay RCK1. Relay LI connects 20-ohm ground to the same terminal. This causes the negative terminal to be positive with respect to the 48-volt battery voltage. The positive terminal of the primary winding is connected to 48-volt battery through the RC relay winding. Since the positive terminal is thereby placed at a lower voltage than the negative terminal, the current through the primary winding prevents the operation of relay RCK1. When the ringing selection switch crosspoints are closed, a holding ground is supplied over the G lead to relay RC in the trunk via the RA lead. This holding ground on relay RC is extended over the RC lead to the positive terminal of the primary winding of relay RCK1. The resulting current is in the proper direction to operate the relay. Therefore, relay RCK1 operates as a check that the ringing selection switch crosspoints have closed. The closure of the ringing switch crosspoints also connects the selected ringing current and ground to the tip and ring of the trunk, in series with its RT (ringing trip) relay. Finally, ground on the G lead in the trunk circuit is connected through the crosspoints and returned on the RA lead. This ground holds the trunk in the ringing condition until ringing is tripped or until the call is abandoned.

15.10 With code 1 ringing, there is no possibility of the code being misinterpreted, since it consists of only one ring. If the first ring is shorter than the others, no confusion results. Therefore, the code ringing supply is connected at once without waiting for the end of the ringing cycle. The PU (pick-up) relay in the trunk is operated immediately from ground on the PKU lead. On calls that require other than code 1 ringing, relay PU is operated from the pick-up ground after relay F releases. This insures that ringing starts on the beginning of the ringing cycle, and thereby avoids the connection of a clipped ringing code to the trunk. Ringing of the called line, however, does not take place at this time because the T and R leads to the line are kept open by the operated FB-- (B appearance trunk) connector relay. These relays are under control of the F relay in the trunk. Relay F does not release until various channel, junctor, and double connection tests for both the originating and terminating connections are completed.

16. Class Information and Class Check

General

16.01 On some intraoffice calls, the marker operates relays to set a charge condition in the trunk, to identify tip or ring party or to identify class of service of calling subscriber. On some other intraoffice calls, the marker does not have to send class information to the trunk. Just what information the marker passes to the trunk and whether it need pass any class signals at all are determined by the type of intraoffice trunk circuit and the calling subscriber's class of service.

16.02 The route series relay determines what, if any, information is sent to the trunk. Therefore, when the marker cross connections are laid out, the route series relay is chosen so that it fills the requirements for class signal (information) to the trunk. While some of the route series relays have descriptive names (NCNC - noncharge, noncoin, etc.), these names should not be accepted as a criterion for their use. The route series relay is chosen because it causes the marker to ground certain class leads or not to ground any leads. Reference sheet RM 702-1 is a table which lists various trunk circuits, including intraoffice, gives the conditions under which the trunk requires or does not require class signals, and also shows the marker relays involved. The student will find this table helpful in understanding the selection of route series relays used on the route relay (OS 716-1).

16.03 Where the marker does send class information to a trunk, it operates a class ground supply relay (CLG) and operates a relay in the trunk and one of its own relays from the same ground. It operates a timer to give the trunk a chance to lock operated its class relay. The trunk returns ground to the marker on the same lead. This ground from the trunk holds the marker class relay operated after the marker cuts off the original ground supply (CLG) relay. Then the marker makes a check to see if its class relay is still operated.

16.04 When no class ground is sent to the trunk, the marker operates a no-class check (NOC) relay. On any originating call, a marker must operate either the class check (CLK) relay or no-class check (NOC) relay.

Flat Rate Call

16.05 Now let us take some practical examples of class check operation. On OS 716-1, Sheet 2, we have the route relay cross connections for intraoffice routes. Three kinds of intraoffice trunks are represented: flat rate, message rate (AMA) and coin. First we shall discuss a flat rate subscriber in either PO-5 or PO-6 making an intraoffice call. The operated route relay is R10, the route series relay is NCNC. The table on RM 702-1, indicates that NCNC does not send class information grounds to the trunk (no-class leads grounded) since we have a flat rate customer calling a route which is a free call using a flat rate trunk. There is no need to "set" any of the conditions mentioned in the first paragraph. On SD-26002-01, FS-42, we should be able to operate the no-class check (NOC) relay. Here is its operating path; an underlined relay is normal.

NOC — CLT1, AMA4, CLG, NSI, SON, (RP, TP) or (RP, TP), TC, CNC, NCNC, OPR, BL, VP, CAA.

The operated NOC relay satisfies the marker that no class was transmitted to the trunk.

Coin Charge Call

16.06 If we consider a coin subscriber in either PO-5 or PO-6 making an intraoffice call, the route relay is R20 and the route series relay is TCNC (talk charge, noncoin). This is one of the instances where the route series relay name does not fit the case since our subscriber is coin. The reason for this is that the intraoffice trunk represented by R20 is a coin intraoffice trunk (SD-26064-01, for instance). It has a TC lead but no CN lead. It is designed to handle only coin traffic; it does not require a coin signal. Route series relay TCNC provides a ground on the TC (talk charge) lead to the trunk.

16.07 On this call, we can't find a path for operating NOC relay on FS-42. However, later in the call when the RCK3 relay operated, it closed a path for operating the CLG (class ground supply) relay. On FS-43, CLG operates TC through contacts of TCNC.

TC — TCNC, FNB, FNA, VP, PBY, CAA, CLG.

This same ground goes through normal TOS and normal TER2 to the TC lead of the trunk operating the trunk TC relay. The trunk TC relay locks and returns ground on TC lead to hold operated the marker TC relay. On FS-42 the CLG operates the CLT (class ground timer) relay. The CLT operates CLT1 which releases the CLG. The marker and trunk TC relays remain locked to ground in the trunk if the transfer of class ground has been successful. The CLT1 operates CLT2 and this closes a path for the CLK (class check) relay.

CLK — CLT2, AMA4, CLG, NSI, SON, RP, TP, TP, TPK, TC, FNB, FNA, CNC, TCNC, OPR, BL, VP, CAA.

The operation of the CLK satisfies the marker that class information has been successfully transferred to the trunk.

16.08 The process of class transfer and check for a message rate subscriber using a message register charge trunk is similar to the coin call just described. However, if the intraoffice message rate trunk is equipped for AMA operation, the process is different.

Message Rate Call

16.09 Suppose on OS 716-1, Sheet 2, a message rate class of service makes an intraoffice call. The operated route relay is R10 and the route series relay is MBS1 (message billing index No. one). On AMA charge calls, the marker does not send class information to the trunk. It does send tip or ring party identification to the outgoing sender. The sender, later on, passes this information to the AMA equipment. In order to check the transfer of the RP or TP to the sender, the marker goes through a class check process.

16.10 On AMA intraoffice calls, the marker selects an outsender. The sender does no pulsing, but is required for passing information from the crossbar equipment to the AMA equipment. The marker functions for selecting a sender on intraoffice AMA calls are the same as for outgoing calls. The details of this process are explained in Section 6. Those relays which would have been operated, by the time the marker makes class check, will be assumed to have been operated.

The marker operates the CLG relay on intraoffice AMA calls. Path of CLG starts on FS-42:

CLG — AMA4, RK3 (to FS-77) TGS2, AMA3, TGS1, ORK2, ORK1, KK (to OSC) MA, MB, SB, SA, SC, MC.

On FS-43, the operated CLG provides a ground for operating RPK (ring party check) if RP relay is operated, or TPK (tip party check) if TP relay is operated. Either RP or TP was operated when the originating register passed the calling subscriber's line location to the marker. The same ground operates either RP or TP in the sender, the sender RP or TP relay returns ground to hold operated the marker check relay RPK or TPK. The CLG operates the OST1 (out sender timer) on FS-77. OST1 operates OST which in turn operates OST2. A detailed explanation of the OST relay operation is in CD-26002-01. The operated OST2 releases the TGS1 and TGS2 on FS-77. The TGS1 and TGS2 open the operating path of the CLG relay.

On FS-42 we can operate the CLK relay when the CLG releases. The path is:

CLK — AMA4, CLG, NDK, NSI, SON, (RP, TP) or (RP, TP), (TP, TPK), (RP, RPK) or (TP, TPK), (RP, RPK) AMA, AMA4.

The operated CLK relay indicates to the marker that it has successfully transferred tip or ring party information to the sender. The marker checks the class check results when it operates the DCT2 relay. Either NOC or CLK must be operated to operate DCT2 relay.

17. Channel Test and Selection

General

17.01 The marker has seized a trunk link frame that has idle intraoffice trunks and is connected to one of these trunks. The marker is also connected to the line link frame that has the called line appearance. Now the marker proceeds with the selection of the connecting path from the trunk to the called line.

17.02 There are at least half as many trunk link frames as line link frames. Each line link frame terminates 100 junctors and each trunk link frame terminates 200 junctors. Depending on office size, there are ten to fifty junctors common to a line link frame and a trunk link frame. They are divided into subgroups, the first containing ten and the others ten or fewer junctors. For offices with more than twenty line link frames, extension trunk link frames are provided. They allow a pair of trunk link frames to share a group of junctors, thereby maintaining at least ten junctors available for connections to each line link frame.

17.03 In selecting a channel, the marker tests:

(a) The ten line links on the line switch connecting to the called line.

(b) A subgroup of junctors to the trunk link frame connecting to the intraoffice trunk.

(c) The ten trunk links from these junctors to the trunk switch connecting to the intraoffice trunk.

By testing the ten channels formed by these elements, the marker selects an idle channel for the connection.

17.04 If no channel is found, the marker steps the junctor subgroup selection and again makes channel test. If this fails or if there is only one subgroup, another ~~register~~ trunk is seized and channel selection is again attempted (marker recycle).

Junctor Distribution (FS-12, 13, 14, 17, SD-26002) (OS 707-1)

17.05 Office size determines junctor distribution. When junctor distribution is uniform for all frames, the operation of relay TLC1 (trunk link control) operates one of the 2TLF-10TLF relays via the SZD to SZ- cross connection. Relay TLC1 also operates relay STF (single-trunk link frame) or relay PR (paired-trunk link frame) via the SPF to SF or SPF to PR cross connection. The 2TLF-10TLF relay indicates how many trunk link frames or pairs of frames are in the office, therefore, the junctor distribution is indicated. The STF or PR relay indicates single frames or pairs of frames. In addition to these relays, auxiliary indication of office size is given by relays 20F (maximum of 20 line link frames), 40F (21 to 40 line link frames), 7Q (7 quad) for 7 trunk frames or pairs of frames, or RQ (regular quad) for 6, 8 or 9 trunk link frames or pairs.

17.06 During changes in office size, the trunk link frames are arranged for different junctor distribution. As the work progresses some trunk link frames will have junctor distributions corresponding to the new office size, some to an intermediate size, and some to the original size. For example, suppose that the 10 line link - 5 trunk link frame office is to be expanded to the 12 - 6 office. In the 5-trunk link frame size the junctor groups contain twenty junctors, ten in each subgroup. The change in distribution resulting from the addition requires the removal of some of the junctors from the second subgroup to form new junctor groups to the added line link frames. During this work the subgroup is unusable. To prevent the selection of this subgroup, the trunk link frame is temporarily arranged to indicate to the marker that it has the same junctor distribution as a trunk link frame in an office with ten trunk link frames, namely, only one subgroup of ten junctors. After completion of work on this frame, it is then arranged to indicate its new distribution - for an office with six trunk link frames.

17.07 For an office being expanded from 5 to 6-10 trunk link frames, relay 10TLF is used as an intermediate office-size relay; for expansion from 3 to 4 or 5 frames, relay 5TLF is used; and for expansion from 2 to 3 frames, relay 2TLF-3TLF is used. It should be noted that the 2TLF-3TLF relay is used only as an intermediate office-size relay.

17.08 During transition, the 2TLF-10TLF relays are operated via cross connections SZA, SZB, and SZC to SZ- in the marker and G to SZA, SZB, and SZC in the individual trunk link frames; punching SZD is not used during this period. When the transition involves adding extension trunk link frames to pair the frames, the G to SF or G to PR cross connection in the trunk link frame permits the operation of relays STF or PR in the marker until the changeover is complete.

Junctor Subgroup Selection (OS 706-1, OS 707-1) (FS-12, 13, 15, 17, 46, SD-26002)

17.09 The junctor subgroup to be tested depends on the frames to be connected, the junctor distribution, and the junctor sequence circuit setting.

17.10 As stated in 17.02, the number of junctors in a junctor group (particular trunk link to particular line link frame) may vary from a maximum of fifty junctors to a minimum of ten junctors. When the number of junctors in a junctor group is in excess of ten, the junctor group is divided into subgroups. Since a subgroup may contain from one to ten junctors, the number of junctor subgroups may vary from a maximum of five to a minimum of one.

17.11 The STP1 (stepping) relay and the JSQ0-5 (junctor sequence) relays control junctor subgroup selection for the first step. When more than one subgroup is provided, the second step in subgroup selection is controlled by the STP2 relay and the JSQ0-5 relays. The first selected subgroup always contains a full complement of ten junctors. The second selected subgroup may contain from one to ten junctors.

17.12 When the marker selects a subgroup which contains the full complement of ten junctors, the PNR (pattern normal) relay is operated. However, when the selected junctor subgroup consists of less than a full group of ten

junctors one of the junctor pattern tens digit number PA, PB or PC relays and one of junctor pattern units digit PO-9 relays will be operated to identify the junctor subgroup pattern and to identify the junctors within the junctor subgroup which are available.

17.13 The number of junctors within a junctor subgroup will vary from a maximum of ten junctors to a minimum of one junctor depending upon the office size and the selected junctor subgroups. The marker is equipped to simultaneously test ten separate channels therefore the marker must determine those channels which are incomplete because of nonexistent associated junctors within the selected junctor subgroup. The marker must then consider these incomplete channels unavailable so that the marker will not select one of these incomplete channels for service.

17.14 As outlined in 17.03, the marker tests the line links, trunk links, and junctors to select an idle channel. The test leads for 20 junctors, which are associated with a particular horizontal level on the trunk link frame junctor switches, are under control of a junctor connector relay JCO-19. Of the twenty junctors, ten are connected to the left half and ten to the right half ot the switches. The left half is controlled by relay L (left) and the right half by relay R (right). In single frame or paired frame offices the JCO-9 relays control horizontal levels 0 through 9 on the regular junctor switches. In paired frame offices, the JC10-19 relays control horizontal levels 0 through 9 on the extension junctor switches. When there are extension frames, relays EL (extension left) and ER (extension right) are also provided. The JCK relay operates in the marker as an indication that the JC- has operated on the trunk link frame (OS 707-1).

17.15 Each junctor in the subgroup has a J-test lead. By operating one JC- relay and either the L or R relay, the marker connects these leads to the CHTO-9 (channel test) relays. A busy junctor would cause the operation of the associated CHT- relay.

17.16 Relay R operates when relay JGO or JG3 and an odd-numbered FUT- relay are operated, or when relay JG1, 2, or 4, and an even-numbered FUT- relay are operated. Relay L operates from JGO or JG3 and an even FUT- or JG1, 2, or 4 and an odd FUT- relay.

Selection of the Group of Line Links(FS-46, SD-26002)

17.17 The operation of relay HG (A,B)- in the line, line link, and marker connector control circuit, as a result of horizontal group identification, connects the sleeves of the ten line links on the calling line switch to the windings of the CHTO-9 relays in the marker. A busy line link would cause the operation of the associated CHT- relay. The HGK relay in the marker operates as an indication that the HG (A,B)- has operated in the line, line link and marker connector control circuit.

Selection of a Group of Trunk Links (FS-1, SD-26032) (FS-45,46, SD-26002)

17.18 The operated F relay in the intraoffice trunk circuit operates the associated FA- (A appearance) and FB- (B appearance) relays in the trunk link circuit. The FBK relay in the marker operates as an indication that the

FB- is operated in the trunk link circuit. The operated FA or FB operates the LV6, 7, 8, or 9 (level) relay (intraoffice trunks appear only on levels 6, 7, 8, or 9).

17.19 Battery on the "BLC" lead from the marker operates the LC- (link connector) relay associated with the trunk switch where the B appearance of intraoffice trunk appears. The LCK relay operates in the marker as an indication that the LC- has operated in the trunk link circuit. Relay LC-, together with an operated L (left) or R (right) relay, extends the ten trunk links to be tested to the CHTO-9 relays in the marker; a busy trunk link would cause the operation of the associated CHT- relay.

Test Check (OS 708-1) (FS-44, SD-26002)

17.20 Before the marker proceeds with channel selection it first determines whether the necessary preliminary functions were performed. These functions are checked by the operation of relay TK (test check).

17.21 The following relays must be operated for this check to be successful:

Relay	Functional Meaning	Indication
FBK	(frame B appearance check)	Relay LV6, 7, 8, or 9 and an FB- relay are operated
RK or LK	(right- or left-half frame check)	Relay R or L is operated
HGK	(Horizontal group check)	Line link sleeves are closed through to the marker
LCK	(trunk link connector check)	Trunk link sleeves are closed through to the marker
JCK	(junctor connector check)	Junctor sleeves are closed through to the marker
TCHK	(test channel check)	One or more TCH- relays are operated

Channel Test (OS 706-1, 707-1, 708-1) (FS-46, SD-26002)

17.22 The channel test CHTO-9 relays are provided to test the sleeve leads associated with the selected group of junctors for a busy indication. Ground on any of the three leads associated with a particular CHT- relay indicates a busy channel and will operate the relay. The CHTO-9 relays will simultaneously test these three leads (line link, trunk link and junctors) to determine if the associated channel is busy. Therefore the operation of a CHT- relay indicates that at least one of the three linkages that make up the channel are busy and prevents the marker from selecting that channel for this call.

17.23 The windings of the CHTO-9 relays are connected to the sleeve circuit through the associated LO-9, JO-9, and TO-9 diodes, LO-9, JO-9, and TO-9 resistances through the back contacts of the CHO-9 relays and to the respective LLO-9, JC-9 and LHO-9 leads.

17.24 The diodes are used to prevent the high negative surges produced by the release of hold magnets, which had been associated with busy linkages, from reaching the winding of the CHTO-9 relays. A voltage divider effect is provided by the LO-9, JO-9, and TO-9 resistances. The LO-9, JO-9, and TO-9 capacitors reduce the transient voltages.

17.25 When the marker is normal a standing cross test is made on these leads by the XCH relay. During this period the negative side of the windings of the CHTO-9 relays is connected to the XCH relay. When the marker is off-normal the STX relay shifts the windings to battery potential.

17.26 The LL- (line link) relays do not operate during the terminating stage of the call.

Channel Selection (FS-44, SD-26002)

17.27 The CHO-9 relays are provided as channel select relays and are under control of the (channel test) CHT- and (test channel) TCH- relays.

17.28 It is necessary to delay the action of the selection CH- relay until all the CHT- relays have had sufficient time in which to operate. This delay function is performed by the operate time of the CHT (channel timer) relay.

17.29 After the TK relay operates, the CHT relay is delayed in operating until the CHT capacitor has been charged. When the capacitor is charged the effect of the secondary winding of the CHT relay is eliminated and it operates on its primary winding.

17.30 Following the operation of the CHT relay one preferred channel selection, CHO-9 relay, associated with a released CHT- relay, will be operated. This selects the connecting path associated with an idle line link, trunk link and junctor. The operated CH- relay operates the CHA and CHA1 relays. The CHA relay is used as an indication that a channel has been selected.

Channel Preference (FS-15, 44, SD-26002)

17.31 The original preference of the selection of the connecting path will be from the CHO relay being the most preferred, through the CH1 to CH8, to the CH9 relay being the least preferred. This preference will exist when the following cross connections are made.

"S"	punching	cross-connected	to	"IN0"
"M"	"	"	"	"	"OT4"
"M1"	"	"	"	"	"IN5"
"E"	"	"	"	"	"OT9"

17.32 To equalize life of equipment the original preference of selection of the CHO-9 relays will be rotated so that the preference will be from the CH5 relay being the most preferred, through the CH6-9, through the CH0-3, to the CH4 relay being the least preferred. This preference will exist when the following cross connections are made.

"S" punching cross-connected to "IN5"
"M" " " " " "OT9"
"M1" " " " " "IN0"
"E" " " " " "OT4"

The preference is also shifted when the TR2B operates on second trial.

17.33 In order to reduce current drain the MT7 relay will be operated to release the TCHO-9 relays, after the channel has been selected and the CHA relay operated.

18. Select and Hold Magnet Operation

Select Magnet Operation (OS 709-1) (OS 710-2)

18.01 The operation of the FBK relay in the marker causes the operation of the B (level 1) and one of T6-9 select magnets through contacts of the FB-, LC- and LV- relays in the trunk link circuit.

18.02 The operation of the CH- relay in the marker which corresponds to the selected channel closes through the JS- lead to the trunk link circuit through the operated JC- relay to operate the J- select magnet.

18.03 The operation of the CH- relay in the marker also closes through the SM- lead to the line, line link and marker connector control circuit through the operated HGA relay to operate the L- and LJ- select magnets.

Hold Magnet Operation

General

18.04 Where there is an absence of ground on the sleeve conductor of any of the three linkages which comprise a channel, the marker recognizes this as an idle linkage indication and may select that channel. The marker does not know how long this channel has been idle and therefore, this channel may be selected just after it becomes idle from a previous connection, but before the hold magnets and select fingers have had time to release. To insure against trying to reoperate a hold magnet before the hold magnet and select finger have released from a previous connection, the marker is equipped with a hold magnet timing circuit consisting of the HMT (hold magnet timing) relay and the HMT1 relay. The HMT relay produces a hold magnet timing interval which is a time delay introduced into the progress of the marker to allow time for hold magnets and select fingers to release from a previous connection. The release time of a hold magnet is determined by the time required to release the armature and crosspoints, while the release time of the select finger is determined by the time required for the select finger vibration to dampen out after it has released from the trap. False operation of crosspoints would occur if the hold magnet was reoperated before this select finger vibration had dampened out.

18.05 At the completion of the hold magnet timing interval, which insures the complete release of the hold magnets and select fingers, the hold magnets will be operated. During light traffic conditions the line link frame J (junctor switch) hold magnet and the trunk link frame J (junctor switch) and T (trunk

switch) hold magnets will be operated immediately at the completion of the hold magnet timing interval. After these hold magnets have operated, a false cross and ground test on the tip and ring conductors will be made. After allowing sufficient time for the false cross and ground test, the marker will operate the line link frame L (line switch) hold magnet associated with the calling line.

18.06 During heavy traffic conditions the false cross and ground test will be eliminated. Therefore, in this case, all of the hold magnets, including the line link frame line switch hold magnet, will be operated at the completion of the hold magnet timing interval.

18.07 To decrease the time of operation of the hold magnets and of the marker machine time, a new feature has been added to the wire spring relay markers. With this new feature the hold magnets may be operated by the use of a momentarily applied dual voltage of 178 volts (130 + 48) instead of the usual 48 volts. In this case, when a hold magnet is to be operated, the marker will momentarily apply a voltage of +130 volts to the hold magnet winding. Since the other end of the hold magnet winding connects to -48 volts, this will give a total operating voltage of 178 volts, which will operate the hold magnet in about one-third the time required for 48 volt operation. Since the marker machine time is not of the greatest importance during light traffic conditions, this dual voltage operation of hold magnets will be cancelled under light traffic conditions.

18.08 To prevent falsely connecting into busy linkages associated with another connection, linkage tests are made. Before the hold magnets are operated, a test for false ground is made on the line hold magnet sleeve, the line link sleeve, the junctor sleeve and the trunk link sleeve.

18.09 After the crosspoints are closed, linkage tests are made to check the closure of the sleeve crosspoints and then an over-all check is made to insure that the connection will hold when control is shifted from the marker to the particular trunk circuit used.

Idle Check of Channel Links Before Operating Hold Magnets (FS-46, 47, SD-26002) (OS 710-2)

18.10 An idle channel requires that the associated CHT- relay did not find ground on any of its 3 test leads. Since an open wire or dirty contact would give an idle indication, the marker makes a secondary check of the channel before operating relay HMS1 to operate the hold magnets. The secondary test is made to prevent the marker from connecting to busy channels.

18.11 The operation of the CH- relay removes the line link sleeve test leads "LLO-9" and connects the "LB-" test lead to check that the line link is idle. The LLT (line link test) relay is connected to the "LB-" lead and will operate if the line link is busy or if there is a trouble ground on the lead.

18.12 After the particular channel is selected, the operated CH- relay will disconnect the CHT- relay from the sleeve test leads and connect the "J-" lead (junctor sleeve) to the JGCK (junctor ground check) and the "LH-" lead, (trunk link sleeve) to the TGCK (trunk ground check) relays in series with the Junctor and Trunk Link Hold Magnets.

18.13 To check that the LL junctor switch hold magnet is idle and its operating circuit is free of trouble grounds, the JGCK relay will operate, in series with the idle junctor switch hold magnet. Because of the high resistance of the JGCK relay, the hold magnet does not operate. In the same manner, if the trunk link junctor switch and trunk switch hold magnets are idle and their operating circuit is free of trouble grounds, the TGCK relay will operate.

18.14 If all of the linkages are idle and if all of the operating circuits are free of trouble grounds, the associated JGCK and TGCK relays will be operated and the LLT and LLTA relays will not be operated. This provides an operating circuit for the HMS1 relay when the hold magnets are to be operated. If any of the linkages are busy or if any of the operating circuits have trouble grounds, the associated JGCK or TGCK relay will not be operated or the LLT and LLTA relays will be operated. Therefore, in this case, the HMS1 relay will be prevented from operating to block the hold magnet operation. The marker will time-out and a trouble record will be taken.

18.15 To indicate that all of the check relays are released before their use is required, the SLRK relay was operated. If one of the check relays is falsely held operated before its use, the SLRK relay will not operate which in turn will prevent the operation of one of the CHO-9 relays. The marker will time out and a trouble record will be taken.

Hold Magnet Timing and Control (FS-47, SD-26002) (OS 710-2)

18.16 After the selection of a connecting path, the marker will delay the operation of the hold magnets. Sufficient time is allowed for the select magnets to fully operate and for the full release of any previously operated hold magnet. The desired hold magnet may have released just prior to the operation of the CHO-9 relay and will be reoperated in setting up this connecting path. The time delay in the operation of the hold magnets is to prevent double connections caused by closing two crosspoints by the operation of one hold magnet. This time delay function is performed by the condenser timed HMT (hold magnet timing) relay and the HMT1 (hold magnet timing auxiliary) relay.

18.17 Battery has been extended to both the primary and secondary windings of the HMT relay. With the CHA relay nonoperated, ground has been extended to bias the secondary winding of relay HMT to the nonoperated position and ground has been extended through resistance to bias the primary winding of relay HMT to the operated position. However, the effect of the secondary winding predominates and relay HMT will remain in the nonoperated position. When the CHA (channel auxiliary) relay operates the effect of the secondary winding is eliminated and relay HMT operates. Due to the momentary current flow in the secondary winding caused by the HMT condenser charging, the HMT relay operation is delayed for a short period of time. The operation of relay HMT will operate the HMT1 relay.

18.18 If the linkage test LGCK, JGCK and TGCK relays are operated, relay HMT1 will operate the HMS1 (hold magnet start) relay. The proper operation or nonoperation of these linkage test relays indicates that no false crosses or grounds exist on the linkages tested.

Hold Magnet Operation - Light Traffic

18.19 During the light traffic condition the dual voltage operation of the hold magnets will be cancelled and relay DVO is nonoperated. Also, the operation of the line link frame line hold magnet will be delayed until after the false cross and ground test.

Operation of Trunk Switch and Junctor Switch Hold Magnets - Trunk Link Frame (FS-46, 47, SD-26002) (OS 709-1) (OS 710-2)

18.20 The operation of relay HMS1 will operate the one trunk link frame J hold magnet (when extension trunk link frame junctor switches are provided two hold magnets will be operated) and the one trunk link frame T hold magnet associated with the selected connecting path.

18.21 The windings of the trunk link frame T and J hold magnets which are associated with the same trunk link frame trunk link are interconnected by means of the associated trunk link frame trunk link sleeve conductor. The ten trunk link frame trunk link sleeve conductors associated with the ten selected channels have been extended to the marker over the "LHO-9" leads. Within the marker, the one "LH" lead associated with the selected connecting path will be extended through the one operated CHO-9 relay contact to ground when relay HMS1 operates.

Operation of Junctor Switch Hold Magnet - Line Link Frame (FS-46, 47, SD-26002) (OS 710-2)

18.22 The operation of relay HMS1 will operate the one line link frame switch hold magnet associated with the selected connecting path.

18.23 The windings of the line link frame J hold magnets are connected to the junctor sleeve leads which are extended to the trunk link frame. These sleeve leads are further extended to the marker over the "JO-9" leads. Within the marker, the one "J" lead associated with the selected connecting path will be extended through the one operated CHO-9 relay contact to ground (through the JXP relay primary winding) when relay HMS1 operates.

Operation of Line Hold Magnet - Line Link Frame (FS-46, 47, SD-26002) (OS 710-2)

18.24 During light traffic conditions, the marker will perform a false cross and ground test on the tip and ring conductors of the selected connecting path. A light traffic condition will be indicated by relay HTR being nonoperated. This false cross and ground test is made after the line link frame J hold magnet and the trunk link frame J and T hold magnets have operated but before the line link frame L hold magnet is operated. After the line link frame J hold magnet and the trunk link frame J and T hold magnets have operated, sufficient time must be provided for the false cross and ground test before the line link frame L hold magnet operation may start.

18.25 After the line link frame J hold magnet and the trunk link frame J and T hold magnets have operated, the linkage check SLA, LLTA, and JXP1 relays will operate as described in following paragraphs. The operation of these relays with the HTR (heavy traffic) relay nonoperated will operate the LTR (light traffic) relay. The operation of relay LTR will operate the GLH relay, which in turn will operate the GLH1 relay.

18.26 The LTR relay is a slow operating relay so that if there is a false cross of the tip and ring conductors, a false ground on the ring conductor, or a false battery on the tip conductor, the FCG (false cross and ground detection) relay will have sufficient time in which to operate. The operation of relay GLH will remove the FCG relay from the tip and ring conductors. When relay GLH operates, the charge due to the capacitance of the tip and ring conductors is discharged through the GLH resistance.

18.27 The operation of relay GLH1 will operate the line switch hold magnet associated with the calling customer. The windings of the five line switch hold magnets associated with the customers within the selected line group of five lines are extended to the marker over the "LHO-4" leads. Within the marker, the one "LHO-4" lead associated with the selected vertical file will be extended to ground through the operated VFTO-4 relay contact (through the LXP relay primary winding) when relay GLH1 operates.

Hold Magnet Operation - Heavy Traffic (OS 710-2)

Dual Voltage Operation

18.28 During a heavy traffic condition, the hold magnets will be operated by dual voltage in offices not equipped with message registers. If the dual voltage operation was used when there were customer message registers on the Line Link Frame, it might be possible to falsely operate the registers.

18.29 During the hold magnet timing interval the +130 volt battery will charge either one 4.32 MF or two 4.32 MF capacitors to +130 volts. When a hold magnet is to be operated, the +130 volts on the capacitor is extended from the marker to the winding of the hold magnet. The +130 volt charge on the capacitor will then be discharged through the hold magnet. The capacitor discharge current will operate the hold magnet very quickly. When the voltage across the capacitor drops to about -.5 volts the diode will become conducting and will supply the steady current flow to hold the hold magnet operated.

18.30 To indicate that the hold magnets should be operated by dual voltage (-48v. and +130v.) the DVO (dual voltage operation) relay will be operated when relay HTR operates.

18.31 One side of the LH, JH, and TH capacitors are connected to ground through either the LXP or JXP relay or TXP lamp. When relay CHA operates and the DVO relay is operated, the +130 volt battery will charge the other side of the capacitors to +130 volts. The operation of the HMT1 relay will open these charging circuits. While the capacitors are charging, the LH, JH, and TH diodes are not conducting current and will have no effect.

Operation of Trunk Switch and Junctor Switch Hold Magnets - Trunk Link Frame (FS-46, SD-26002) (OS 710-2)

18.32 The operation of relay HMS1 will operate the one trunk link frame J hold magnet (when extension trunk link frame junctor switches are provided two junctor switch hold magnets will be operated) and the one trunk link frame, T hold magnet associated with the selected connecting path.

18.33 The windings of the trunk link frame J and T hold magnets have been extended to the marker over the "LHO-9" leads. Within the marker, the one "LH" lead associated with the selected connecting path will be extended through the one operated CHO-9 relay contact to the +130 volts on the JH capacitor when the HMS1 relay operates. When the voltage on the capacitor drops from +130 volts to about -1/2 volt, the JH diode will become conducting and will supply the steady current necessary for holding the hold magnet operated.

Operation of Line Hold Magnet - Line Link Frame (FS-46, 47, SD-26002) (OS 710-2)

18.34 During heavy traffic conditions the marker will not perform a false cross and ground test but will operate the line hold magnet immediately after the hold magnet timing interval.

18.35 The operation of relay HMS1 will operate the line link frame L hold magnet associated with the calling customer's line.

18.36 The windings of the five line link frame L hold magnets associated with the customers within the selected line group are extended to the marker over the "LHO-4" leads. Within the marker, the one "LHO-4" lead associated with the selected vertical file of the calling customer, will be extended through the one operated VFTO-4 relay contact to the +130 volts potential on the LH capacitor when relay HMS1 operates. When the voltage on the capacitor drops from +130 volts to about -1/2 volt, the LH diode will become conducting and will supply the steady current necessary for holding the hold magnet operated.

Sleeve Crosspoint Check After Operating Hold Magnets (FS-46, 47, SD-26002) (OS 710-2)

18.37 To indicate that all sleeve crosspoints are operated, the SLA, LLTA, JXP1, and LXP1 relays will be operated.

Trunk Switch Crosspoint Check - Trunk Link Frame

18.38 When the trunk link trunk switch hold magnet operates, the ground (or +130 volts) which has operated the hold magnet will be extended through the operated sleeve crosspoints and over the "AST" or "BST" lead to the marker, thereby operating the SL relay. The operation of relay SL will operate the SLA relay.

Junctor Switch Crosspoint Check - Trunk Link Frame

18.39 The current for operating the line link junctor switch hold magnet will flow through the primary winding of the JXP relay, thereby operating this relay. The operation of the JXP relay will operate the JXPA relay. When the trunk link junctor switch hold magnet operates, the ground (or +130 volts) which has operated the hold magnet will be extended through the operated sleeve crosspoint and over the "JO-9" lead to the marker, and to the windings of the JXP relay. This ground (or +130 volts) applied to the windings of the JXP will result in the release of this relay. The release of the JXP relay, with the JXPA relay operated, will operate the JXP1 relay.

Junctor Switch Crosspoint Check - Line Link Frame

18.40 When the line link junctor switch hold magnet operates, the ground (or +130 volts) which has operated the hold magnet will be extended through the operated sleeve crosspoint and over the "LBO-9" lead to the marker, thereby operating the LLT relay. The operation of relay LLT will operate the LLTA relay.

Junctor Switch and Line Switch Crosspoint Check - Line Link Frame

18.41 The current for operating the line link line switch hold magnet will flow through the primary winding of the LXP relay thereby operating this relay. The operation of relay LXP will operate the LXPA relay. When the trunk link junctor switch hold magnet operates, the ground (or +130 volts) which has operated the hold magnet will be extended over the sleeve junctors to the line link. When the line link junctor switch and line switch line hold magnets operate, this ground (or +130 volts) will be further extended through the operated sleeve crosspoints and over the "LHO-4" lead to the marker and to the windings of the LXP relay. This potential applied to the winding of the LXP relay will result in the release of this relay. The release of the LXP relay, with the LXPA relay operated, will operate the LXP1 relay.

18.42 The operation of the LXP1, JXP1, and SLA cuts in the DCT relay for making the double connection test and closes a circuit for controlling the LTR and GT1 relays.

19. False Cross-Ground Test (FS-48, SD-26002)

19.01 During light traffic conditions the marker operates the line link J hold and the trunk link J and T hold magnets except the line hold magnet and momentarily applies the FCG, false cross-ground test relay to the tip and ring leads, before completing the connection.

19.02 The FCG relay is a sensitive double wound relay, with ground on one winding and battery on the other winding. The operation of the FCG relay will indicate a false cross between the tip and ring conductors, a false ground on the ring conductor or a false battery on the tip conductor.

19.03 The primary winding of the FCG relay is extended over the "ART" or "BRT" lead from the marker to the trunk link and through the operated trunk link trunk switch and junctor switch hold magnet crosspoint contacts and over the ring conductor of the junctor to the line link frame, through the operated line link junctor switch hold magnet crosspoint contact and over the ring conductor of the line link to the nonoperated line link line hold magnet crosspoint contacts.

19.04 The secondary winding of the FCG relay is extended over the "ATT" or "BTT" lead from the marker through the trunk link and over the tip conductor of the line link to the nonoperated line link line hold magnet crosspoint contacts in a similar manner as above.

19.05 If there is a false ground on the ring conductor at any point from the nonoperated line link line hold magnet crosspoint contacts to the primary winding of the FCG relay, the FCG relay will be operated by a current flow in

the primary winding. If there is a false battery on the tip conductor at any point, the FCG will operate from the current flow in the secondary winding. If there is a false cross between the tip and ring conductor at any point the FCG relay will operate by a current flow in both the primary and secondary windings.

19.06 The FCG relay in operating will lock operated when the LTR, light traffic relay operates. This will prevent the GLH (ground line hold magnet relay) from operating), blocking the call, and forcing a timeout and a trouble record.

19.07 If the FCG relay is nonoperated, indicating that no trouble was encountered, the operation of the LTR relay will operate the GLH relay. The GLH relay operates the GLH1 relay to operate the line hold magnet. During the time the GLH1 relay is operating the tip and ring conductors will both be grounded to discharge any conductor capacity and prevent false operation of the continuity test.

20. Continuity Test (FS-48, SD-26002)

20.01 The continuity test is made to check that all crosspoints of the selected channels are closed and does not require an off-hook condition to complete satisfactory test.

20.02 The continuity test is made only when light traffic conditions exist in the office.

20.03 The operation of the line link frame and trunk link frame hold magnets extend the tip and ring conductors of the line through the selected channel to the marker and initiates the continuity test. Ringing voltage of 20-cycle frequency is applied to the primary of the CON2 repeating coil, which by its transformer action, steps up the voltage. This voltage from the secondary is applied to a series circuit consisting of the CON2 capacitor, the channel crosspoints, and the line. Before the line switch crosspoints are closed by the operation of the line hold magnet the series circuit is open, therefore, no current flows in the repeating coil secondary circuit and the voltage drop across the CON2 capacitor is zero. The operation of the line hold magnet to close the line switch crosspoints completes the path for the CON2 repeating coil secondary, therefore alternating current flows from its secondary circuit through the CON2 capacitor, and through the channel crosspoints and the line.

20.04 The current flowing in the CON2 capacitor, repeating coil secondary, channel crosspoints and line causes the voltage of the secondary to be divided across the CON2 capacitor and the line, the amount of voltage across each being determined by the impedance of each. The impedance of the subscriber line is relatively low compared with the impedance of the CON2 capacitor, and therefore the greater portion of the voltage from the CON2 repeat coil secondary will appear across capacitor CON2. This voltage across the CON2 capacitor is sufficient to break down the control gap of the CON tube, which is connected across capacitor CON2. The breakdown of the control gap results in the main gap becoming conductive and the CON (continuity) relay operating in series with the main gap of the CON tube. If one of the channel crosspoints fails to

close, the current through capacitor CON2 is determined by leakage in the central office local cabling and other circuit elements but is insufficient to cause the breakdown of the control gap of the CON tube.

20.05 For the condition of a false customer start the continuity test must not result in a false continuity test failure if at the time of the continuity test the customer's receiver is on the switchhook. When the receiver is off the switchhook a continuity test current is extended through the operated switchhook contacts from either the ring conductor to the tip conductor or from the tip conductor to the ring conductor according to the setting of the reverse continuity test relays. However, if the receiver is on the switchhook, because of a false customer start, the continuity test current may be extended through the customer's ringing. If the calling party keeps the receiver off the switchhook, the continuity test will check on individual customer lines and on multiparty customer lines regardless of which party is calling. If the receiver is on the switchhook when the continuity test is made, because of a false customer start, the continuity test will check on the individual customer lines. However, to check the continuity of a 2-party customer's line under a condition of a false customer start, the test of the conductors might have to be reversed after the first test indicated failure because the calling customer's ringer may be on the opposite conductor.

Operation of the CON Tube and CON and CONA Relays (FS-48, SD-26002)

20.06 The CON relay in operating will check and indicate that a successful continuity test has been performed. The winding of the CON relay is in series with the anode circuit of the CON vacuum tube. When the CON tube becomes conductive the CON relay will operate on the current flow from +130 volts through the CON8 resistance, through the winding of the CON relay, from the CON tube anode (terminal #2) to the CON tube cathode (terminal #4) and to ground. The CON tube will become conductive if the voltage on the control anode (terminal #1) exceeds approximately +72 volts. Therefore, to indicate a successful continuity test a voltage will be applied to the control anode of greater than +72 volts.

20.07 The operation of the frame "A" or "B" appearance relay, the level relay, and the connector cut-through relay in the trunk link have extended the tip conductor of the selected channel over the "ATT" or "BTT" lead to the marker, and the ring conductor over the "ART" or "BRT" lead to the marker. The tip and ring conductors will alternately be connected to ground and to the CON2 repeating coil according to the setting of the RCTA (reverse continuity test relay). The tip or ring conductors will be extended to ground with the FAK or FBK relay operated, the GT1 relay nonoperated, the GLH1 relay operated, through the RCTA contacts according to the setting of the reverse continuity relay will be extended with the FAK or FBK relay operated, the GT1 relay nonoperated, the GLH1 relay operated, through the RCTA relay contacts, through the CON6 resistance, the CONA relay nonoperated, the CON1 retard coil, the secondary of the CON2 repeating coil, through the CON2 capacitor (for a 20-cycle frequency ringing current) to ground on the "RING G" lead.

20.08 The operation of the CHA relay has applied ringing potential to the primary winding of the CON2 repeating coil which is a step-up transformer. A 20-cycle stepped-up voltage is induced in the secondary winding and this voltage is used to test the continuity of the circuit and to operate the CON tube.

20.09 The operation of the line link and trunk link hold magnets has extended the tip and ring conductors over the calling customer line to the customer set. Therefore, after the trunk link and line link crosspoints have closed, the 20-cycle voltage will cause a current to flow through the line and charge the CON2 capacitor. The voltage drop across the CON2 capacitor is determined by the ratio of the impedance of the capacitor as compared to the impedance of the customer's line. With continuity over the tip and ring conductors the voltage drop across the CON2 capacitor will be large enough to break down the CON tube, as the impedance of the customer's line is relatively small as compared with the CON2 capacitor impedance.

20.10 If there is an open condition at any of the crosspoints or in any of the cabling within the office in the continuity check path the 20-cycle ringing current which will flow will be very low, being controlled by the capacity and leakage of the switches and cables. Therefore, the voltage drop across the CON2 capacitor due to this current flow will be very low and will be less than the voltage required to cause the breakdown of the control anode gap of the CON tube. Thus the CON relay will not operate.

20.11 The operation of the CON relay will operate the CONA relay which will operate the CON1 relay. The operation of the CON1 relay indicates that the continuity test had been satisfactorily completed.

Operation of the RCTA and RCTB Relays (FS-48, SD-26002)

20.12 The continuity test on the customer line is made by the marker when it establishes the connection. The RCTA relay operated or released will direct the marker to the side of the line that is to be tested first. Continuity test is arranged to be made over the ring side of the line with the marker supplying the return ground on the tip side when the RCTA relay is nonoperated. When party lines are involved, the RCTA relay is operated for either originating or incoming calls to a tip party line or when a call is originated from a multiparty line. The marker is not informed which side of the line to test when a call is originated from a multiparty line and therefore, the marker will test on the ring side first. This arrangement generally gives successful continuity test because the originating customer has the receiver off the switchhook.

20.13 However, the customer may have abandoned the call after the marker has been engaged and the receiver will be back on the switchhook. The abandoned call cannot be recognized until the channel is cut through to the register. Thus the marker makes continuity test to the line after the dc bridge of the transmitter has been opened. If the line is individual class of service (bridged ringer) the continuity test will be successful, as it will be made through the customer's ringer. If the line is a party line the continuity test will be successful if the customer's ringer to ground is on the side of the conductor that is being tested. However, if the customer's

ringer is on the conductor that is not being tested, the continuity test may fail. It will be then necessary to switch the continuity test to the other conductor in order to operate the CON tube through the customer's ringer. The continuity test is designed so that it will not fail on abandoned calls.

20.14 On any call-forward linkage connection, the setting of the ringing combination informs the marker which side of the line the station ringer is located. Relay RCTA will operate when the RCT7, 9, 11-15 relay (tip party ringing combination) operates.

20.15 During a call-back linkage the RCTB relay will operate from the ground through the HTR relay contacts normal and will prevent the RCTA relay operation for ring party stations. During continuity test of a multiparty line the ring side of the line is tested first. When the line crosspoint LXP1 relay operates it starts the release of the RCTB relay. If continuity test is satisfied, the operation of the CON1 relay will lock the RCTB relay operated. If continuity test is not satisfied the RCTB relay will release and cause the RCTA relay to operate which will reverse the continuity test to the tip conductor.

21. Ground, Loop, and Receiver-off-Hook Tests

General

21.01 "Ground test" is made by the marker on any called customer line over the tip and ring conductors if the line is a non-PBX and nonground start coin line. The test is made from the trunk link trunk switch to the line link line switch and to the customer set to detect a false conductor. "Loop test" is made by the marker on a called PBX line over the tip and ring from the trunk link trunk switch to the PBX switchboard. It will detect a false cross between the tip and ring, or a plug in the jack at the PBX switchboard. The "Receiver-off-hook test" is made on the tip and ring conductors from the trunk link trunk switch to the coin station of a ground start coin line. It will detect a false ground on the tip or a false cross between the tip and ring.

GT1 Relay (FS-47, SD-26002)

21.02 The ground test GT1-2 relays will be operated when the line link line and junctor switch crosspoints have operated and the trunk link trunk and junctor switch crosspoints have operated, if a heavy traffic condition exists. However, during light traffic conditions it will also be necessary for the continuity test to be completed before the GT1 relay will be operated.

21.03 Under heavy traffic conditions the CGT (cancel ground test) relay will be operated when the GTK relay operates (FS-48, SD-26002). The CGT relay operated will open the operating path for the GT relay thereby cancelling ground test.

21.04 To indicate that the called line is a PBX line and therefore a loop test should be made instead of ground test, the LGT relay is operated. The CKR relay which operates only when the called line is a PBX line will operate the LGT relay which will transfer the operate path for the GTK relay through the operated LGT, PBXA and CKR relays. Relay LGT will also prevent the CGT relay from operating and insuring that loop test is made for both light and heavy traffic conditions.

21.05 To indicate that the called line is a ground start coin line and therefore a receiver-off-hook test instead of a ground test should be made, the LGT relay will operate when the CN relay operates. The GTK relay will in this case operate through the operated LGT relay and the nonoperated AOC relay. This test will be made under both light and heavy traffic conditions.

GT Relay (FS-48, SD-26002)

21.06 The GT relay is provided to indicate the success or failure of the ground, loop, or receiver-off-hook test. The customer line will be tested on the basis of holding the GT relay operated if the line test is not satisfactory. If the line test is satisfactory the GT relay will be released permitting the marker to proceed and to operate the DCT1 relay if the double connection test is satisfactory.

21.07 The tertiary winding of the ground test GT relay is energized by the operation of the LLC3 relay which operates the GT relay in the non-operated position. The operation of the GTK relay with the GT2 relay non-operated will extend ground to the primary winding of the GT relay thereby operating the GT relay to the operate position.

Ground Test

21.08 When "ground test" is being made the primary winding of the GT relay is extended to the tip and ring conductors over the "ART or BRT" and "ATT or BTT" leads which are extended to the trunk link and then to the tip and ring of the selected connecting path. The operation of the GT2 relay will remove the local operating ground from the primary winding of the GT relay. Therefore, the primary winding is only connected to the tip and ring of the called line. The GT relay will hold operated if there is a false ground on the tip or ring of the customer line. A successful ground test is indicated by the release of the GT relay.

Loop Test

21.09 When "loop test" is being made the primary winding of the GT relay is extended to the tip over the "ATT or BTT" lead which is extended to the trunk link and then to the tip conductor of the selected connecting path. Ground is extended over the "ART or BRT" lead to the ring through the PBXA and LGT relays operated. The operation of the GT2 relay will remove the local operate ground from the primary winding of the GT relay. Therefore, the primary winding will be connected only to the tip of the called line. The GT relay will hold operated if there is a false ground on the tip, a false cross between the tip and ring, or if there is a plug in the jack at the PBX switchboard.

Receiver-off-Hook Test

21.10 When "receiver-off-hook test" is being made, the primary winding of the GT relay is extended to the tip over the "ATT or BTT" lead which is extended to the trunk link and to the tip of the selected path. Ground is extended through the PBXA relay nonoperated and the LGT relay operated and through the winding of the PU relay over the "ART or BRT" lead to the ring conductor. The operation of the GT2 relay will remove the local ground from

the primary winding of the GT relay, therefore, the primary winding is only connected to the tip of the called line. Relay GT is held operated if there is a false ground on the tip or a false cross between the tip and ring conductors.

22. Double Connection Test (FS-47, SD-26002) (OS 710-2)

22.01 The double connection test DCT relay will test the sleeve conductor associated with the selected path for false ground. If a double connection or cross exists between two sleeves, ground will be transferred from the busy sleeve to the other sleeve.

22.02 The operation of the LXP1, JXP1, and SLA relays transfer the holding ground for the line link and trunk link hold magnets to the "LHO-4" leads from the line link. This holding path is in series with the primary winding of the DCT relay and all the hold magnet current will pass through the DCT relay, if the sleeve is not falsely grounded.

22.03 The DCT relay has a secondary or biasing winding which has a current flowing through it in such a direction as to hold the relay nonoperated. Thus the DCT relay will only operate, when the hold magnet holding current passes through the primary winding.

22.04 When the DCT relay operates it indicates that the double connection test is satisfactory and there are no false grounds on the sleeve lead. The operation of the DCT will operate the double connection test auxiliary DCT1 relay. Before the DCT1 relay is operated, the ground test circuit is checked for proper operation.

22.05 A satisfactory ground test check is indicated when the GT2 and GTA relays operate, with the GTK relay operated.

22.06 The operation of the DCT1 relay does not release the F relay in the trunk on the terminating stage. Relay F is held operated through the operated ITR2 and nonoperated DCT2 relays in the marker. The operation of relay DCT1 connects ground to the BST lead to hold operated the hold magnets associated with the connecting path to the called line.

23. Release of the Select Magnets (OS 710-2)

23.01 The GT1 relay will be operated when all crosspoints are closed if a heavy traffic condition exists. If a light traffic condition exists continuity test must be completed before the GT1 operates. When it does operate and with the DCT1 relay operated the ONX (off-normal cross) relay will release. This will cause the release of all the select magnets.

24. Linkage Check Circuit

24.01 Before the marker gives the release indication it will check that the connecting path through the crosspoints has been tested to determine that it is in condition for service. A satisfactory linkage check indicates that the marker can release and will be available for other connections.

24.02 The linkage check circuit checks the following:

(a) Double Connection Test - Which indicates that there is no false ground on the sleeve conductor of the connecting path, no double connection.

(b) Ground Test or Line Test - This test is made to prevent false charging of the calling customer when the connection cannot be completed.

(c) RNG Relay - Indicates that the number group has been released after the called line location has been recorded in the marker.

(d) RSK Relay - Indicates that the ringing selection switch has been set up.

24.03 When double connection test has been completed, relay DCT (double connection test) releases and operates the LK1 and LK2 (linkage check) relays in series (FS-49, SD-26002). The operation of the linkage check relays indicates the completion of the call-forward linkage in which the called line was connected to the B appearance of the intraoffice trunk. At this point the marker will recycle its functions and will attempt to establish the call-back linkage.

C. ESTABLISHING THE ORIGINATING CONNECTION - CALL-BACK LINKAGE

1. General

1.01 Establishing the originating connection consists of the selection and connection of a channel between the A appearance of the intraoffice trunk and the calling line. Before the marker does this, however, it releases certain relays that it used when establishing the terminating connection.

1.02 Then the marker, through the line link connector, selects the line link frame on which the calling line is terminated. The calling line identification was made when the dialing connection was established and the information was stored in the originating register during dialing. This information is now used by the marker for selecting the ten line links available to the calling line. Since the marker is already connected to the trunk link frame on which the intraoffice trunk is terminated, it has access to the junctor and trunk link test leads. By the use of these and the ten line link test leads, the marker tests for and selects an idle channel. For purposes of this test, the channel connecting the calling line and the originating register (dialing connection) is considered idle.

1.03 After channel selection, the dialing connection is released and the marker establishes the originating connection from the A appearance of the intraoffice trunk to the calling line. The trunk then assumes control of the connection. The marker and register are now released.

2. Release of Certain Relays Used in the Terminating Connection - Call-Forward Linkage

2.01 The operation of relays LK1 and LK2 (linkage check) indicates the completion of the terminating connection. These relays, together with the FLG, FLG1 (first linkage ground), LLC1, LLC2 (line link control) relays that are released by the operation of relay LK1, perform the following functions:

(a) Release the MP- (marker preference) relay in the preference control and make-busy circuit.

(b) Release the line link connector that connects the marker to the line link frame on which the called line is terminated.

(c) Release the marker relays that were operated by the number group to indicate the equipment location of the called line.

(d) Release the marker relays that operated to select the connecting path from the B appearance of the trunk to the called line.

(e) Step the marker sequence walking circuit.

3. Start of the Call-Back Linkage

3.01 The marker must release all of the registered number group information that was used on the call-forward linkage. When this occurs and the LK1 relay operates the CB and CB1 (call-back) relays will operate. These in turn cause the operation of the CB2, 3, 4, and 5 (call-back) relays.

3.02 The operation of the CB1 relay will cause the operation of the SCB1 and SCB2 (start call back) relays if the channel check relays have all been released (FS-33, SD-26002). The CB2 relay operates the LOT (LO lead start) relay.

3.03 The operated CB relay reoperates the LLC1 relay and the SCB1 relay reoperates the LLC2 and LLC3 relays (FS-33, SD-26002).

4. Selecting the Connecting Path to the Calling Line

General

4.01 The operations for this part of the intraoffice call are similar to those for the dial tone connection. In this part, however, it is not necessary for the marker to identify the calling line. This was done when the dialing connection was established. The marker received this information from the originating register while setting up the call-forward linkage and now uses it to select the desired line (see Paragraph B-6).

Selecting the Line Link Frame

4.02 The operated CB and CB1 relays, together with the one operated FT- (frame tens) and two out of five operated FU- (frame units) relays, operate one FTT- and one FUT- relay in the marker (FS-3, 4, SD-26002). These latter two relays complete a path from battery to the associated ST- lead to the MP- (marker preference) relay chain in the preference control and make-busy circuit (FS-5, SD-26002) for the selected line link frame (see Paragraph B-13). The operation of relay MP- seizes the line link frame by causing the operation of the marker connector relays in the associated line link connector. These relays provide connections between the marker and the line link frame.

Selecting the Vertical Group (FS-6, 9, SD-26002) (FS-2, SD-26030)

4.03 The operated CB3 and CB4 relays, in combination with two out of six VG- (vertical group) relays, operate the VGT- relay that corresponds to the calling line vertical group. The operation of one VGT- relay operates the VTK1 (vertical group test check) relay. The operation of relay VTK1 is a check that one and only one VGT- relay is operated. The operation of relay VTK1 with one VGT- relay operated extends battery to the line link frame on the VGB- lead to operate the corresponding VGB- relay.

Selecting the Horizontal Group (FS-7, 9, SD-26002) (FS-2, SD-26030)

4.04 The operated CB3 relay in combination with two out of five HG- (horizontal group) relays, operate the HGT- relay that corresponds to the calling line horizontal group. The operation of one HGT- relay operates relay HTK1 (horizontal group test check), which checks that one and only one HGT- relay is operated. With relay LLC1 operated, the operation of relays HGT- and HTK1 place battery on one HG- lead to the line link frame to operate relays HGA- and HGB-.

Selecting the Line Hold Magnet (FS-5, 8, SD-26002) (FS-1, SD-26030)

4.05 The marker provides battery over the BS lead to the line link frame. This battery is passed through contacts on the operated VGB- and HGA- or HGB- relays to operate relay LG- on the line link frame. The operation of relay LG- extends five LH- leads from the line link frame to the marker. The operation in the marker of the CB2 relay, in combination with one out of five VF- (vertical file) relays, operates relay VFT-. Relay VFT- operates relay FTK1 (vertical file test check) as a check that one and only one VFT- relay is operated. The operation of relay VFT- in conjunction with relay FTK1 completes the selection of the line hold magnet connected to the calling line.

Selecting the Line Link Test Leads (FS-1, SD-26030)

4.06 The operation of relay HGB- extends ten LL- leads from the line link sleeves to the CHT- (channel test) relays in the marker (FS-1, SD-26030) (FS-46, SD-26002). Busy line links are grounded; therefore, the CHT- relays that correspond to busy line links operate.

4.07 The dialing connection is released before the originating connection is established. Therefore, the line link used in the dialing connection is also available for use in the originating connection. In order that it may be selected, it must be made to appear idle on the channel test for the originating connection.

4.08 The originating register has stored the number of this line link. It passes this number to the marker and operates two out of five LL- relays (FS-46, SD-26002). The operation of these two relays opens the LL- test lead that corresponds to this line link. This makes the line link appear idle by preventing the operation of relay CHT- (FS-46, SD-26002). The operation of two out of five LL- relays also completes the path for the operation of the RK1 and RK2 (registration check) relays (FS-2, SD-26002). The operation of relays RK1 and RK2 indicates that the calling line information and channel number of the dialing connection are recorded in the marker. To verify this, the RK3 (registration check) relay operates.

Selecting the Junctor Subgroup

4.09 The operated FT-, and CB relays operate the FTB- (frame tens auxiliary relay that corresponds to the frame tens digit of the line link frame (FS-4, SD-26002). This relay, in combination with the FUT- relay that corresponds to the line link frame units digit, operates a P- (pattern) relay if the junctor subgroup contains less than ten junctors (FS-14, SD-26002) (FS-4, SD-26033). The remainder of the junctor subgroup selection is the same as explained in Paragraph B-17. The operation of a JC- relay at the end of the subgroup selection extends a group of ten junctor test leads from the junctor subgroup sleeves to the CHT- (channel test) relays in the marker. The CHT- relays that correspond to busy junctors operate.

Selecting the Group of Trunk Links

4.10 The operation of relay LK1 releases the LC- relay that corresponds to the trunk switch connecting to the B appearance of the trunk (FS-47, SD-26002). The operation of relay SCB2 operates the LC- relay that corresponds to the trunk switch connecting to the A appearance of the trunk. Since both appearances of the trunk are on the same level, although on different switches, the same LV- relay remains operated.

4.11 The operation of relay LC- connects a group of ten trunk link test leads from the trunk switch to the CHT- relays in the marker (FS-46, SD-26002). The CHT- relays that correspond to busy trunk links operate.

Test Check and Channel Selection

4.12 The marker then makes the test check and channel selection, as described in Paragraph B-17.

5. Release of the Dialing Connection

5.01 The operation of relay CHA (channel selection auxiliary) at the end of channel selection operates relay RL (release) in the originating register (FS-51, SD-26002). This relay, in operating, opens the 10-ohm ground on the sleeve circuit of the established dialing connection (FS-1, SD-26040). The hold magnets on the line link and trunk link frames release.

6. Dial Tone Lockout

6.01 The release of the line hold magnet during the interval between the release of the dialing connection and the setting up of the originating connection allows relay L- (line) to operate. Relay L- operates the VGS- (vertical group start) relay that corresponds to the vertical group of the calling line. If there are no other customers on this line link frame who are waiting for dial tone, relay VGS- starts the seizure of a dial tone marker. This marker then attempts to establish another dialing connection for this customer. In order to detect and prevent this condition, the dial tone lockout circuit is used.

6.02 At the start of the originating connection, relay CB2 operates relay LOT (OS 728-1). During channel selection, relay TCHK (test channel check) operates. These relays extend ground on the G lead to the line link frame (OS 728-1). If there is a customer connected to this frame who has already requested dial tone, relay DT (dial tone) is operated. The ground passes through the operated DT relay contacts and operates relay DTK (dial tone check) in this marker, and in addition, places ground on the DTK lead to any other marker that is connected to this frame. A dial tone marker, in responding to the dial tone request, is connected to the frame through the line link marker connector. The grounded DTK lead operates its DTK relay, which prevents relay HGG (horizontal group gate) from operating (OS 728-1). This prevents relay GK (gating check) from operating, and therefore, prevents this marker from making line identification. This keeps the marker from identifying the line to which the originating connection is being made. If, however, relay GK has operated and locked, relay DTK releases relay HGG and prevents horizontal group identification. In either case, the setting up of the originating connection and the consequent release of relay L- makes it possible to release the DTK relays by the release of relay ONX (OS 728-1). The setting up of the dialing connection then proceeds.

6.03 If there are no customer requests for dial tone at the time relay TCHK operates, the ground is passed through the nonoperated contacts of relay DT and operates relay LOT1, which locks. Relay LOT1 operates relay LO (lockout). Relay LO opens the start leads, thereby preventing marker seizure by the frame until relay ONX releases LO at the conclusion of the originating connection.

7. Select and Hold Magnet Operation

7.01 The operation of the FAK relay in the marker causes the operation of the A (level 0) and one of T6-9 select magnets through contacts of the FA-, LC- and one of LV6-9 relays in the trunk link circuit.

7.02 The circuit action from this point will be the same as explained in Paragraph B-18.

8. Continuity Test

8.01 This test is the same as that described in Paragraph B-20.

9. Double Connection Test

9.01 The double connection test to the calling line is similar to that described in Paragraph B-22. However, relay DCT1 which operated and locked on the call-forward connection is not used again. It provides sleeve holding ground for the call-forward (terminating) connection, and therefore must remain operated (FS-46, 47, SD-26002).

9.02 If the double connection test is successful then the DCT2 relay will operate in the marker (FS-49, SD-26002).

10. Transfer of Connecting Path Supervision to the Intraoffice Trunk

10.01 The operation of relay DCT2 at the conclusion of the double connection test removes the operating ground from the F relay in the intraoffice trunk, allowing it to release (OS 718-1). Relay F releases FA-- and FB-- in

the trunk link circuit. This transfers the calling and called lines to the intraoffice trunk (FS-3, SD-26032). The trunk S1 (supervisory) relay that was operated from ground in the marker, through the LV- and F relays, now provides the 10-ohm holding ground for both originating and terminating connections (OS 741-1). Relay S1 is slow in releasing in order to hold between the release of relay F and the operation of relay S (supervisory). Relay S operates over the calling line loop (OS 741-1). It re-establishes an operating path for relay S1 if the calling customer has not abandoned the call.

11. Marker Release

11.01 The release of relay FA-- removes the battery supplied to relay DCT through the SL (sleeve) relay winding (FS-46, 47, SD-26002). Relay DCT releases, and operates the DIS1 and DIS2 (disconnect) relays (FS-49, 50, SD-26002). The DIS1 relay releases the LLC1 relay which in turn releases the LLC2 and LLC3 relays. The operation of the DIS1 and DIS2 and the release of the LLC1, LLC2, and LLC3 relays will start the functions necessary to release the marker and associated circuits. After the marker has released it will appear idle so as to be available for assistance to other calls.

12. Originating Register and Originating Register Marker Connector Release

12.01 Relays DIS1 and DIS2 operate relay MRL in the originating register (FS-51, SD-26002, FS-1, SD-26023, FS-4, SD-26024 and FS-5, SD-26040). Relay MRL removes operating battery from the RS- relay in the originating register marker connector register part and the MS- relay in the preference control circuit thereby releasing the connector (FS-1, SD-26024, FS-2, SD-26029 and FS-5, SD-26040). Relay MRL also causes the register control relays to return to normal, thereby making the register available for a new usage.

13. Ringing the Called Customer (OS 725-1)

13.01 The particular ringing code to be used was set up during the terminating connection. The release of relay FB-- applies this ringing code to the called line. A portion of the ringing current is applied through the T and R capacitors to the calling line as an audible signal that ringing is in progress. When the called customer answers, the increased current flow resulting from the closed switchhook contacts causes relay RT to operate and release relay RC. Relay RC removes the ringing current from the line and releases relay RT. The release of relay RC connects talking battery to the called line through relay CS (called party supervisory), which operates (FS-1, SD-26060).

13.02 Relay CS causes the operation of the CH (charge) relay. Assuming that this is a flat rate trunk the CH relay has no charge function but serves to indicate that the call is complete to the called subscriber and as a result enables the timed disconnect feature to function.

13.03 Relay CH remains locked until relays S, CS, and S1 release at the end of the call. Relay CH supplies an additional holding ground on the terminating or call-forward connection.

14. Disconnect at the End of the Call

Called Customer Disconnects First

14.01 When the called customer disconnects, relay CS releases. With relay CS released and relay CH operated, 48-volt battery is applied across the RL (release) heater element. Relay RL operates after a minimum of 13 seconds. This timed release feature prevents a calling customer from holding the called line out of service indefinitely.

14.02 The operation of the RL thermal relay reoperates the RC relay. This will release relay S1 which opens the holding circuit to both connecting paths. The calling and supervisory relay S will release when its circuit is opened by the release of the calling end connecting path and this will permit relay CH to release and restore the circuit to its normal idle condition.

Calling Customer Disconnects First

14.03 When the calling customer disconnects, relay S releases relay S1. Relay S1 releases the connection to the calling line by removing the holding ground. The connection to the called line, however, is held by ground through the CH relay contacts. If this connection were allowed to release, the release of the called line hold magnet would permit relay L- to operate. This would start a false seizure of an originating register.

14.04 The release of relay S1 applies ground to the RL heater element. Relay RL operates after a minimum of 13 seconds. This reoperates relay RC, thereby removing holding ground from the called line. The terminating connection releases and the trunk restores to normal.

14.05 If the called customer disconnects before the RC relay operates from the timed release feature, relay CS releases. This releases relay CH, thereby releasing the terminating connection and restoring the trunk to normal.

14.06 If the trunk is selected by a marker while being held by the called customer, the marker operates the trunk F relay. Relay F operates relay FB-- in the trunk link circuit, thereby opening the tip, ring, and sleeve leads. This releases the CS and CH relays, removing the called end holding ground. The trunk is now disconnected from the called line so that it is available to serve the new call.

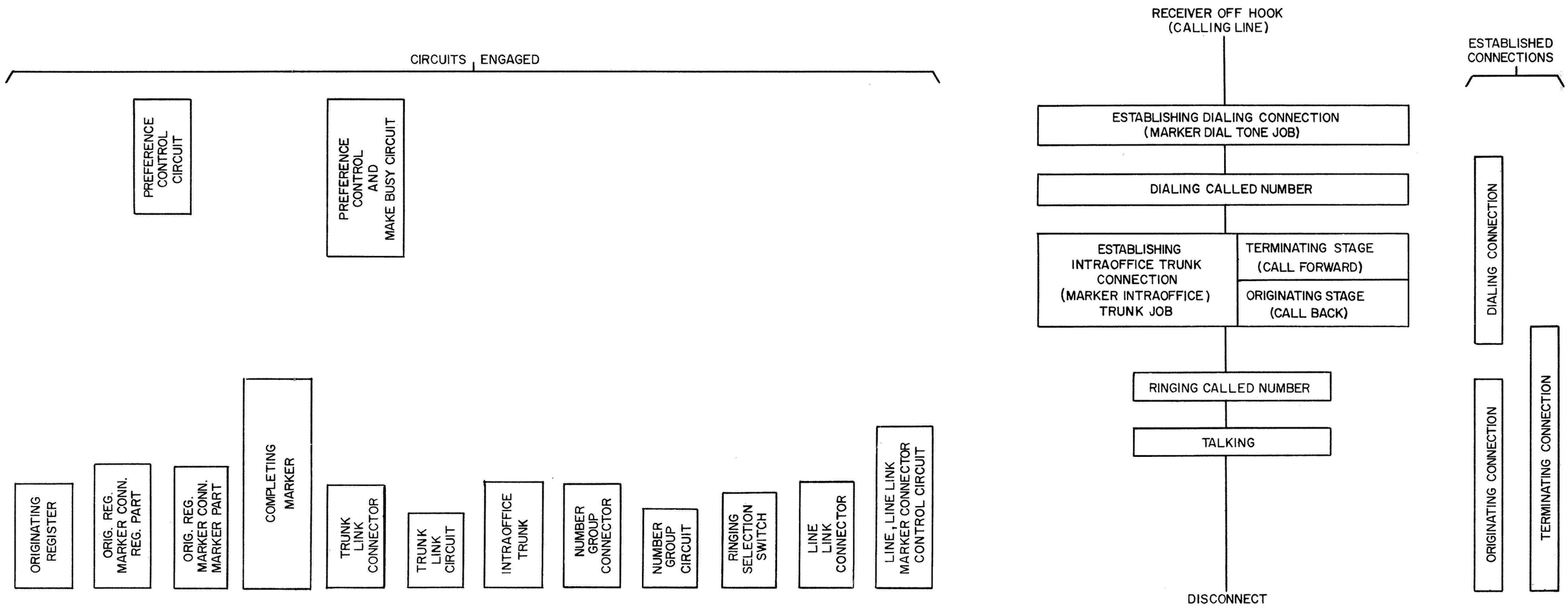
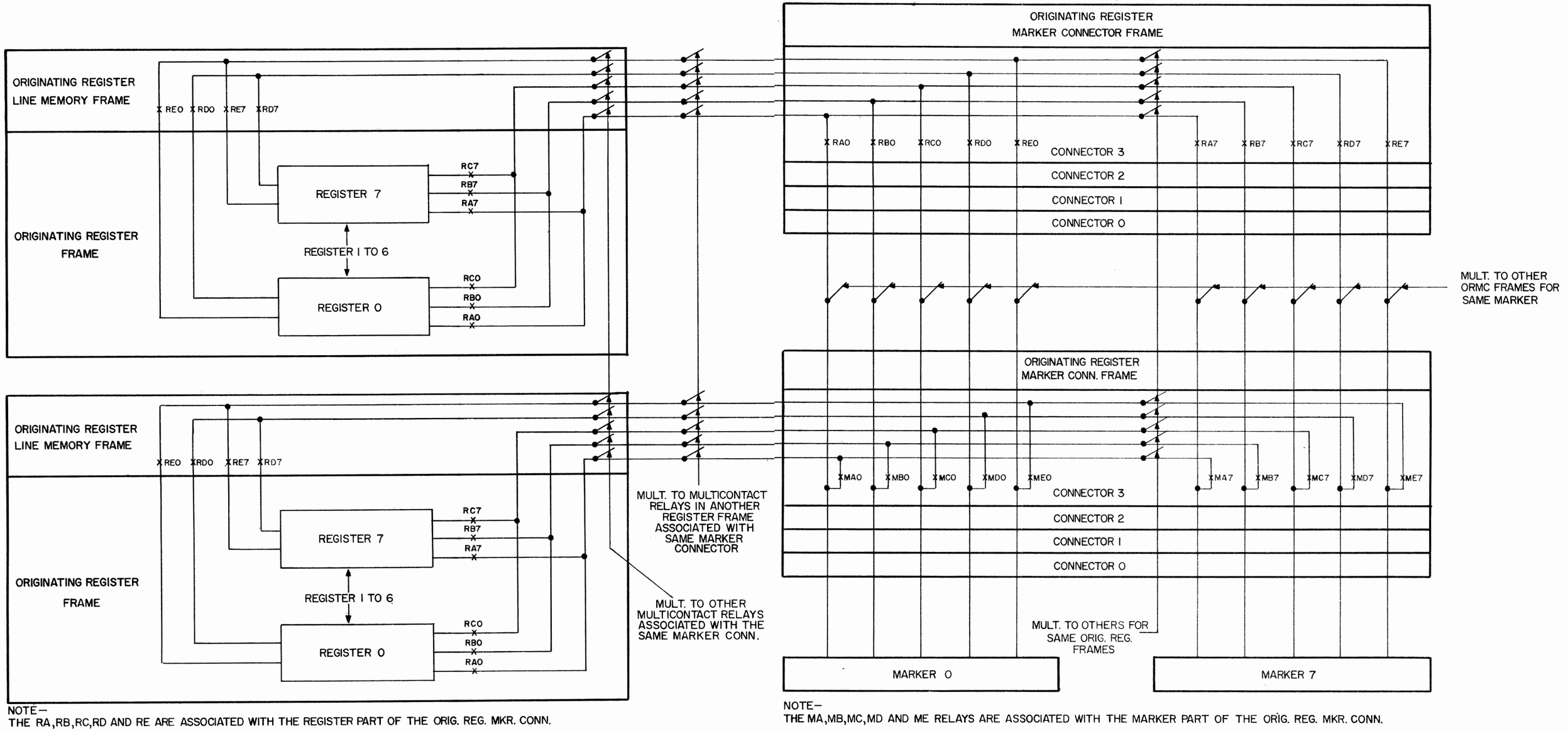


FIG. I—PROGRESS DIAGRAM INTRAOFFICE CALL

FIG. I



NOTE—
THE RA,RB,RC,RD AND RE ARE ASSOCIATED WITH THE REGISTER PART OF THE ORIG. REG. MKR. CONN.

NOTE—
THE MA,MB,MC,MD AND ME RELAYS ARE ASSOCIATED WITH THE MARKER PART OF THE ORIG. REG. MKR. CONN.

FIG. 2—TYPICAL MULTIPLE ARRANGEMENT OF THE ORIGINATING REGISTER FRAMES AND THE ORIGINATING REGISTER MARKER CONNECTOR FRAMES.

FIG. 2

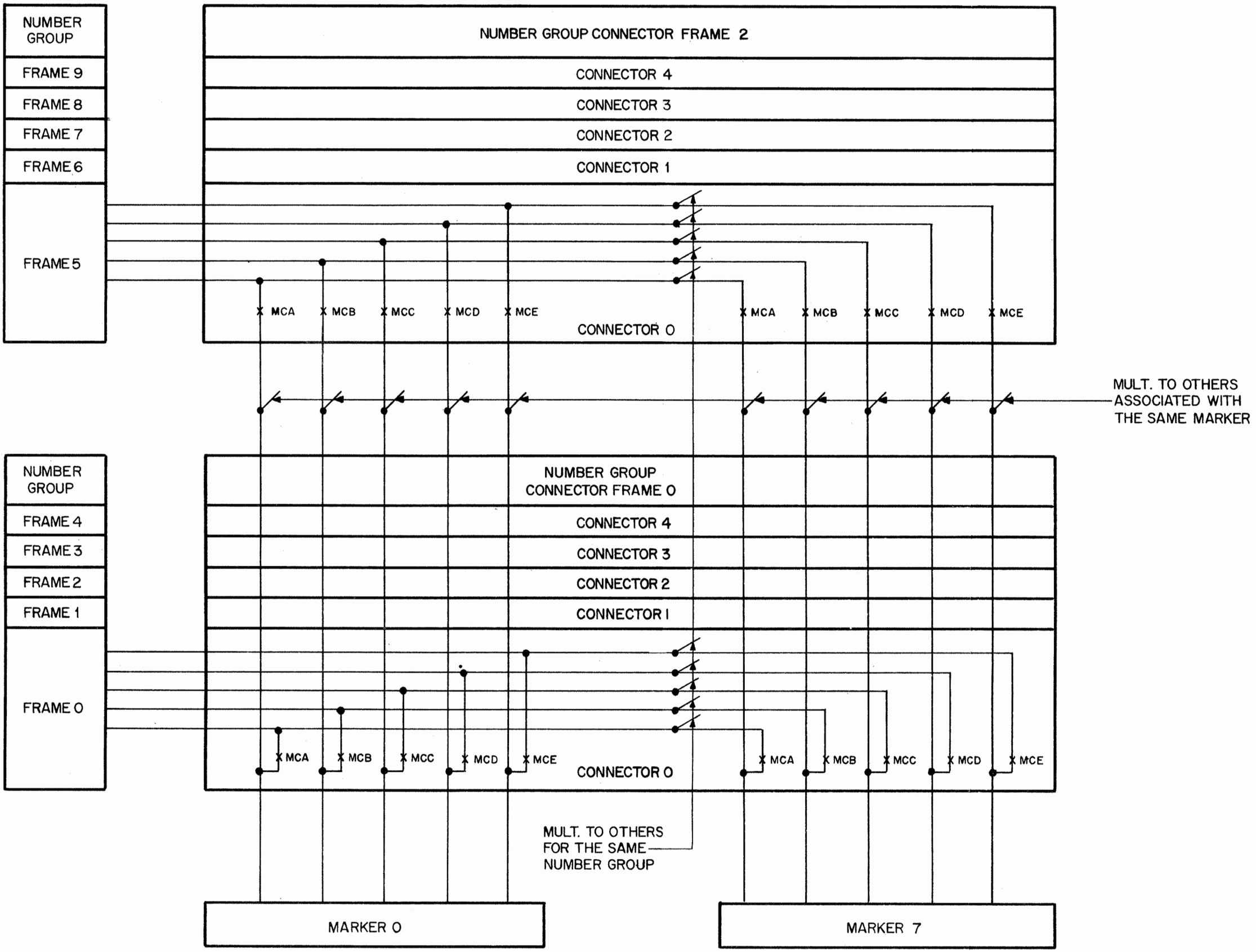


FIG. 3—TYPICAL MULTIPLE ARRANGEMENT OF THE NUMBER GROUP CONNECTOR FRAMES

FIG. 3

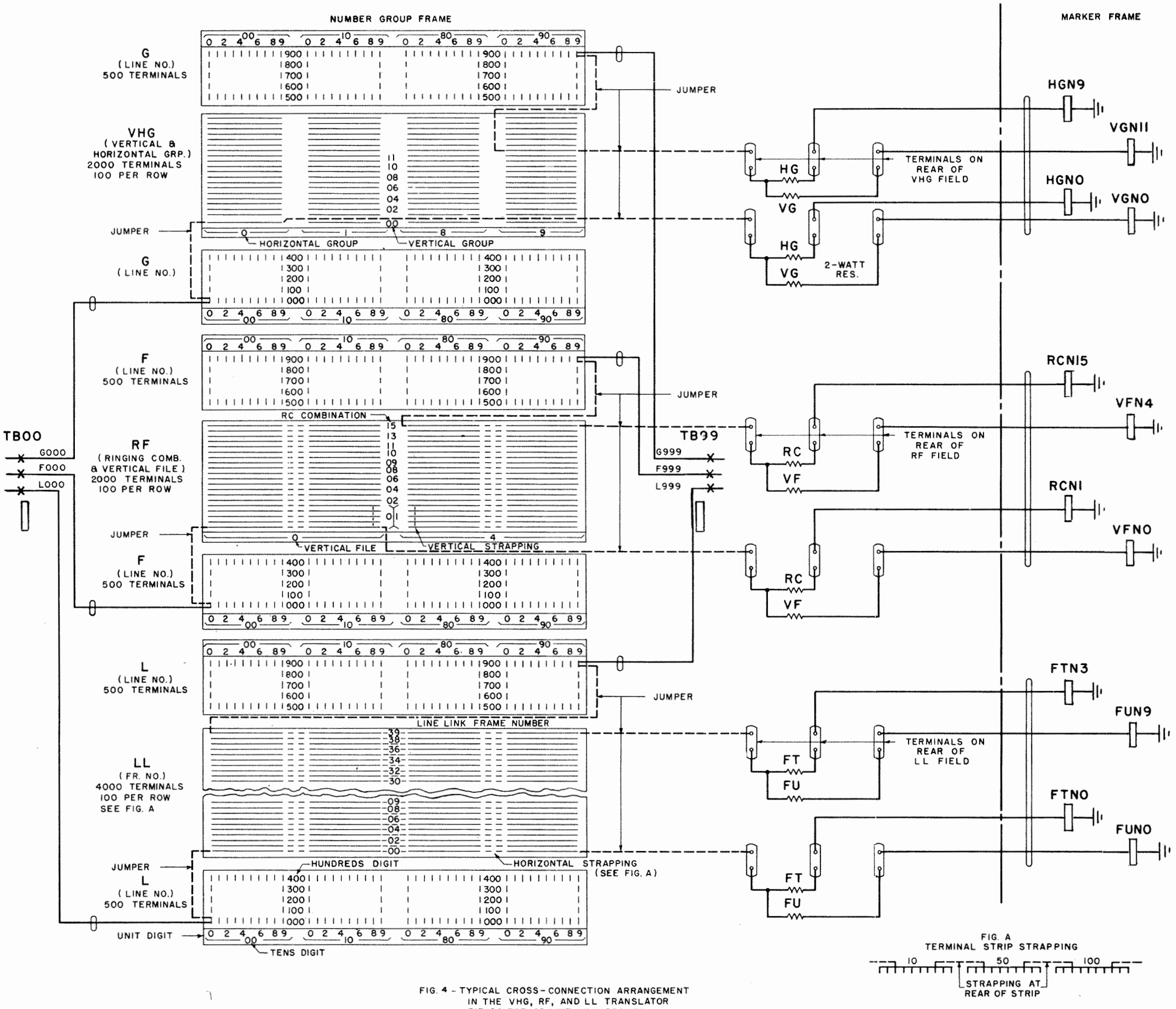
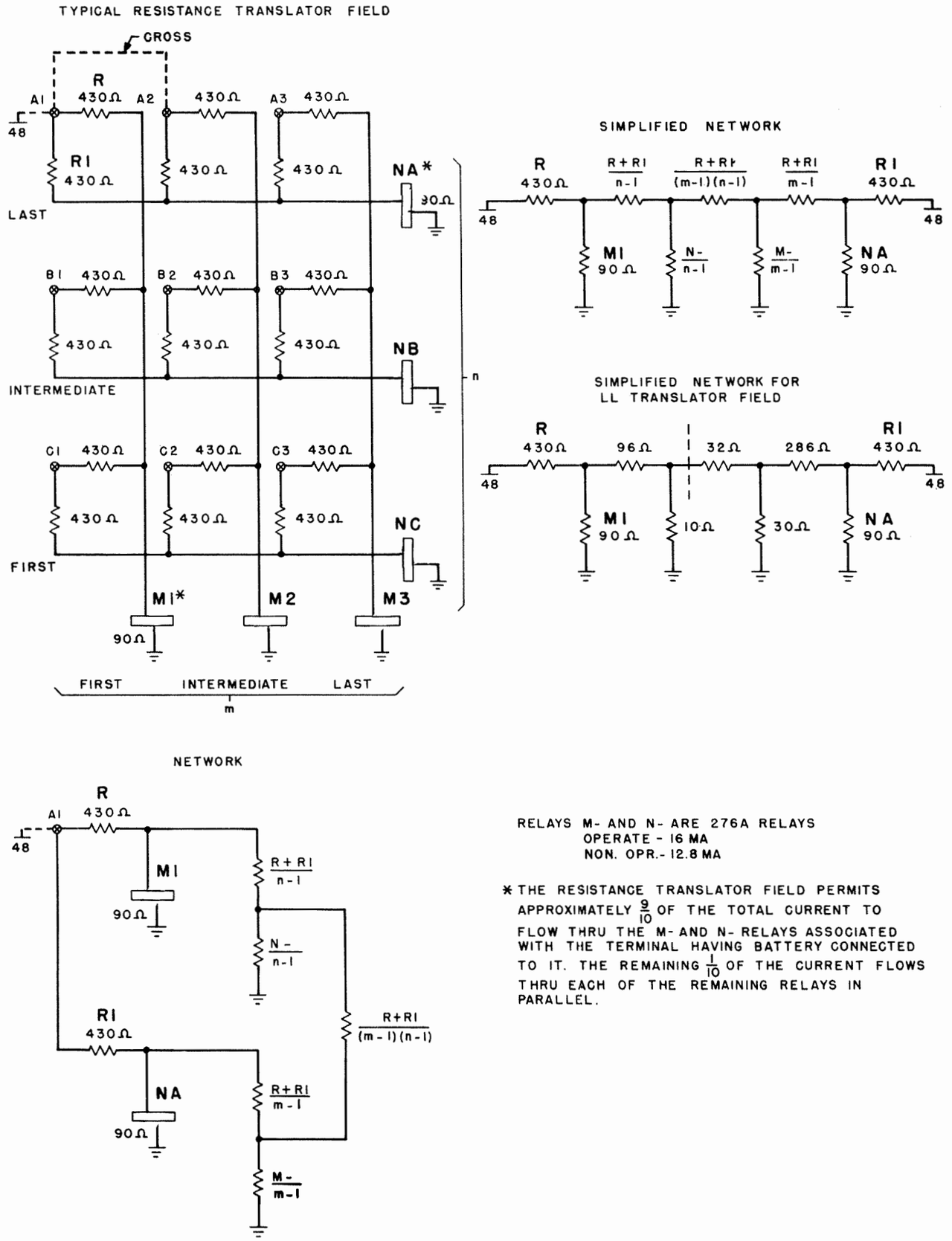


FIG. 4 - TYPICAL CROSS-CONNECTION ARRANGEMENT IN THE VHG, RF, AND LL TRANSLATOR FIELDS FOR 40 LINE LINK FRAMES

Fig. 4



RELAYS M- AND N- ARE 276A RELAYS
OPERATE - 16 MA
NON. OPR.- 12.8 MA

* THE RESISTANCE TRANSLATOR FIELD PERMITS APPROXIMATELY $\frac{9}{10}$ OF THE TOTAL CURRENT TO FLOW THRU THE M- AND N- RELAYS ASSOCIATED WITH THE TERMINAL HAVING BATTERY CONNECTED TO IT. THE REMAINING $\frac{1}{10}$ OF THE CURRENT FLOWS THRU EACH OF THE REMAINING RELAYS IN PARALLEL.

FIG. 5 - THEORY OF NUMBER GROUP TRANSLATOR NETWORK OPERATION

Fig. 5

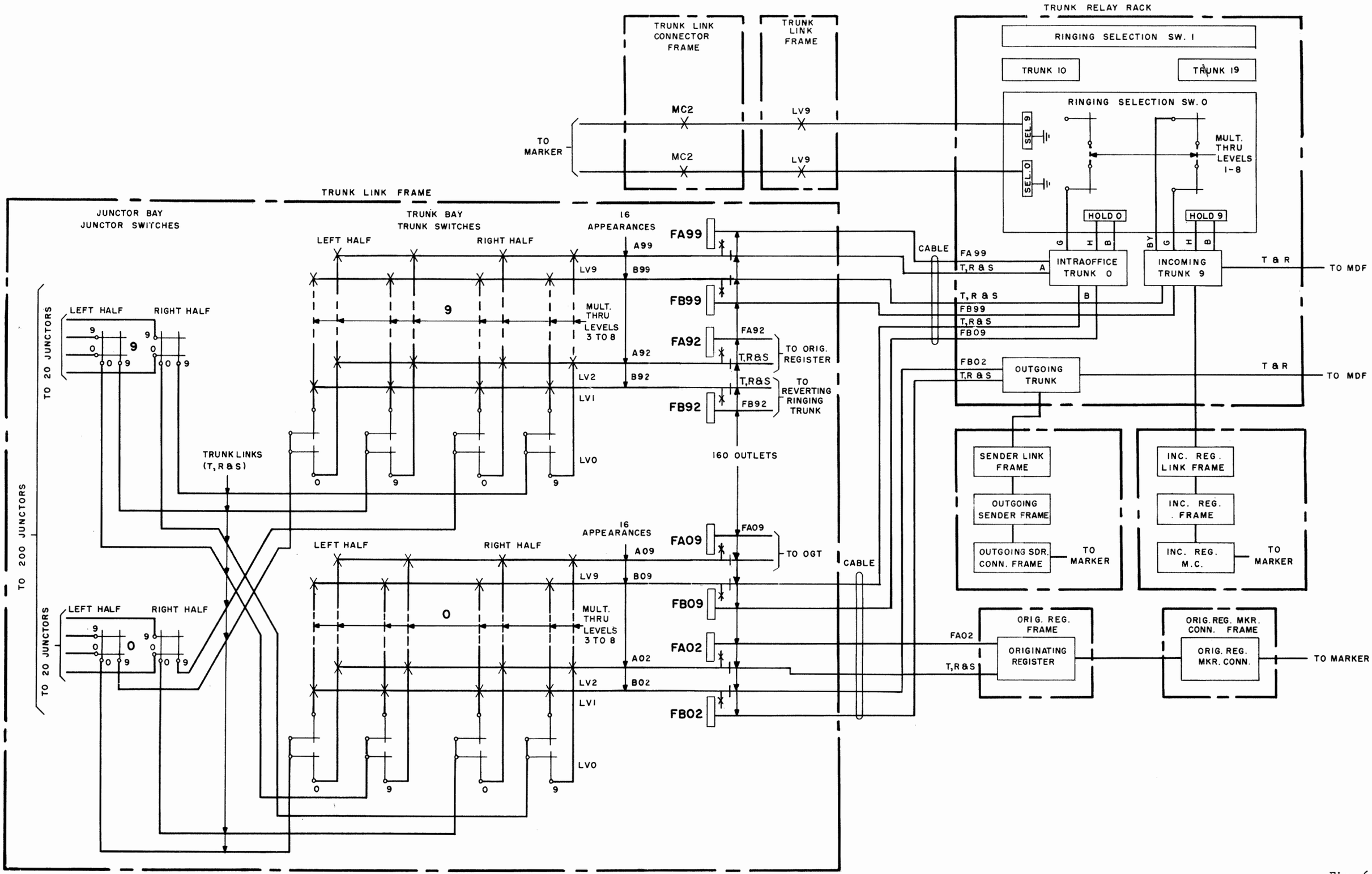


FIG. 6 - TYPICAL CONNECTING ARRANGEMENT OF TRUNKS AND REGISTERS TO THE TRUNK LINK FRAME

Fig. 6