SECTION 7

INCOMING CALLS

INCOMING CALLS

NO. 5 CROSSBAR OFFICES

CONTENTS PAGE

A. INTRODUCTION

1.01 This section is one of a group which describes the detailed circuit operation of the various types of calls handled by the No. 5 Crossbar System with wire spring relays.

1.02 Calls that originate in one central office and terminate in another are interoffice calls. Those originating in the central office are outgoing calls; those terminating in the central office are incoming calls. This section describes the operation of incoming calls. Section 6 describes the operation of outgoing calls using senders.

1.03 The terminating (called) office receives these calls over incoming trunks which are seized from the calling end. The called line directory numbers are pulsed over the trunk conductors and stored in an incoming register in the called office. Three types of incoming registers are provided:

(1) Dial pulsing (DP).

(2) Revertive pulsing (RP).

(3) Multifrequency pulsing (MF).

A table in Section 1 of this volume describes the conditions which require the use of these registers.

1.04 The pulsing operation of the incoming registers is described in the circuit description sheet (CD) of each incoming register. This process will not be repeated in this section.

1.05 When the incoming trunk is seized from the calling end, it seizes an incoming register through the incoming register link. The calling office passes the called number into the register, which then seizes a completing marker through the incoming register marker connector. The marker then establishes a connection from the trunk to the called customer. The trunk controls ringing, talking, and disconnect for the call.

1.06 The general description of incoming calls is included in Section 1 of this volume. The entire operation is shown on SC 708-1. A progress diagram for the incoming call is shown in Fig. 41 of Section 1.

B. ESTABLISHING THE INCOMING CONNECTION

1. Description of Incoming Register Links

1.01 The numericals of the called directory number are passed over the trunk conductors, through the incoming register link, then into the incoming register. The links are mounted on incoming register link frames. Each frame consists of crossbar switches and control apparatus for selecting and seizing incoming registers.

1.02 There are two kinds of incoming register link frames (IRL). One has six switches and control relays in one bay. It has a capacity for 120 dial pulse by-link trunks. The limit of the capacity of this link arrangement is one bay - 120 trunks.

1.03 Another link frame is available for RP, MF and direct pulsing DP trunks. Its capacity is 160 trunks per frame. Each frame has eight crossbar switches and associated control relays. A second or third frame can be added to this basic frame. The three frame group provides for 480 trunks served by the same ten incoming registers. The capacity of the multifrequency and revertive pulse link groups is three frames - 480 trunks. The limit of the dial pulse link for direct pulsing trunks, is two frames - 320 trunks.

1.04 On any link frame or on any link frames making up an incoming register link group, all incoming registers must be the same kind, and, of course, it follows that all the incoming trunks assigned to an incoming register link group must use the same kind of pulsing.

1.05 There is no common control equipment present which can steer a trunk to the proper kind of incoming register, and so because of this all trunks and incoming registers are on incoming register link frame use the same kind of pulsing.

1.06 In the six switch, 120 trunk incoming register link frame, each crossbar switch is a horizontal group. The trunks on the link are then divided into six horizontal groups. These trunks compete with one another, within their horizontal group, for register preference. Simultaneous seizures of registers by trunks can occur so long as the trunks are in different horizontal groups.

1.07 The incoming trunks are assigned one trunk to each vertical of the crossbar switches. Vertical zero on the first switch is always assigned as a test position for the automatic monitor and incoming register test circuit.

1.08 Each frame of a group and each horizontal group of a frame can be identified by trouble card punches. There are three punches which are used to identify the frames in the three frame, 480 trunk link group. The first, RPB, identifies the basic or first frame. The second, RPAB, identifies the auxiliary or second, and the third punch RPSA identifies the second auxiliary or third frame in a group. If we have in an office a full incoming register link group serving 480 incoming trunks, these three punches break the link down into groups of 120 trunks each.
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1.09 The RP- punches are used to further divide each frame. The eight crossbar switches on each frame are arranged into four horizontal groups of 40 trunks each. Fig. 1 shows the arrangement. Each two switches (one horizontal group) are represented by an RP- punch. Now we have broken down our 120 trunks on a frame into groups of 40 trunks each using the RPO to 3 punches. This is the smallest division obtained from the trouble card.

1.10 There is a slightly different assignment of the trouble card punches to the parts of the bylink IRL frame. This link group can only have one frame. However, the frame has six switches, each one a horizontal group. There are only five (RPO to 4) punches on the card. Here is how the identification works. The first five switches use punches RPO to 4 and also RPB. The last switch (horizontal group 5) uses punches RPO and RPAB. The assignment of punches to the horizontal groups does not fit perfectly because the card has been designed for the U and Y type link which had no more than five horizontal groups.

1.11 The incoming registers are assigned to the levels of the switches. An incoming register is multipled to the same horizontal of each switch in the link group. For example, in a full 480 trunk incoming register link, there would be twenty-four switches served by ten registers. Every register would appear once on each of the twenty-four switches on the same numbered level of each switch.

1.12 This discussion has revolved about maximum size links. A link group need not have ten registers or its full complement of switches and trunks. Size depends on traffic requirements. The principle of operation is the same for any size.

2. Connecting An Incoming Trunk to An Incoming Register

2.01 The connection of an incoming trunk to an incoming register is controlled by three relay preference chain circuits in the incoming register link. These chain circuits are as follows:

(a) TP- (Trunk Preference) Relay Chain: One of these circuits is provided for each horizontal group on the incoming register link frames. There is a TP- relay for each trunk in the horizontal group. For a single switch, we have twenty TP relays in a chain. If there is a supplementary switch then there are forty TP relays in the chain. This chain determines which trunk seizes the register.

(b) RB- (Register Busy) Relay Chain: One of these chain circuits is provided for each horizontal group on the register link frames. There is an RB- relay for each register in each of these chain circuits. When an incoming register is busy on a call or out of service, its associated RB relays are operated in the link group. For a full size link, we would have twelve RB- relays for each register, one RB relay in each register busy chain for each horizontal group.

(c) RP- (Register Preference) Relay Chain: One of these chains is provided for each register. There is an RP- relay for each horizontal group which has access to the register. This chain determines which horizontal group seizes the register.

2.02 On OS 733-1 we have the circuit for the nonbylink incoming register link frame. When the trunk loop is closed at the calling office end, relay A in the incoming trunk operates. Relay A closes a battery start (ST) lead to the TP- relay for the associated trunk. The operation of the TP- relay opens the operating path for all higher numbered TP- relays. Lower numbered TP- relays may operate, but perform no function because the functional chains are opened by the operation of any higher numbered TP- relay. The operation of a TP- relay closes a ground start (ST) lead to the RB- relay chain. Operated RB- relays indicate that their associated registers are busy.

2.03 The starting points (ST leads) of the RB- chains are connected so that each horizontal group of trunks has a different first choice register. The initial preference of a horizontal group is for the similarly numbered register. This allows calls from different horizontal groups to be served at the same time.

2.04 The start ground on lead ST is applied to normal contact of relay RB- for the first choice register. If this register is idle, the ground is applied to its RP- relay. If the first choice register is busy, the ground is transferred to the next RB- relay contacts, etc.

2.05 If the start ground reaches a normal RB- relay, it is applied to the corresponding RP- relay winding. If this RP- relay is associated with a first choice register in the horizontal group, battery is connected directly to its winding, otherwise, battery is connected to its winding through normal contacts of other RP- relays in the chain.

2.06 There is a time interval during which more than one RP- relay in a given chain may operate. For example, let us assume that all registers except the ninth are busy (OS 733-1). If start leads are grounded in rapid succession in horizontal groups 0, 1, 2, 3, in that order, the corresponding RP- relays operate. The operation of any or all RP- relays grounds lead ON to the register, which operate register relays ON (off-normal) and RB (register busy). Relay RB extends resistance battery leads to all of its associated RB- relays. All of these relays operate except RBO, which is associated with the preferred RP- relay. This occurs because ground from the register is applied over lead LO (lockout). This ground shunts relay RBO, keeping it unoperated. The other RB- relays operate and switch ground from their RP- relays to the next RB- relays in their respective chains. The RP- relays release.

2.07 In order to prevent a horizontal group from reverting to a higher choice register, should one become available after a seizure, all operated RB- relays are locked when a TP- relay operates. The locking ground is connected through break contacts on relay RB- and is therefore effective only when one or more RB- relays are normal. This arrangement prevents a horizontal group from locking itself out of service if an all-registers-busy condition occurs. When the last available register is made busy, the locking battery is removed and any RB- relay corresponding to an idle register is then free to release, making the register available to the horizontal group.

2.08 On OS 733-1, sheet 2 battery is supplied from the register on lead SM- (select magnet) and passed through a contact of the operated RP- relay to operate the S- and SS- select magnets for the level to which this incoming register is assigned. Ground on lead OH- (operate hold magnet) is supplied from the register through off-normal contacts of select magnets and contacts of the highest number operated TP- relay to operate its corresponding LH- hold magnet. The crosspoint that is associated with the register and corresponds to the TP- number is closed. The operating ground from lead OH- passes through the crosspoint and returns to the register on lead HM-. Relay H (hold) in the register operates to check the crosspoint closure. In operating, relay H opens lead OH- and connects holding ground for the hold magnet through the primary winding of relay DCK (double connection check). If ground is supplied to the hold magnet from another register, lead HM- is grounded. This shunts relay DCK and prevents its operation. If lead HM- is not grounded, relay DCK operates in series with relay H. Relay H also opens lead SM-, releasing the select magnet. The hold magnet is now held by the register through the crosspoint and is independent of the preference chains.

2.09 Relay H operates the CO relay in the trunk when MF pulsing is used and operates the DP when dial pulsing trunks are used. DP in the register in turn operates CO in the trunk. In either case, the operated CO in the trunk opens the path of the A relay in the trunk. The H relay, when it operated, closed a path for operating the A relay in the register. When this occurs, the register assumes control of the incoming connection. The H relay also opens the battery for operating the select magnets associated with the incoming register.

3. Incoming Trunk Class and Trunk Link Frame Number

3.01 Incoming trunks to No. 5 crossbar offices are assigned certain classes. These classes divide trunks into groups according to the traffic arrangements of the office. For example, incoming trunks which serve one central office designation are given a class such as OA (office A) or OB (office B). Incoming trunks which serve either of two such offices are given a class such as AB (office A and B). Other trunk classes are FVD (five digits) TAN (tandem) TOLL (toll). The class mark is handily used by the completing marker to identify the class or group of a particular incoming trunk on a call. Trunks are assigned to their classes by cross connections in the incoming register link. These cross connections for incoming trunks are recorded on assignment sheets. As an incoming trunk seizes an incoming register, the trunk class mark is passed through the link to the incoming register. The register stores the class mark until it connects to a marker after pulsing has been completed. Then it passes it to the marker.

3.02 On OS 734-1, sheet 3, we have some register connector relays in the link. There is a C- relay for each incoming register in each horizontal group. When any horizontal group contains trunks which have line link appearances (which require trunk directory numbers) a CA- relay is provided for each incoming register in that horizontal group. This drawing shows a CA- relay for each register in each horizontal group. We would have this arrangement if each of the six horizontal groups had trunks with line link frame appearances.

3.03 The C- and CA- relays are operated by the RP- relay which is operated. The RP- contacts are wired in a preference chain circuit. More than one horizontal group can have a demand in the link if they have simultaneous seizures of incoming trunks. If this happens, several RP- relays may be operated. However, the working contacts of the RP- relays are wired in a lockout chain so that only one RP- relay is effective.

3.04 On sheet 1 of this OS, we have some TP- relay contacts. The three horizontal groups shown represent the six complete groups of the 160 trunk link circuit. Each TP- relay has a terminal TPC-. The highest operated TP- relay grounds is associated punching. This TPC- terminal is cross-connected to a CL- punching according to the assignments for IRL cross connections. Each one of these CL- punchings represents an incoming trunk class. These punchings are wired to the contacts of ten C- relays. Only one can be operated at a time. The ten C- relays are numbered according to the horizontal group. On sheet 3, we saw how various horizontal groups compete for one another to get connected to the same register. On OS 733-1 we saw how the registers were wired in a chain circuit through the RB- relay contact chains. Of the ten C-relays in horizontal group zero on OS 734-1, sheet 1, only one can be operated at this time. It sends the eleven class leads to its own incoming register where they terminate on a cross connection block. These punchings are cross-connected to the class punchings in the incoming register according to cross connection assignments. Through this path, an incoming trunk gives its class mark to the register. The register locks up the operated class relay.

Trunk Link Frame Number

3.05 There may be as many as twenty trunk link frames in an office. If there are more than ten, they are divided into two groups. Trunk link frames 0 to 9 are in frame group 0, and frames 10 to 19 are in frame group 1. All the trunks in any horizontal group on the incoming register link frames must be the same trunk link frame group. It is therefore possible to identify the tens digit of the trunk link frame number through the horizontal group on the incoming register link frame.

3.06 The C- relay which has operated to connect our incoming trunk to the selected incoming register has acted as a connector to pass class information from trunk to register. It also serves as a connector to pass the trunk link frame number, of this trunk, to the incoming register. On OS 736-1 we see some other contacts of the TP- relays of incoming trunks. Just as each TP- relay grounded a terminal for trunk class, it also grounds another terminal for trunk link frame units number. The cross connections from the TPU00 to 19 punchings in each horizontal group, are cross-connected to the TF0 to 9 punchings according to IRL cross connection assignments. Because all the trunks assigned to one horizontal group must be in one group of ten trunk link frames, we use only one contact on the C- relay to indicate either G0 (frames 00 to 09) or G1 (frames 10 to 19). We use this arrangement in order to save relays and cross connections.

3.07 For any incoming trunk, we have two leads grounded from IRL to IR. The FG0 or FG1 leads operate the FG0 or 1 relay. One of the leads TF0 to TF9 is grounded. The TF leads carry trunk frame units number as one-out-of-ten information. The incoming register translates it into a two-out-of-five code. The grounded TF- lead operates one of the five TF- relays which in turn locks and operates TFT. This relay switches in incoming TF lead ground from the original TF- relay (which is locked up to ON ground) to the mate TF relay.

4. Transfer of Trunk Directory Number

4.01 Certain kinds of incoming trunks appear on line link frame verticals. Any incoming trunk which can be connected to an outgoing trunk must have a line link frame appearance. Coin junctors, operator junctors, tandem incoming, and intertoll trunks have line link frame appearances. In order for the marker to locate this trunk vertical on a line link frame, we give the trunk a directory number. Actually, the trunk has two directory numbers. The hundreds, tens and units digits are the same. The thousands digits must be different. Trunks with directory numbers are assigned certain blocks of numbers in an odd and even numbered number group. If the number of these trunks requiring trunk numbers warrants it, we may provide two special trunk number group frames. In either case, each trunk which has a directory number, appears once in two number group frames. The two number group frames must be one odd and one even numbered frame. This is necessarily so because the marker does not select trunk number groups by the thousands digit; it merely uses an odd or even selection device for one of the two trunk number group frames.

4.02 On sheet 1 of OS 735-1, we see how a trunk is given a number by the cross connections in the IRL, and how this number is stored in an incoming register. On the left of the sheet, we have the contacts of forty TP relays in horizontal group zero. This example is typical of all horizontal groups. TP relays 00 to 19 are on the basic switch and TP20 to 39 are on the supplementary switch. The three contact chains of the TP- relays belong to one set of twenty TP- relays. The TP relay contacts of a trunk send three grounds through the link into the incoming register. One of these supplies the trunk hundreds number information, another the tens and the third the units information.

4.03 Starting at the bottom of the sheet, we can follow the trunk units number. Suppose that our incoming trunk is located on vertical nineteen (which is really numbered vertical nine on the right side of the switch) of basic switch zero. Its TP relay is TP19. Operated TP19 grounds the CU9 lead to the register through the operated CA0 relay (this relay was operated in parallel with CO when our trunk seized the incoming register). If we examine the other LU- leads for a moment, we can see that the LU- lead number is the same as the units number of the TP-- relay. This is always true. The trunk directory number units digit is the same as the trunk vertical number.

4.04 Ground on lead LU9 operates LU7 relay which locks to ON ground. LU7 operates LUT relay. This relay switches the incoming ground signal from LU7 relay to LU2, operating it. This gives us a two-out-of-five trunk units digit. All other grounded LU- leads work the same way. At first one of the two-out-of-five relays is operated and locked, then LUT operates and switches the ground to the mate relay.

4.05 The trunk tens digit information comes from another chain of contacts on the same forty TP relays. The tens digit number is the same for the ten verticals, zero to nine, on any switch. For instance, on this sketch we see that TP relays 00 to 09 ground the LT0 lead through operated CA0 connector relay. TP10 to 19 ground LT1 lead. TP20 to 29 ground lead LT0 (the same lead grounded by TP00 to TP19) and TP30 to 39 ground LT1 lead (the same lead grounded by TP10 to 19). Since on this call, our trunk has operated TP19 relay, the ground from its contacts operates LT1 relay in the incoming register. LT1 locks to ON ground.

4.06 The grounding of the LT2 to LT9 leads, if they are equipped in the link, occurs in the same way as the process we just examined. The two sets of ten TP- relays associated with any switch, ground two LT leads. The nonbylink (120 trunk) link frame uses LT leads zero to seven. The 160 trunk link frame uses LT leads zero to nine which take care of five of the switches (ten half switches) and leads LT0 and LT1 are used again for the sixth switch, horizontal group five.

4.07 Now to examine the hundreds digit process. The top set of TP- relay contacts, on this page, give the trunk hundreds information. The first twenty TP relays, TP00 to TP19, are on the basic switch; they ground the A0 punching on nonbylink frames. The second group of TP relays, TP20 to TP39, ground punching B0 in a nonbylink frame. The TP00 to 19 relays are on the basic switch and TP relays 20 to 39 are on the supplementary switch of horizontal group zero. The A0 and B0 punchings are cross-connected according to

Note 3 on this OS. In any case, the cross connection will serve to operate one of the four relays REG, REG1, SUP, SUP1 in the MF register or one of two relays REG or SUP in DP registers.

4.08 The operated REG, REG1, SUP, or SUP1 relay and operated LT- relay in the register ground associated terminals. These terminals are cross-connected so as to translate the hundreds digit of the trunk number.

4.09 Actually there are several conditions which limit the assignment of trunk numbers to incoming trunks which require them. If the directory numbers assigned to these trunks fall in a subscribers number group series, then only those numbers reserved for trunks can be used. There are various limitations on the assignment of trunk numbers in the incoming register link groups. There can't be duplication of numbers. For instance, in the example above we had forty trunks in horizontal group zero. The first ten trunks (TPO to 9) are assigned LTO lead. The third set (TPO to 9 on the supplementary switch) use the same lead LTO. Obviously trunks in these two groups must have different hundreds numbers. This is controlled by the AO and BO punching cross connections. In any case, the units digit of the trunk number must be the same as its vertical number on the incoming register link switch. The tens and hundreds digits are governed according to the several frames of a link group. These limitations are spelled out in detail in notes in the schematic drawing of the Incoming Register Link Frame, SD-26048-01.

5. Link Release Check

5.01 After the trunk has been connected to the incoming register, after the crosspoints have closed and after the trunk passes the required information to the register, the incoming register makes a check to see if the information is stored properly. If it is, the check relay (CK) operates in the register. Then the register starts a timer which controls the length of the start pulse signal to the distant end. The process of making the check is timed by a special timer - LR (link release). If the check is unsuccessful, this timer operates and causes the incoming register to seize a completing marker immediately. The register passes to the marker all the information it has which is horizontal group (RP-), frame identity (RPB, RPAB, or RPSA), trunk class, trunk link frame number and trunk directory number. The marker in turn passes this information to the trouble recorder for the LR card which it produces. If the check is successful then the LR timer will not operate because the operated CK will prevent it. The register then sends a start dialing or start pulsing signal to the outgoing office.

5.02 The CK path for MF registers is shown on OS 740-1, sheet 2. It checks the frame group tens (FGO or FG1) and trunk frame units (TFT) trunk class (OA, OB, etc.). If the trunk class is TAN or TOLL, it also checks the trunk directory number (LT-, LUT, REG, SUP, Etc.). The path continues through the register busy relays to the IRL. The path through the RP- relay contact chain varies according to the preference position a register has in a particular horizontal group. Whichever horizontal group contains our incoming trunk, has its RP- relay operated. This takes the BL lead into the contact chain of TP- relays. The operated TP- relay which is highest in the preference circuit has to be the same one selected by the link control circuit, and also happens to be the one associated with our incoming trunk. In this example it is TP01; the trunk CO is supplying a ground to operate the CK relay in the incoming register.

5.03 The CK operates RLK which in turn starts the RV timer. When RV relay operates, it reverses the tip and ring through the register A relay. This reverses the battery and ground towards the outgoing office. The reversal supplies a start signal to the distant end. These operations can be followed on sheet 2 of OS 740-1.

5.04 The operation of the CK relay in the dial pulse incoming register is similar to the MF register. In both registers, when the CK operates it starts the RV timer and operates the RLK relay. The RLK relay releases the operated TP- relay which is associated with the incoming trunk. The RLK also allows the RB relay associated with this register, which has been shunted down to operate. The operated RB- relay transfers the start lead from this to a succeeding register. The TP- relay, being released, allows the next preferred trunk to put out a demand for an incoming register.

6. Inpulsing - Dial Pulse Registers

6.01 A No. 5 crossbar office may use incoming dial pulse registers to receive inpulsing from the following types of offices:

No. 5 Crossbar
Step-by-Step
Manual (Operator positions equipped with dials)
Panel Sender Tandem
Crossbar Tandem
Nos. 4, 4A, 4M, and A4A Crossbar Toll

The sequence of relay operations for incoming dial pulse registers is shown on SC1 on sheet E1 of SD-26041-01, the dial pulse incoming register schematic drawing.

6.02 When the register is seized by an incoming trunk, it receives and registers the dialed information together with the class of trunk. It then connects to a marker and transfers this information to it. The marker sets up the connections to the called party and the call is completed. Dial pulse incoming registers are arranged to receive pulsing from bylink or direct pulsing trunks. Bylink trunks originate in step-by-step offices. Pulsing on these trunks starts shortly after register seizure. A quick pulsing path is established through the control relays of the incoming register link, and pulsing is repeated from a relay in the bylink trunk. Direct pulsing trunks wait until a start pulsing signal is returned by the register.

6.03 When a direct pulsing trunk is connected to an incoming register, relay C- in the incoming register link operates the DP (direct pulsing) relay (OS 738-1). When the crosspoints are closed, relay DP operates trunk relay CO (cutoff). Relay CO removes trunk relay A from the tip and ring to provide T and R leads to the register. DP also operates L (line) relay. Relay CO sends a ground to the register, which checks the operation of the register class and trunk link frame number relays. Properly operated class and trunk link frame number relays are indicated by the operation of relay CK (class check). Relay CK closes the charging circuit to capacitor RV, and in about 140 to 300 milliseconds, tube RV conducts, operating relay RV (reversal). Relay RV reverses the tip and ring conductors. This is a start pulsing signal to the calling office. Relay RV also operates relay RV1. Relay RV1 removes the holding ground from the ACC (abandoned call control). This ground holds the ACC relay during the interval when relay L may be released by the tip and ring reversal. Relay RV1 is slow operate, and maintains this ground during the momentary release of relay L. If dial tone is required, as in calls from an operator, relay RV1 connects ground to the TN (tone) coil, inducing dial tone on the tip and ring conductors.

6.04 Where step-by-step offices do not use senders, the customer dials directly and controls the pulsing of digits to the called office. The first one, two, or three dialed digits (office code) cause the step-by-step equipment to seize a trunk to the called office. If this is a No. 5 crossbar office, the incoming register must be ready to receive pulsing during the interdigital interval. This is done by an auxiliary or bylink path through the control relays in the register link. The operation of the register preference relays in the link circuit closes a path to operate register relay L from the trunk. The operated C- (class) relays in the link circuit indicate a bylink type of trunk and operate register relay BL (bylink). Relay BL prepares the register for the pulses. Relay BL also prepares a path for the operation of relay CK which checks that the class and trunk link frame number is recorded in the register.

6.05 The dial pulse counting feature records the number of pulses in each digit. When dialing of a digit is completed, the count is transferred to register relays. The counter then recycles to prepare itself for the next digit. The pulse dividing, pulse counting, and register relays operate in the same manner for both types of trunks. The operation of the various relays in the register is described in CD-26041-01, Incoming Register Dial Pulsing.

7. Inpulsing - Multifrequency Registers

7.01 A No. 5 crossbar office may use incoming multifrequency pulse registers to receive inpulsing from the following types of offices:

No. 5 Crossbar
Manual
Nos. 4, 4A, 4M, and A4A Crossbar Toll
Crossbar Tandem

The sequence of relay operations for incoming multifrequency pulse registers is shown on the SC's in the E section of SD-26042-01 - Incoming Register Multifrequency. The multifrequency incoming register is seized by an incoming trunk through the incoming register link. The register prepares itself for inpulsing and returns a signal to the trunk, indicating that inpulsing may start. A multifrequency receiving circuit is used with the register to translate the ac pulses into dc pulses which can be registered. Multifrequency pulsing and the signaling receiving circuit are described in Paragraph 8. After pulsing is completed, the register seizes a completing marker which completes the connection to the called number.

7.02 When relay RLK operates (OS 740-1), indicating that the trunk link frame number and the class information are recorded in the register, the RV tube is fired and operates the RV relay. Relay RV reverses battery and ground to the tip and ring conductors. This is recognized as a start-pulsing signal by the operator or outgoing sender. At the completion of the start-pulse signal, relay SP (start pulse) in the outgoing sender operates.

7.03 In this type of incoming register, receiving is done by the multifrequency receiving circuit. The frequencies are received and translated into dc pulses and passed to the register where they are recorded on a two-out-of-five code basis on registration relays A- through L- (OS 740-1). Associated with each registration relay is a digit-steering relay (AS through LS).

7.04 When the register is seized, the operated ON (off-normal) relay operates relay AS (A digit steering). The register proceeds to the operation of relay SP in the sender, as described in 7.02. When the KP (keypulse) signal is received, relays KP, KP1, and KP2 (keypulse) operate in the signaling receiving circuit (OS 740-1), indicating that the receiver is ready to receive digit frequencies. The A digit frequencies operate two corresponding channel relays on a two-out-of-five code basis. The operated channel relays operate the A digit register relays. The CK2 relay operates if two frequencies are received. The operated channel relays operate RA (register advance) which in turn operates the next steering relay (in this case, BS). BS restores the signal receiver to normal. When the digit tones are removed at the distant end, RA releases. RA releases the previous digit steering relay (in this case, AS) and the receiver and register are ready for the next digit.

7.05 The B digit is recorded in the same manner. Two of the B digit registration relays and the CS steering relay operate. The channel relays and the BS digit relays release. The rest of digits proceed in the same way. If the number of digits registered is less than the maximum number for which the register is equipped, a start signal is required for marker seizure.

8. Signal Receiving Circuit

8.01 A signal receiving circuit is provided for each incoming multifrequency register. The receiving circuit receives multifrequency signals (ac voltages) in the form of pulses over a trunk from a keyset or multifrequency sender. It converts these pulses to dc signals which are stored in the register and are used to control the receiver and the register.

8.02 Multifrequency pulsing makes use of six voice frequencies, spaced 200 cycles apart, to transmit the digits zero through nine and two additional signals. One of these signals, KP (keypulse), is sent at the start of pulsing and the other, ST (start), is sent when pulsing is completed. The frequencies are designated in a two-out-of-six coding arrangement. Table A shows the frequency designations with the digits and signals which they represent.

TABLE A

Digit	Frequencies Designated
0	4,7
1	0,1
2	0,2
3	1,2
4	0,4
5	1,4
6	2,4
7	0,7
8	1,7
9	2,7
KP	2,10
ST	7,10

Table B shows the frequency designations with the frequencies used.

TABLE B

Frequency Designation	Frequency Used, CPS
0	700
1	900
2	1100
4	1300
7	1500
10	1700

8.03 A signal receiver performs the following functions:

(a) Establishes a fixed amplitude for the incoming signals.

(b) Separates, by a filtering arrangement, the two frequency components of each pulse.

(c) Converts the two ac components of the signal to dc for controlling and registering the digits of the called number.

8.04 The filaments of the vacuum tubes in the receiver are continuously energized, except when the receiver is removed from service. Signaling receiving circuit on OS 740-1 should be used with this description of the receiver.

8.05 The KP (keypulse) signal is a relatively long pulse of frequencies two and ten. It primes the receiver for the digit pulses. When the receiving circuit is connected to a multifrequency sender, there is a period when it is exposed to outside speech or noise currents. This might cause false registrations in the associated incoming register. To prevent this, the receiver is arranged so that it does not register digits until it is unlocked by a KP signal.

8.06 The input circuit consists of an IN transformer, an impedance-correcting network, and an IN input transformer. Transformer IN is so designed and shielded that the effect of outside currents which might cause false operations of the receiver are kept at a minimum. Resistors P1, P2, and P3 make up the impedance-matching network. Input transformer IN is used to increase the voltage of the signals before they enter the voltage limiter.

8.07 The volume limiter consists of vacuum tubes L1, L2, and their associated input and output circuits. The limiter controls the signal amplification to the extent that only the desired channels will operate. It also limits the volume of high-level incoming signals so that undesired channels do not operate because of "spill over" from adjacent channels. The limiting action is obtained by the control grid resistors and capacitors L1 and L2. The actual point at which limiting occurs is controlled by the screen grid and cathode voltages as well as the control grid voltage on tubes L1 and L2. Potentiometer P adjusts the screen grid voltages. The cathode voltage is obtained from the voltage drop across resistor L3. The output of the volume limiter is connected to three circuits:

(1) Signal present circuit (SP filter).

(2) Variable bias circuit.

(3) Channel filters.

8.08 The signal present circuit consists of the OUT (output) transformer, SP (signal present) input transformer, SP filter, BR vacuum tube, its associated resistors and capacitors, and the SP vacuum tube. The voltage from the output limiter is applied through filter SP and input transformer SP to grid No. 3 of tube BR. Tube BR functions as a rectifier because of negative grid bias supplied by potentiometer SP. The output of tube BR (a dc potential taken from its cathode) is connected through resistor P to vacuum tube SP after the KP signal is received and the KP condition established. Before and during the KP signal, tube BR is held nonconducting by a negative bias on grid terminal three. Vacuum tube SP acts as a dc amplifier and also operates relay SP, indicating the presence of a signal.

8.09 The variable bias circuit consists of half of vacuum tube BR, the grid bias control apparatus which is connected to terminal seven of tube BR, and the voltage doubler apparatus which is connected to terminal six.

8.10 During reception of the KP signal the variable bias circuit adds a negative voltage, determined by the signal strength at the volume limiter output, to the fixed negative bias which is on the grids of the channel and SP tubes. In addition, potentiometer SP is used to adjust the bias on the SP tube grids in order to control the sensitivity of the receiver during reception of the KP signal.

8.11 During the reception of the digit and ST signals, the variable bias circuit places variable negative bias on the grids of the channel tubes but not on the grids of tube SP. The variable negative bias is large for strong input signals and small for weak signals; it prevents the tube from conducting in unwanted channels, since a strong positive signal from the channel rectifier must overcome both the variable negative bias and the fixed negative bias.

8.12 Each receiving channel (there are six) consists of a filter, half of a vacuum tube connected as a diode rectifier, a thyratron, and a relay. The purpose of the receiving channel is to receive the ac current from the output limiter, rectify it to dc, and operate its associated channel relay. Voltage from the volume limiter through the OUT transformer is applied across resistors B and C in the six db transmission pad (formed by resistors A, B, and C). This pad acts as an impedance smoothing device between the varying output of the volume limiter and the input to the channel filters. It also decreases the effect that outside currents (which build up and die down in the filters) might have on the operation of relay SP (signal present).

8.13 The filters are assembled with elements for two frequencies under a common cover. Common input terminals for both filters are one and two, three is the output terminal for the lower frequency and four for the higher. Two other filter elements appearing on terminals four and five of the SP filter unit are also connected in parallel with the channel filter inputs to simulate the effect of filters immediately below the 700-cycle filter and above the 1700-cycle filter. This results in an appreciable improvement in the 700- and 1700-cycle wave shape at the output of those filters.

8.14 The start signal ST, consisting of frequencies seven and ten, is sent after all digits are transmitted. If the number of digits registered is less than the maximum number for which the register is equipped, a start signal is required to start marker seizure. If the number of digits registered is the same as the maximum number for which the register is equipped, the register starts seizure automatically and the start signal is not required. However, to simplify operating practices, the start signal is always sent.

8.15 When a multifrequency incoming register is seized, its operated ON1 relay closes battery over leads BAT1 and BAT2. Battery over lead BAT2 energizes the primary winding of relay KP (keypulse). This relay does not operate at this time because its secondary winding is energized by battery through its own winding and normal contacts, and normal contacts of relay SP and jack KP to ground. Lead BAT1 supplies battery to relays KP1 and KP2 for later operation.

8.16 When the KP frequencies (two and ten) are received, they pass through the volume limiter for either amplification or limiting, as required. The output of the volume limiter passes through pad A and the 100- and 1700-cycle filters. Channel rectifier tube A changes the output of the channel filter to a positive dc voltage.

8.17 The variable bias circuit operates in the following way when the KP signal is received. Energy from plate terminal five of tube L1 is connected via capacitor AA, resistor AC, and potentiometer BIAS to grid terminal seven of twin triode BR. This grid is biased 10 volts negative through the connection to the potentiometer formed by resistors AD and AE.

8.18 The amount of signal voltage applied to grid seven of tube BR is determined by the setting of potentiometer BIAS which is a part of the calibration procedure. The signal at the output of tube BR appears as a voltage across plate resistor AF and is applied to the voltage doubler rectifier consisting of capacitors AB and D, varistors A and B, and resistor N. The negative dc voltage derived from the rectified signal appears across resistor N and is added to the negative 18-volt fixed bias derived from the potentiometer formed by resistors D, E, and F. This negative voltage is connected through one-megohm resistors BA and BB to a point in each channel at the output of the channel rectifier tube. Here the negative voltage is applied to the grid of channel thyratrons for channels two and ten and to the suppressor and control grids of tube SP. During the reception of the KP signal, relay LK is normal and the positive 130 volts on the make contacts of relay LK is not placed on the plates of the thyratron tubes. Thus no conduction takes place in thyratrons for channels two and ten because of the absence of plate voltage.

8.19 Both the positive voltage from the rectifier tubes in channels two and ten and the negative voltage from the fixed and variable bias circuits appear on the grids of tube SP. Tube SP has a characteristic such that it conducts when both the grid and suppressor elements approach a positive voltage. Thus, as the grid is connected to the output of channel two and the suppressor is connected to the output of channel ten, the positive rectified signals overcome the negative bias present on these two tube elements. With both elements positive or nearly positive, the resultant plate current operates relay SP. This removes ground from the contact seven of relay KP and connects ground to lead J to the MF incoming sender circuit. In the register, the J and L leads are connected together so that the operation of relay SP operates relay LK, which supplies plate battery to all thyratrons except two and ten.

8.20 Relay KP, which was held on its back contacts from battery through the secondary winding to ground on the back contact of relay SP, remains in this condition for approximately 50 to 55 milliseconds after relay SP operates. This is because of the charging current through capacitors E, F, and G to ground at resistor K. At the end of this interval, the current in the secondary winding has decreased to such an extent that the primary winding takes control and operates relay KP to its front contacts. Relay KP remains operated to its front contacts while the digits are received.

8.21 If a third frequency accompanies the KP signal, a positive voltage is placed on a channel thyratron grid for a channel other than two and ten. This thyratron immediately becomes conducting, thereby operating its associated channel relay. Ground from the contact of this channel relay, via a back contact of relay KP2, stops the timing capacitor from charging and holds relay KP to its back contacts. Thus, no recognition takes place.

8.22 At the end of a normal KP signal, consisting only of 1100- and 1700-cycle frequencies, and lasting a minimum of 55 milliseconds, tube SP again becomes nonconducting and relay SP releases. The normal SP relay releases relay LK and again connects ground through the front contacts of relay KP to operate relays KP1 and KP2.

8.23 The operation of relays KP1 and KP2 at the end of the KP signal conditions the receiver for the receipt of digit signals by the following changes.

(a) In the SP circuit, the high negative voltage on grid three of tube BR is removed. Also, the cathode output circuit of this tube is connected to the grid and suppressor elements of tube SP. At the same time, these elements are disconnected from the filter outputs of channels two and ten.

(b) The plates of channel thyratrons two and ten are connected via their associated relays and resistors to the contacts of relay LK. When relay LK is reoperated, 130 volts are connected to the plates of all thyratrons so that subsequent operation is the same in all channels.

(c) The circuit shunting the windings of relays CK2 and CK3 is opened so that the plate current of all thyratrons in a conducting condition flows through these windings.

8.24 On this call, the first digit transmitted is a five. Therefore, 900- and 1300-cycle frequencies are sent to the receiving circuit where they traverse the input circuit and the volume limiter in the same way as described for the KP signal.

8.25 At the output of the volume limiter, the voltage across the 600-ohm resistor in the shunt element of the six-db pad is applied through band-pass filter SP and input transformer SP to grid terminal three of tube BR. This voltage is rectified, and the resulting dc voltage is taken from cathode terminal two of tube BR and applied through the smoothing filter (consisting of capacitors C and H and resistor P) and the make contacts of relay KP2 to the grid and suppressor elements of tube SP. After fourteen milliseconds, capacitor H becomes sufficiently charged so that the current flow in the plate circuit of tube SP operates relay SP which operates relay LK. The operation of relay LK connects 130-volt battery to the plate circuits of all six channel thyratrons.

8.26 Part of the energy from the digit five signal is taken from the plate of tube L1 for the operation of the variable bias circuit. The ac voltage from tube L1 is connected to grid terminal seven of tube BR, is amplified, and is passed to a rectifier circuit. The negative dc voltage derived from the rectifier is added to the negative 18-volt bias on the grids of the thyratrons.

8.27 The ac voltage across resistors B and C in the six-db pad is applied to the rectifier tubes of channels one and four through the 900- and 1300-cycle filters. The rectified positive voltage is added to the 18-volt fixed negative bias increased by the negative voltage controlled by the incoming signal amplitude. It is then applied to the grid terminals of the thyratrons for channels one and four. With the incoming signal voltage on the grid terminals of the thyratrons for channels one and four and with battery on the plate terminals of all thyratrons, tubes B and C (for channels one and four) the two thyratrons conduct. The operation of relay CK2 results in the following actions:

(a) Removes ground from resistor F, increasing the fixed bias on the thyratron grids from -18 to -48 volts to insure that no other channel thyratrons conduct from the end transient condition when the signal ceases.

(b) Connects ground to lead H.

(c) Places a second ground on leads J and Q. This ground is independent of relay SP.

8.28 When the register was first seized, the register relay AS (A digit steering) operated. Receiver relay CK2 operates the register relay RA which operates relay BS (B-digit steering). The channel relays one and four ground leads one and four to the register to operate counting relays A1 and A4. Register relay BS opens the J-L loop to release receiver relay LK. Relay LK opens the 130-volt lead, causing relay CK2 and the channel thyratrons to release. Relay CK2 releases register relay RA which releases relay AS. When the channel thyratrons stop conducting, the channel relays release.

8.29 The end of the signal for the A digit causes tubes BR and SP to stop conducting. Varistors C, D, and E in the SP circuit are poled so as to reduce the time constant of resistor P and capacitor H at the end of the signal. While the first digit is being received, relay CK3 operates if three thyratron tubes conduct current because of the presence of a third frequency. When relay CK3 operates, it removes ground from lead K to the register and grounds lead RO to the register. The grounded RO lead operates relay RO and the call is routed to reorder. The B digit and the succeeding digits are detected by the receiver and then registered by the operation of their respective register relays in the same manner as described for the first digit. After all the digits have been transmitted, the ST (start signal) signal, consisting of frequencies seven and ten, is sent. The receiver functions in the same way as on digit pulses, except it grounds the seven and ten leads.

9. Marker Start-Dial Pulse and Multifrequency Incoming Registers

General

9.01 Where inpulsing is completed, the incoming register calls for a completing marker. It gives the marker all the information it has received. This includes:

Registered Digits
Trunk Link Frame Number of Incoming Trunk
Class of Incoming Trunk
Directory Number of Incoming Trunk (for Tandem and Toll Class Trunks with line link frame appearances)

The completing marker establishes a connection from the trunk link frame appearance of the incoming trunk to the line link frame appearance of the called subscriber's line. It makes the usual tests and then disconnects.

9.02 OS 740-1 shows some typical cross connections for marker start with different trunk classes and varying numbers of digits in a multifrequency incoming register. The cross connections represent trunks which would serve the offices shown in the block diagram on OS 734-1.

9.03 OS 739-1 shows typical cross connections for marker start in dial pulse incoming registers. Examples using stations delay and various trunk classes are shown.

10. Incoming Register Connects to a Marker

10.01 An incoming register selects an idle marker in the same manner as an originating register does in the terminating stage of an intraoffice call. This is described in Section 5 - Intraoffice Calls. OS 701-2 illustrates the circuit arrangement.

10.02 The trunk link frame number is passed from the incoming register link to the incoming register where it is recorded. When an incoming register marker connector is selected, its RS- (register start) relay (OS 701-2) is operated by the incoming register. The operated RS- relay prepares a path to operate the marker connector RA (register connector) and MA (marker connector) relays. The operated RA and MA relays close a path to operate marker relays FGO or FG1 (trunk frame group) and TF- (trunk frame) (OS 736-1). Relay FGO represents a frame in trunk frame group 0 through 9, and relay FG1 represents a frame in trunk frame group 10 through 19. The TF- relays operate on a two-out-of-five code basis. For example, if the selected trunk is located on trunk link frame 10, relays FG1, TF4, and TF7 in the marker are operated.

10.03 The operated marker connector RS relay also prepares a path to operate the marker connector RB, RC, RD, RE (register connector) MB, MC, MD and ME (marker connector) relays (OS 701-2). These relays close a path from the incoming register, where the class information was recorded, to the class relays in the marker (OS 734-1).

10.04 The operated marker connector and relays also close paths to operate marker code register relays AC $\frac{2}{5}$, and BC $\frac{2}{5}$, CC and the INC (incoming) relays (OS 715-1). Relay INC indicates to the marker that the call terminates in this office.

10.05 An office consisting of one 10,000-directory number series requires no office identification. The called numericals identify the called line. The incoming register operates marker relay OA (office A), which operates relay N1 to prepare paths for operating the marker registration relays (OS 734-1). An office consisting of two 10,000-directory number series requires office identification in addition to the numericals of the called line to identify the called line. If this office is provided with one group of incoming trunks serving one 10,000-directory number series and another group of incoming trunks serving the other 10,000-directory number series, the incoming register will operate either relay OA (Office A) or OB (Office B). However, if the same group of incoming trunks has access to both directory number series, an office identifying digit is received from the calling office and passed from the incoming register to the marker. The office identifying digit precedes the numerical digits and identifies the office directory number series as office A or B. The office identifying digit is recorded on relays AC $\frac{2}{5}$, (A digit code) on a two-out-of-five code basis. Relays OA and OB do not operate.

10.06 OS 734-1 has a block diagram which illustrates examples where separate trunk groups, five, six and seven digit trunk groups are used.

10.07 The circuit arrangement for an office equipped to handle four, five, or seven digit calls is shown on OS 720-1. On a four digit call, relays AC $\frac{2}{5}$, BC $\frac{2}{5}$, and CC $\frac{2}{5}$ are used to prepare a path to the marker numerical digit registration relays (TH-, HN-, and T-). On a four digit call requiring an office identification digit, the office digit is recorded on relays AC $\frac{2}{5}$. Relays BC $\frac{2}{5}$ (B digit code) and CC $\frac{2}{5}$ (C digit code) are used to prepare a path to marker registration relays TH- and HN-.

10.08 If an office identification digit is required in addition to the called line numericals, the incoming register grounds marker punching FVD (OS 734-1). This ground operates relay FVD (translator control, 5 digits). The register also operates two of the five AC- relays in the marker (OS 715-1). Relays FVD and AC $\frac{2}{5}$, ground a code point to operate the LPA, LTA, LEA, LPB, LTB, or LEB (local physical, local theoretical, or local extheo office A or B) relay (OS 716-1).

11. Trunk Link Frame Seizure

11.01 Each trunk link frame has an MP- (marker preference) relay associated with each marker (OS 702-2). All markers in an office have access to each trunk link frame, but only one marker at a time can connect to a trunk link frame. If the trunk link frame to be used on a call is engaged by one marker, the second marker must wait until the trunk link frame becomes idle. This is controlled by the MP- relay chain.

11.02 When a marker seizes a trunk link, it operates its associated MP- relay for that trunk link frame. A trunk link frame seizure on an incoming call, is indicated by the operated marker TFK3 (trunk frame check) relay. Relay TFK3 checks that the selected trunk link frame MP- relay associated with this marker is operated and all other more preferred MP- relays in the same trunk link are not operated.

11.03 On an incoming call, the marker is directed to seize the trunk link frame on which the incoming trunk is located. The marker does not choose a trunk link frame as it does on other calls. The operated frame group (FG $\frac{0}{1}$) and trunk frame units (TF $\frac{2}{5}$) relays **establish a path** over which the marker seizes the proper trunk **link frame**.

12. Trunk Link Frame - Link Connector and Select Magnet Operation

12.01 Link Connector Operation: Marker relay TFK3 closes battery through the incoming register marker connector and incoming register link circuits to operate trunk relay F. This path is on SD-26002-01, FS33. Relay F operates relay FB-- (B appearance trunk connector). Relay FB-- operates relay LC- (link connector). One LC- connects the twenty links of the associated switch to the marker. Ten of these links are connected through by relay R (right); the other ten by relay L (left). Therefore, only ten links are connected through for channel test.

12.02 Select Magnet Operation: The operation of the select magnets is similar to the operation of the select magnets for setting up the connecting path to the calling line on intraoffice connection (Section 5). However, instead of operating the trunk link frame trunk switch select magnet A, select magnet B is operated through contacts of the operated marker FBK (frame B appearance check) relay. This is because an incoming trunk is always associated with the B appearance on the trunk link frame.

13. Priming the Incoming Trunk for Charging

13.01 On full selector calls requiring charging and on manual, dial switchboard A operator, and toll operator calls, the marker sets the incoming trunk for a charge condition. When the marker LI (line idle) relay (OS 725-1) operates, trunk relay TC (talking charge) is operated through the primary winding of the TCK (talking charge check) relay. Polar relay TCK does not operate at this time. Trunk relay TC locks and returns ground to the marker which operates relay TCK. This checks the operation of trunk relay TC.

14. Marker Selects Number Group to Locate Called Line

14.01 The number group is selected by the marker in a manner similar to that described for intraoffice calls (Section 5).

15. Number Group Locates Called Line and Transfers Information to the Marker

15.01 Number group translation and transfer of called line information are identical to that described for intraoffice calls (Section 5).

16. Releasing the Number Group

16.01 Number group release is similar to that described for intraoffice calls (Section 5).

17. Selecting the Line Link Frame

17.01 Line link frame selection is similar to that described for intraoffice calls (Section 5).

18. Operating the Called Line Identification Relays

18.01 Operation of the called line identification relays is similar to that described for intraoffice calls (Section 5).

19. Number Group Makes Ringing Selection

19.01 Ringing selection is made in a manner similar to that described for intraoffice calls (Section 5).

20. Junctor Control, Channel Test, and Channel Selection

20.01 Junctor control, channel test, and channel selection are similar to that described for the intraoffice call (Section 5).

21. Operating the Select and Hold Magnets

21.01 After a channel is selected, the various select and hold magnets are operated. This operation is the same as that described for the intraoffice call (Section 5).

22. False Cross and Ground and Continuity Tests

22.01 These tests are made in a manner similar to those for the intraoffice call, Section 5. After the operation of all the crosspoints except the line hold magnet, the false cross and ground test is made. If successful, the line hold magnet is operated and a continuity test is applied. The marker has been informed by the number group whether the called party is a tip or ring party, therefore, in the continuity test, the test relay is applied to the proper side of the line.

23. Ground, Loop and Receiver Off-Hook Tests

23.01 These tests are made in a manner similar to that described for intraoffice calls, Section 5.

24. Sleeve Double Connection Test and Holding Ground Check

24.01 Sleeve double connection test and holding ground check are similar to those described for the intraoffice call, Section 5.

25. Releasing the Select Magnets

25.01 After the operation of DCT (double connection test) relay indicating a successful double connection test, relay DCT1 (double connection test) operates. This releases the ONX (off-normal cross) relay which releases the select magnets.

26. Marker and Register Release

26.01 When the tests and checks described above are completed, relay DCT releases. Relay DCT operates the LK1 (linkage check) relay. Relay LK1 indicates a completion of the incoming trunk connection. Relay LK1 also operates the DIS1 and DIS2 (disconnect) relays. This causes the line link, trunk link, incoming register, and marker to release.

27. Ringing and Disconnect

27.01 Release of trunk link relay FB--, after marker double connection test, transfers the tip and ring from the marker to the trunk and return control of the ringing selection switch hold magnet to the trunk circuit. Ringing of the called party now starts. When the called party answers, ringing is tripped.

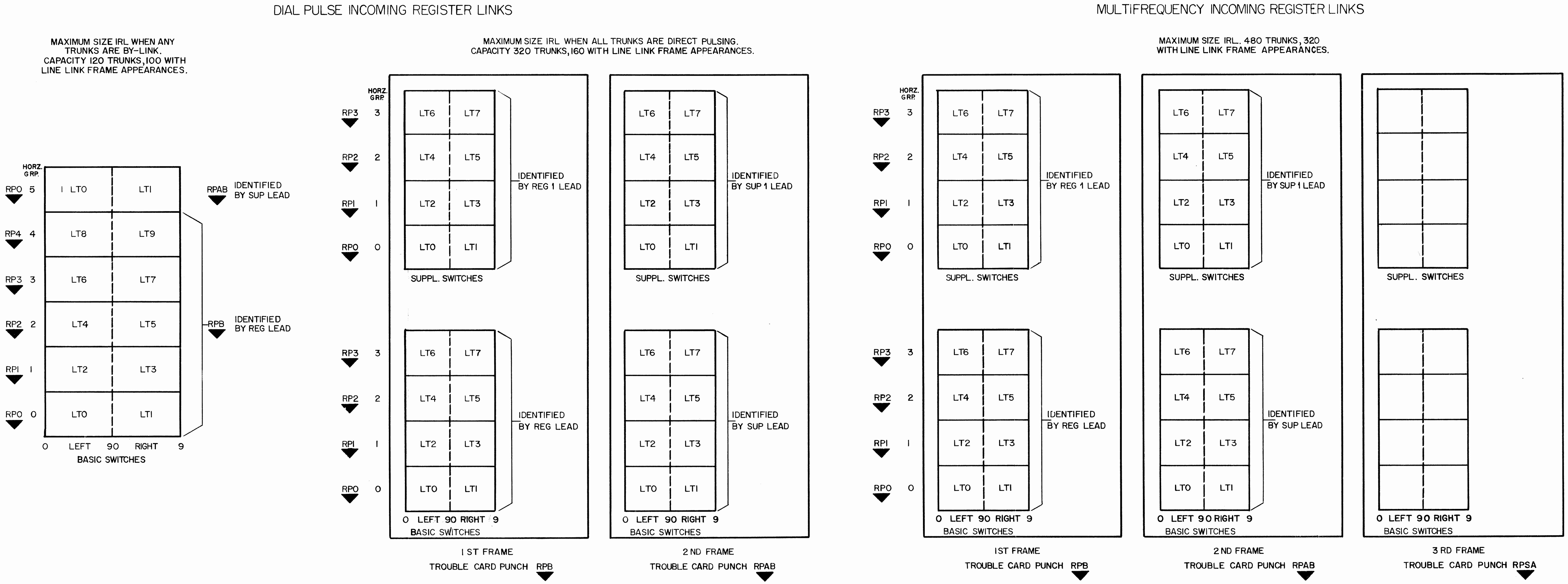

FIG.1 INCOMING REGISTER LINK ARRANGEMENTS

FIG. 1