DETAILED CIRCUIT OPERATION

CALL FROM AN OUTWARD OPERATOR TO A NO. 1 CROSSBAR OFFICE

ARRANGED FOR MF PULSING VIA TWO NO. 4A TOLL OFFICES

3- AND 6-DIGIT TRANSLATION

NO. 4A TOLL SWITCHING OFFICES

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FIGURES

1. GENERAL

1.01 This section is one of a group of sections, all having the base number A828.121. These sections describe the detailed circuit operations of the No. 4A Toll Switching System.

1.02 This section describes the circuit operations necessary for switching a call from an outward operator to a No. 1 crossbar office via two No. 4A toll offices. (See Fig. 1.)

1.03 The following paragraphs give a general explanation of the basic operations required to complete this call. A number of assumptions have been made on this call to describe certain 4A operations. In some cases, these assumptions do not agree with actual equipment arrangements at the offices involved in the call. The detailed description of the circuit operations begins with Par. 2.01.

1.04 This call is assumed to originate at the outward switchboard in Pittsburgh and is completed to a local subscriber, LA5-6328, in Cleveland, which is in foreign area 216. It is assumed that the Pittsburgh outward switchboard has dial equipment and is served by a combined train No. 4A toll switching office. The LA5 local dial office at Cleveland is a No. 1 crossbar office which is equipped to receive MF pulses and is reached through Cleveland which is assumed to be a 2-train No. 4A toll switching office. It is also assumed that there is a group of 15 terminal grade trunks and a group of 50 common grade trunks between the Pittsburgh 4A office and the Cleveland 4A office.

1.05 The outward operator seizes a toll tandem trunk to the Pittsburgh 4A system, and when the dial pilot lamp on her position indicates that a DP incoming sender is attached, she dials 216 (Cleveland area code), LA5 (national office code), and 6328 (numericals of the subscriber number). These digits together with the NVO class mark of the incoming toll tandem trunk are registered in the sender. When the sender receives the first three digits (216) a decoder is seized and the 216 digits and the NVO mark are transmitted to it. The decoder engages the home translator and sends 216-NVO to it. The decoder also sends card grouping signals to indicate that a 3D card is to be dropped. The corresponding code bars are operated and the 216-3D area card drops. The NVO code bar is

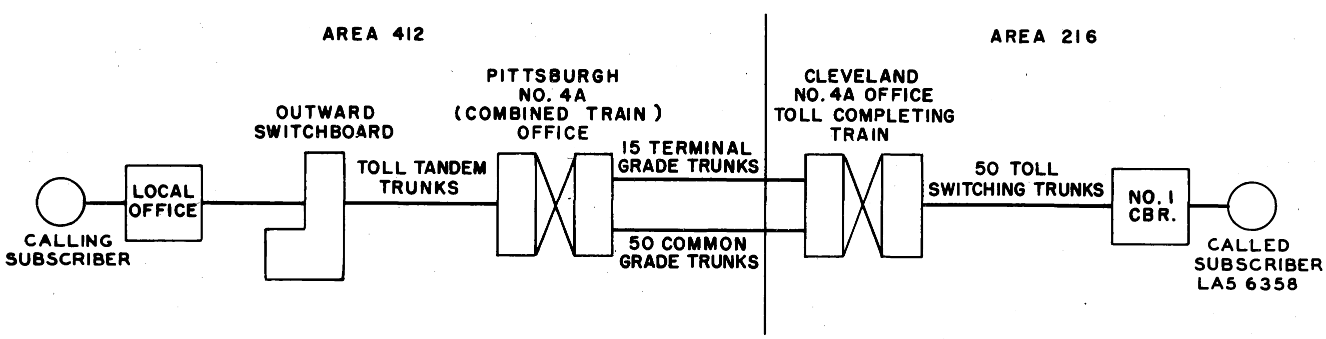


FIG. 1 - CALL VIA TWO 4A OFFICES

operated, but on this call it has no effect on dropping the 216-3D card since it is assumed that the NVO and the VO tabs are cut off the card. It is also assumed that the 3D card has the CA6 (come again six digits) punch enlarged, indicating that 6-digit translation is to be used on the call.

1.06 The two types of trunks (terminal and common grade) to Cleveland constitute two entries into the 216 area from Pittsburgh. By translating the first six digits (the 216 area code and the LA5 office code) the decoder can determine which entry (the terminal grade group, or the common grade group) to use.

1.07 On this call it is assumed that all of the first six digits are not registered in the sender at the time the 3D card is read. Therefore pretranslation is required. When the sender receives the CA6 indication from the decoder, it releases the decoder. The decoder causes the translator to restore the 3D card. The decoder and translator are then free to serve other calls. When the sender has registered six digits (216-LA5), it again causes a decoder to be seized. This decoder causes the associated home translator to drop its 216-3D card. The decoder reads the 3D card to determine the location of the 6D cards for area 216, and then allows the 3D card to be restored. Following this operation, the decoder causes a 216-LA5-6D card to be dropped in a foreign area translator. The 6D card that drops in this case is the 216-LA5-6D-NVO card which represents the 15 terminal grade trunks between Pittsburgh and Cleveland. The NVO card is dropped because the call originates on a toll tandem trunk at Pittsburgh and terminates at the LA5 local office in Cleveland. Toll tandem trunks from outward switchboards always carry a wiring option (NVO) which causes the NVO code bar to operate in the card translator.

1.08 It is assumed that there is another 216-LA5-6D card, the 216-LA5-6D-VO card, in the translator at Pittsburgh. This card is used on through calls at Pittsburgh for the Cleveland LA5 office. These calls originate at another toll office and enter the Pittsburgh 4A office on incoming intertoll trunks (common grade) which always carry a VO wiring option, thereby operating the VO code bar in the card translator (instead of the NVO code bar). These calls require the connection of two intertoll trunks at Pittsburgh, and consequently common grade trunks are required on these calls. A terminal grade trunk can be used on the call here described because only one intertoll trunk is required in the connection.

1.09 The 216-LA5-6D-NVO card, as mentioned above, contains information for routing the call via a terminal grade trunk. In addition, this 6D card indicates a card-to-relay (CR) routing instruction, since the common trunk group serves as an alternate route if all terminal grade trunks are found busy by the marker.

1.10 The first part of the detailed description, beginning with Par. 2.01, assumes that a terminal grade trunk is available. With this condition the marker establishes the connection to the seized terminal grade trunk and is released. In the meantime, however, the marker passes the class information (MF outpulsing) and the variable spill information (skip 3) back to the sender, causing it to outpulse LA5-6328 on an MF basis. In this case the marker reads the SK3 information directly from the 216-LA5-6D-NVO card which was punched to indicate SK3.

1.11 The second part of the detailed description, beginning with Par. 2.29, assumes that a common grade trunk to Cleveland is used. For this condition it must be assumed that the marker finds all terminal grade trunks busy and therefore sends an ATB (all trunks busy) signal to the decoder. During the trunk test the decoder restores the 216-LA5-6D-NVO card and releases the foreign area translator and seizes the home translator. When the decoder receives the ATB signal, an AR card associated with a subgroup with an idle common grade trunk to Cleveland is dropped in the home translator. There are two AR cards available to the decoder since there are over 40 common grade trunks to Cleveland. The decoder is directed to the proper AR card by pretesting the common grade trunk group through the operated route relay associated with the group. The number of the route relay is the same as the alternate route pattern number on the 216-LA5-6D-NVO card. The first AR card is dropped if trunks are idle in the first subgroup but the second AR card is dropped (without initially dropping the first card) if no idle trunks are available in the first subgroup.

1.12 Assuming that one of the AR cards has dropped, the marker proceeds to select and seize a trunk and establish the connection. The marker also registers the class and variable spill information and signals it to the sender. The sender therefore, as previously described, skips the 216 and outpulses LA5-6328 on an MF basis.

1.13 When an AR card is dropped, the marker must register the variable spill information (in this case SK3) by a process known as code matching. This is necessary because the variable spill information must be determined by whether the alternate route trunks terminate in the area to which the call is directed by the sender. The code conversion punches on AR cards are always enlarged to indicate the area in which the trunks terminate - in this case 216. When the card is read by the decoder, relays in the decoder match the 216 on the card with the 216 area code registered in the sender. Because the two codes match, the decoder gives the marker an SK3 indication. If this call were alternate routed through Columbus (area 614), the AR card dropped would indicate area code 614. In this case the 216 and 614 codes would not match and the decoder would indicate NSK to the marker. The marker would then signal the sender to outpulse 216-LA5-6328 to Columbus so that the call could be switched to the Cleveland area.

1.14 On the call being described, the Cleveland 4A office switches the call to the LA5 office by using 3-digit translation. The 4A operations are the same regardless of whether a terminal grade or common grade trunk is selected at Pittsburgh. The first 3D card that drops at Cleveland is associated with the first 40 toll switching trunks to the LA5 crossbar office and contains CC (card-to-card) routing instruction. After this card has been read, the decoder waits for the marker to indicate whether an idle trunk has been selected. If the marker finds all of the trunks busy, it signals the decoder to drop a second card. This is an RA1 card and contains information about the last 10 toll switching trunks. Routing instruction on this card, since it is the last card available, is follow-with-reorder. If the marker should find all trunks busy, it would direct the call to a reorder trunk.

1.15 Assuming that an idle trunk to the LA5 office is selected, the sender is instructed to skip the office code (SK3) and outpulse the numericals 6328 on an MF basis to the local office which has attached an MF terminating sender to the trunk.

1.16 The local office then connects the incoming toll switching trunk to the local subscriber line and applies ringing current to the line.

1.17 When the called subscriber answers, an off-hook signal is returned to the outward operator cord circuit at Pittsburgh, indicating that the connection has been established.

2. DECODER OPERATIONS - FIRST 4A TOLL OFFICE

(A) Connecting Decoder to Home Translator

2.01 When a sender has registered the first three digits, connection is made to an idle decoder via a decoder connector. The decoder immediately cuts through to its home translator as described in detail in Part 5 of Section A828.121.2.

(B) Dropping 3D Card in Home Translator (SC 113-1)

2.02 When the A, B and C digits and the 3D leads are connected to the home translator the 216-3D card drops. (See Fig. 2.) The VO and NVO tabs on this card are removed to allow the same card to drop, regardless of whether the three digits registered in the sender are received from an intertoll trunk having a VO mark or, as is the case for the call being described, from a toll tandem trunk which carries an NVO mark.

(C) Reading 3D Card - Pretranslation (SC 114-1)

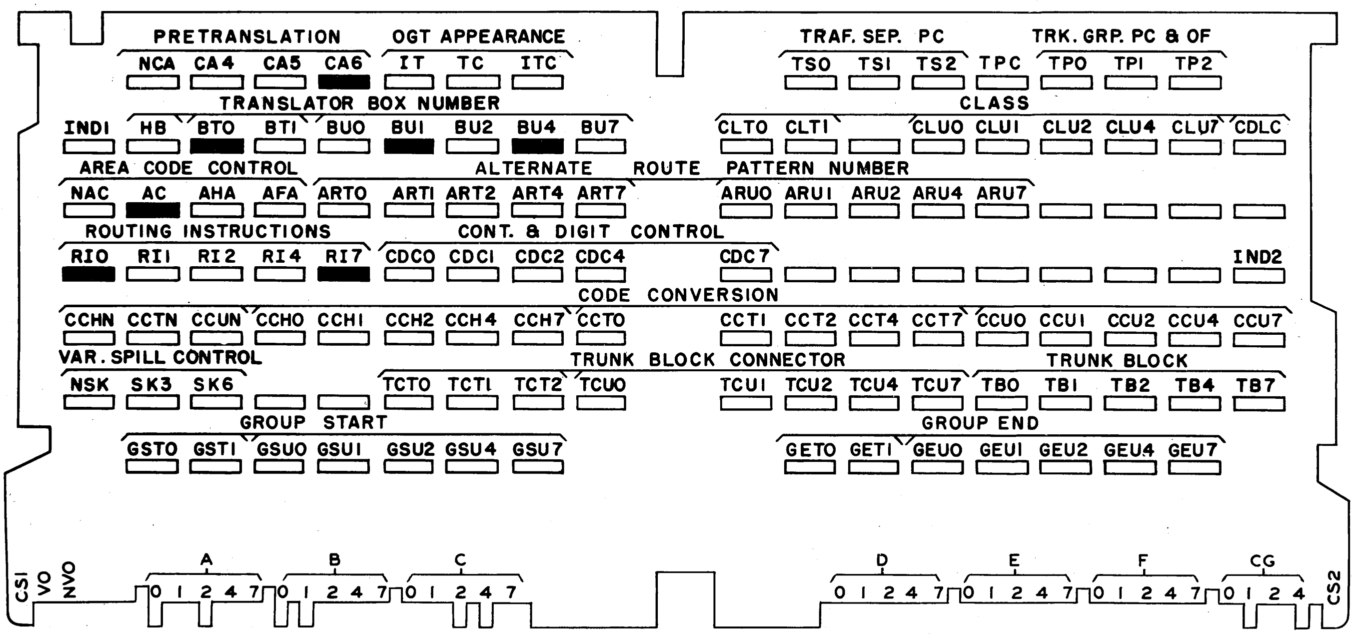
2.03 The COP1 and COP2 (card operated indication) relays, which operate when a card is down, operate the CA (come again battery supply) relay (OS 163-1). The CA6 (come again six digits) punch on this card is enlarged to cause pretranslation by operating the CA6 relay in the decoder (OS 164-1). This call assumes that all of the first six digits have not been registered in the sender at this time; therefore the operation of the CA6 relay causes the decoder connector and decoder to release as follows. Relay CA6 operates the CA6 relay in the sender and the DRL (decoder release) relay in the decoder (OS 166-1), which releases the OC (output control) relay and operates the ARC (automatic restore card) relay in the home translator. The ARC relay in turn operates relay RLT (release after translation). The RLT relay releases the CKG, CKG1 and CKG2 relays (OS 155-1) and operates the DRL relay in the sender to cause the release of the decoder connector, decoder, and home translator by releasing the MS2 (marker start) relay (OS 124-1). The operation of relay DRL in the sender releases the DRL1 (decoder release auxiliary) relay. The decoder connector and decoder are now free to handle other calls.

(D) Requesting Decoder After Registration of Six Digits (SC 113-1)

2.04 When six digits have been registered in the sender as indicated by the operation of the FDR (F digit registered) relay, the sender again seizes a decoder (OS 124-1). This action is started by reoperating relay MS2 through the operated contacts of relays FDR, CA6 and S, and the normal contacts of the DRL1 relay.

(E) Dropping 3D Card in Home Translator - NPCR

2.05 When the A, B and C digit leads are cut through to the home translator



NOTES:
1. VIEWED FROM LIGHT SOURCE.
2. ENLARGED PUNCHES SHOWN IN BLACK.

FIG. 2 - 216-3D CARD AT PITTSBURGH USED FOR PRETRANSLATION

the 3D card again drops. However, as the DRL relay in the sender is locked (OS 166-1) the 6D lead is grounded to the decoder, causing the operation of the 6D (6-digit signal from sender) relay (OS 124-1).

2.06 When the COP1 and COP2 relays operate, indicating that the 3D card has been dropped, the 6D relay prevents the operation of the CA battery supply relay (OS 163-1) and the CA6 punch, although enlarged, is thereby made ineffective. The remaining information as indicated below is read from the 216-3D card and registered in the decoder:

(a) AC - indicating that the first three digits comprise an area code.

(b) RI0 and RI7 - indicating no-principal-city-routing instruction.

(c) BT0, BU1 and BU4 - indicating the number of a foreign area translator.

(F) Using 3D Card Information (Fig. 1 on SC 115-1)

2.07 Since no-principal-city-routing instruction is indicated, the 6D card for the call under consideration must be in paired foreign area translators. The 6D card is located in paired foreign area translators numbers 5 and 6, since the BT0, BU1 and BU4 punches are enlarged. The AC, RI0 and RI7, BT0 and BU1 and BU4 enlarged punches cause the associated channel tubes to fire (OS 164-1). The BU1 and BU4 channels operate relays MBU1 and MBU4 (mercury relays for FAT box units numbers), which in turn operate relays BU1, BU1', BU4 and BU4' (OS 165-1). With relays BT0, BU1' and BU4' operated, the circuit for operating relays BNA, BNB and BNC (translator box number start) is completed.

2.08 When the BNA, BNB and BNC (translator box number start leads 0 to 9) or the BND, BNE and BNF (translator box number start leads 10 to 19) relays operate, a check for foreign area translator availability is made (OS 165-1). This check determines if the foreign area translator is plugged busy. It is made before the decoder seizes either the decoder foreign area or a foreign area translator.

(G) Restoring 3D Card - Releasing Home Translator

2.09 When the decoder is directed to a foreign area translator and it is not plugged busy, the TID (translator idle) relay operates to ground at the normal FBE or FBO jack, and in turn operates the TID1 (translator idle auxiliary) relay (OS 165-1). The TID1 relay releases the OC relay, and in turn the OC1 to OC10 (output control) relays release. The TID1 relay also operates the ARC (automatic restore card) relay in the home translator (OS 166-1), which in turn operates the RHC (restore home connector) relay (OS 167-1). The RHC relay breaks the operating path for the HTR (home translator connector) relay (OS 160-1), causing its release and in turn the release of the HC1 to HC16 relays (OS 161-1). The HTK (home translator check) relay releases and completes a circuit for operating the R6D (receive 6 digits) relay (OS 167-1). The ARC relay in operating also releases the CC1 to CC5 (code cut-in) relays (OS 161-1).

2.10 When the RHC relay has operated and the HTK relay has released, the decoder places battery on the start lead associated with the desired foreign area translator (OS 183-1). The call being described is assumed to have the required 6D card in paired foreign area translators 5 and 6*.

*As the routing instruction on the 3D card is NPCR (no-principal-city-routing), the 6D card must be placed in paired foreign area translators to prevent calls from being blocked when, for any reason, one of the pair is plugged busy.

2.11 When paired foreign area translators are used, the 3D card in the home translator is punched to indicate the first or odd translator of the pair. The foreign area translator which is actually seized is controlled as follows.

(H) Selecting Paired Foreign Area Translator (Fig. 1 on SC 115-1)

2.12 When the decoder is directed to a paired foreign area translator, as is the case when the NPCR relay is operated from the routing instruction on the 3D card, the DBS1 or DBS2 (duplicate foreign area translator box shift) relay operates (OS 165-1). The position of the PF (preference) relay (OS 160-1), which is controlled by the attached sender, determines which DBS- relay is operated. The PF relay is operated when the decoder is connected to even-numbered senders, and is normal when the decoder is connected to odd-numbered senders. On second trial calls, the preference is reversed by the operation of the TR2A (decoder indicates second trial) relay (OS 165-1).

2.13 If the preferred foreign area translator of a pair is plugged busy the FBE- and FBO- (foreign busy even or odd) relays are operated so that the translator is made busy to even-numbered and odd-numbered decoders (OS 165-1). When relay DBS1 or DBS2 operates, the operated FBE or FBO relay causes the TBY (foreign area translator plugged busy) relay to operate. The TBY relay operates the DBS relay which changes the preference by operating the opposite DBS- relay and releasing the preferred DBS- relay. The decoder then places battery on the ST (start) lead to the translator connector associated with the less preferred foreign area translator of the pair (OS 183-1).

(I) Translator Connector Operations

General

2.14 There are three types of card translators normally used in a 4A toll office - namely, home, decoder foreign area, and foreign area translators. The decoder gains access to the home and decoder foreign area translators through U-type connector relays within the decoder. Decoders gain access to foreign area translators by means of translator connectors. Each translator connector provides access to its associated foreign area translator for all decoders. The translator connector also functions to prevent connection of more than one decoder to a foreign area translator at the same time.

2.15 An emergency card translator is also provided. It can be substituted for any foreign area, decoder foreign area, or home translator. When used, the decoder gains access by means of the emergency translator connector. Before the emergency card translator can be used to replace any card translator, it must contain the cards which are identical with those in the card translator it replaces.

Emergency Translator Connector Operation

2.16 The emergency translator connector is used:

(a) To Replace a Foreign Area Translabor - When a decoder is directed to a particular foreign area translator and the foreign area translator has a make busy plug in its FE (foreign emergency) jack, the EME (emergency even) and EMO (emergency odd) relays in the regular translator connector associated with the particular foreign area translator operate (OS 183-1). The operated EME and EMO relays transfer the ST lead from each decoder to the emergency translator connector where they compete, as explained for regular translator connectors, for connection to the emergency translator.

(b) To Replace a Decoder Foreign Area Translator - When a decoder is directed to its decoder foreign area translator for additional information and a make-busy plug is in the DFE (decoder foreign emergency) jack, the DFE relay in the decoder operates and the battery that normally operates the DFTR (decoder foreign translator) relay is transferred to the EST (emergency start) lead (OS 183-1). Battery on the EST lead operates the P relay associated with this decoder in the emergency translator connector, causing it to connect the leads from the decoder to the emergency translator as explained previously. The EST lead does not compete for connection to the emergency translator because only one decoder is connected to a decoder foreign translator.

(c) To Replace a Home Translator - This operation is the same as it is for replacing a decoder foreign translator except that the make busy plug is in the HE (home emergency) jack, causing the operation of the HE relay in the decoder. With the HE relay operated, the battery to operate the HTR (home translator) relay is transferred to the EST lead. Also, as more leads are required between the decoder and a home translator, the HE relay operated causes the EMC (emergency connect) relay in the emergency translator connector to operate when the CO multicontact relay operates. This connects the required additional leads from the decoder to the emergency translator.

Detailed Translator Connector Operation

2.17 For the call being described, it is assumed that the 6D card is in foreign area translators numbers 5 and 6, that the sender is even-numbered, and that no plugs have been placed in FBO and FBE jacks or the FE jack for foreign area translator number 6. With an even-numbered sender attached, the decoder PF relay and the DSB2 relay are operated. Battery through the operated DSB2 relay is placed on start lead number 6 which connects to the translator connector that has access to foreign area translator number 6 (OS 183-1). Each start lead is wired to the winding of a P (preference) relay in a translator connector. These relays are arranged in a double transfer lockout circuit which regulates decoder preference in seizing the connector and insures that only one decoder enters a connector at one time. When the translator connector is idle, battery on the ST6 lead operates the associated P relay. The C (connect) relay associated with the decoder is operated by the P relay. The C relay operates the multicontact relays CO, C1 and C2 to connect the leads from the decoder to the foreign area translator. The decoder then directs the foreign area translator to drop the card that has the information required.

2.18 The operating circuit for all C relays in a connector is through the normal contacts of the LO (lockout) relay. The LO relay operates when any group of CO, C1 and C2 relays are operated. Its function is to insure that the translator connector has time to release before proceeding to serve the next calling decoder.

<u>(J) Dropping 6D Card in Foreign Area Translator</u>

2.19 The operation of relays R6D and RHC, which occurs when the home translator is released (OS 167-1), removes the shunt from relays CC3 and CC4. These relays operate with relays CC1, CC2 and CC5 (code cut-in) when the CO relay in the translator connector operates (OS 161-1). The operated CC1 to CC5 relays cut through leads A to F on a two-out-of-five basis and the NVO lead to pull down the proper code bars. In addition, the operated CC4 relay grounds the CG1 and CG4 leads to pull down the CG1 and CG4 code bars. For the call being described, these code bars allow the 216-525-6D-NVO card to drop. (See Figs. 1 and 3 on SC 118-1.)

<u>(K) Recording Card Information in the Decoder</u>

2.20 When the 6D card has dropped, as indicated by the operation of relays COP1 and COP2 (OS 163-1), the decoder reads the card shown on Fig. 3 and registers the following information:

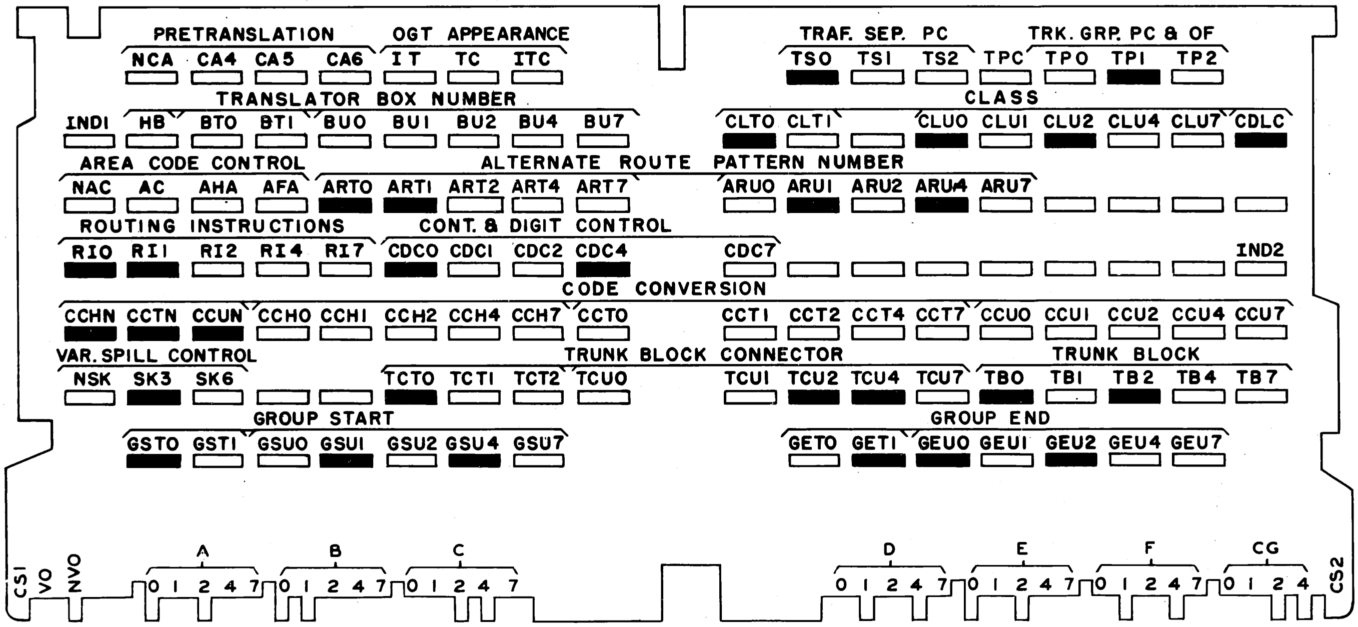
(a) Alternate Route Pattern Number - The decoder ARTO, ART1, ARU1 and ARU4 relays operate to indicate the number of the route relay to be used to gain access to the alternate route trunks (OS 164-1). For the call being described, the alternate route consists of the 50 common grade trunks between Pittsburgh and Cleveland. It is assumed that access to these trunks is gained via route relay 15.

(b) Routing Instructions - The decoder RIO and RI1 relays operate and operate the CRP (card-to-relay preference) and the CR (card-to-relay) relays (OS 167-1).

(c) Code Conversion - The CCHN, CCTN and CCUN (code convert hundreds, tens and units none) relays operate (OS 164-1).

(d) Trunk Block Connector Number - The decoder TCTO, TCU2 and TCU4 relays operate to indicate that the 15 terminal grade trunks appear in trunk block connector number 6 (OS 164-1).

(e) Trunk Block - The decoder TBO and TB2 relays operate to indicate that



NOTES:

1. VIEWED FROM LIGHT SOURCE.
2. ENLARGED PUNCHES SHOWN IN BLACK.

FIG. 3 - 216-525 (LA5)-6D-NVO CARD AT PITTSBURGH FOR 15 TERMINAL GRADE TRUNKS TO CLEVELAND

the trunks appear in trunk block number 2 (OS 164-1).

(f) Continuity and Digit Control - The decoder CDC4 and CDC7 relay operate (OS 164-1).

(g) Outgoing Trunk Appearance - Not punched because this 4A office is assumed to have a combined train.

(h) Traffic Separation Peg Count - The decoder TSO relay operates. (The punches for traffic separation peg count are enlarged as requested by the traffic department.)

(L) Connecting to an Idle Combined Marker (Fig. 1 on SC 118-1)

2.21 When the COP1 and COP2 relays in the decoder operate to indicate that the 6D card has been dropped in the foreign area translator (OS 163-1), the OC (output control) relay operates causing the 6DT (6-digit translation) relay in the decoder and the 6DT relay in the sender to operate in series through the operated R6D (prepare for reading 6D card) relay (OS 167-1). The 6DT relay in the decoder completes a path for operating the IT2 (intertoll marker auxiliary) relay (OS 168-1, option D). The IT2 relay operates an MP (marker preference) relay in the marker connector (OS 188-1), which connects the decoder to a combined marker in the manner described in detail in Part 2 of this section.

(M) Recording Card Information in the Marker

2.22 When the marker is connected to the decoder, the marker RCD relay operates in series with the TC6 relay (OS 191-1). The operation of the TC6 relay registers that the 15 terminal grade trunks to the Cleveland 4A office are terminated on trunk block connector number 6. The operation of the RCD relay allows the marker to register the following information from the decoder:

(a) Trunk block number 2 which is registered by the operation of the TBO and TB2 relays (OS 192-1).

(b) Hold routing control information which is registered by the operation of the HLD relay (OS 191-1).

(c) Even preference which is registered by the operation of the CNE relay (OS 190-1).

(d) First trial which is registered by the operation of the TR1 relay (OS 190-1).

(e) No code conversion which is registered by the operation of the CCHN, CCTN, and CCUN relays (OS 195-1).

(f) 4DG sender digit control information which is registered by the operation of the 4DG relay (OS 176-1).

2.23 The RCD relay operates the RCD1 and RCD2 relays which furnish battery to enable the marker to register the remaining card information. The information registered directly from the card is:

(a) Trunk group start point 10 - The GSTO, GSU1 and GSU4 relays operate and in turn operate the GS 10 relay (OS 192-1).

(b) Trunk group end point 25 - The GET1, GEUO and GEU2 relays operate and in turn operate the GE 25 relay (OS 192-1).

(c) MF class information - The CLTO, CLUO and CLU2 relays operate, and in turn operate the CL2 relay indicating that the outgoing trunks require MF outpulsing (OS 193-1).

(d) Variable spill control - The SK3 relay operates, indicating that the first three digits registered in the sender are to be skipped when outpulsing (OS 194-1).

(e) Trunk group peg count and overflow control - The TP1 relay operates (OS 196-1).

(f) Cancel delay loop closure function-The CDLC relay operates (OS 193-1).

2.24 When the marker has registered all of the information contained on the 6D card, as indicated by the operation of the RCK (read card check) relay in the marker (OS 197-1), the marker signals the decoder to restore the 6D card and to wait for a TKS (trunk selected), or an ATB (all trunks busy) signal. The decoder remains on the connection because the CR relay operates the RCA (restore card and advance) relay (OS 172-1) instead of the RCD (restore card and disconnect decoder) relay when the RCK signal is received from the marker.

<u>(N) Releasing Foreign Area Translator - CR Routing Instruction</u>

2.25 When the RCA relay operates, it completes a circuit for operating the RCA1 relay and releases the OC (output control of card items) relay, which releases relays OC1 to OC10 (OS 163-1). The RCA relay also operates the ARC relay in the foreign area translator (OS 172-1). The RCA1 relay releases the CC1 to CC5 relays (OS 161-1). The operation of the ARC relay causes the foreign area translator to restore the 6D card, operates the HBI (home box indicated) relay in the decoder (OS 172-1) and releases the CON (connect) relay (OS 161-1) in the foreign area translator. The HBI relay when operated removes the battery from the ST lead to the translator connector, which releases the P relay in the translator connector (OS 183-1). The translator connector and the foreign area translator release to handle other calls. The HBI relay also releases the RA relay which operates relay DCB (disconnect 3D and 6D code bars and routing instruction relays) (OS 172-1). The DCB relay operates relays DCB1 and DCBA and the DCB1 relay operates relay DCB2.

<u>(O) Reconnecting to Home Translator (Fig. 3 on SC 118-1)</u>

2.26 When the foreign area translator has released as indicated by the release of the TCK (translator check) relay (OS 161-1), the HTR relay in the decoder operates and in turn operates relays HC1 to HC16. The input leads from the sender are held open to the home translator by the released relays CC1 to CC4 (OS 162-1). The decoder remains connected to the home translator until either a TKS or an ATB signal is received from the marker. The decoder reconnects to its home translator because all AR cards are in the home translators. The TKS signal will cause the decoder to release in the manner explained in the following paragraph. An ATB signal will cause the decoder to drop an alternate route card in the home translator as is explained in Par. 2.29.

<u>(P) Releasing Decoder - Terminal Grade Trunk Selected (Fig. 3 on SC 118-1)</u>

2.27 When the marker has selected an idle outgoing trunk as indicated by the operation of a K- relay, the TKS (trunk selected) relay in the marker operates through the contacts of the operated K-relay (OS 202-1). Relay TKS operates relay TSA (trunk selected check) in the marker, relay TKS in the sender, and relay TKS in the decoder. The TKS relay in the sender starts RTT (round trip transit) timing; the TKS relay in the decoder operates the RLT relay, which in turn operates the RLT relay in the decoder connector (OS 177-1). The RLT relay in the decoder connector releases the DC1 relay (OS 155-1) which opens the leads from the sender to the decoder and operates relays CHK and RLT1 (OS 177-1), which release the DP relay in the decoder connector (OS 155-1). The leads from the sender to the marker remain connected through the MC relay, which locks operated through the make contacts of the RLT relay in series with the winding of the CHK relay in the decoder connector (OS 177-1).

(Q) Marker Operations and Release - Terminal Grade Trunk Selected

2.28 The marker continues its functions, selecting and connecting to an idle outgoing trunk, closes and tests the crosspoints, transmits to the sender the class, variable spill and digit control information, and requests the sender for a release signal in the manner described in Section A828.121.2.

(R) Alternate Routing

Common Grade Trunk Selected

2.29 The alternate route for this call consists of the 50 common grade trunks between Pittsburgh and Cleveland. Route relay 15 is associated with these trunks. This is indicated by the alternate route pattern number contained on the 216-525-6D-NVO card.

2.30 After the decoder has read the card it connects to a marker, determines whether the alternate route trunks are idle, and prepares to drop an AR card in the home translator. In the meantime the marker is testing the 15 terminal grade trunks presented by the card. Should the marker find all of these trunks busy it returns the ATB signal to the decoder. The decoder under this condition drops an AR card in the following manner.

2.31 When the decoder reads the card, it operates the routing instruction RIO and RI1 relays and the alternate route pattern number ARTO, ART1, ARU1 and ARU4 relays. The RIO and RI1 relays operate the CR and CRP relays. The ARTO and ART1 relays operate the CR1 relay through the operated contacts of the CRP relay. The ARU1 and ARU4 relays operate route relay R15 through contacts of the operated CR1 relay. Each R- relay provides means for testing a maximum of 160 trunks. The trunks are divided into four subgroups, each subgroup containing a maximum of 40 trunks. Since, for the call being described, we have 50 trunks to test, the trunks can be divided into two subgroups. The first subgroup contains 40 trunks and the second subgroup contains the remaining 10 trunks and the overflow trunks. The CIO to CI5 (route relay ground supply cut-in) relays in the decoder operate when the CK3 relay is operated during decoder seizure (OS 173-1). Assuming that route relay 15 is associated with ground supply 1, the EG- and EGB leads from the group busy chain relay circuit are closed through the operated CI1 relay and the operated relay R15 to relays GO and G1. The GB1 relay must be modified to agree with option A (OS 173-1), as this is the final route. If both relays GBO and GB1 are released, indicating that all 50 trunks are busy, the G1 relay must operate to cause the last AR card, in this case 151 AR, to drop. This permits the decoder to read the FOF routing instruction from the AR card.

2.32 The GB leads from the outgoing trunks are tested for an idle or busy indication. When there are idle trunks in a subgroup the associated GB- relay remains operated. This extends the ground from relay GBO to operate the lowest-numbered G- relay associated with an operated GB- relay. The testing of the GB- leads continues, and the condition of the G- relays may change until the decoder receives an ATB signal from the marker.

2.33 The receipt of an ATB signal from the marker operates the ATB relay in the decoder (OS 202-1), which in turn operates relay GPL (group lock) (OS 173-1) and releases the RCA1 relay. The GPL relay locks the operated G- relay and operates the CO (cut-off) relay to prevent further testing, and operates the ARS (alternate route start) relay in the decoder (OS 173-1).

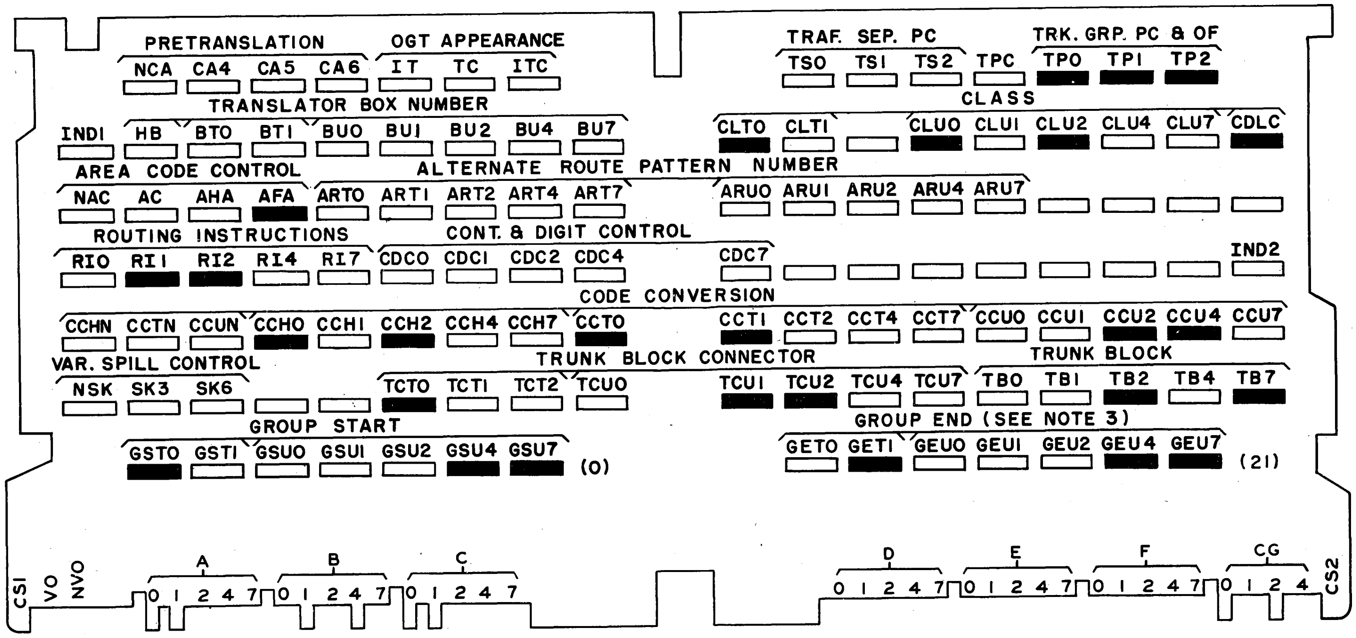
AR Card Drops in Home Translator (Fig. 4 on SC 118-1)

2.34 If the home translator is prepared to drop a card as indicated by the release of the ARC relay, the CCA (code cut-in auxiliary) relay operates through the contacts of the released ARC and operated ARS relays (OS 161-1). The CCA relay grounds the A, B and C digit leads, and the CGO and CG2 leads, to the code bars of the home translator, and the AR card containing an idle trunk is dropped (OS 162-1). The leads grounded for digits A and B are determined by the route relay number; the lead grounded for digit C is determined by the G- relay operated; the CGO and CG2 leads are grounded when the CCA relay operates. If we assume that the 40 trunks in subgroup O are all busy but that there is an idle trunk in group 1, the code to drop the AR card will be: AO and A1, B1 and B4 (because the route relay number is 15); CO and C1 (because relay G1 is operated); and the CGO and CG2 (because the CGO and CG2 leads are grounded when the CCA relay operates).

2.35 When the 151-AR card, which is punched as shown on Fig. 4, has dropped, as indicated by the operation of relays COP1 and COP2 in the decoder, the decoder reads the card containing the remaining ten common grade trunks and the overflow trunks. The decoder registers the following information from the AR card:

(a) Trunk Block Connector Number - The decoder TCTO, TCU1 and TCU2 relays operate.

(b) Trunk Block Number - The decoder TB2 and TB7 relays operate.



NOTES:

1. VIEWED FROM LIGHT SOURCE.
2. ENLARGED PUNCHES SHOWN IN BLACK.
3. 12 SPARE TERMINALS PROVIDED GROWTH OF TRUNK GROUP.

FIG 4 – 151-AR CARD AT PITTSBURGH FOR LAST 10 COMMON GRADE TRUNKS TO CLEVELAND

(c) Area Control - The decoder AFA relay operates to indicate that the alternate route trunks terminate in a foreign area.

(d) Code Conversion - The decoder CCHO and CCH2, CCTO and CCT1, CCU2 and CCU4 relays operate. The code conversion punches are used on AR cards for code matching in the manner explained in the next paragraph. The punches are enlarged as shown because the alternate route trunks terminate in Cleveland which is in the 216 area.

(e) Routing Instructions - The decoder RI1 and RI2 relays operate and in turn operate the FOF (follow-with-overflow) relay.

Code Matching

2.36 When the CGO and CG2 code bars are operated by the operation of the CCA relay, the CGO and CG2 slave relays operate in the home translator which in turn operate the ARB relay in the decoder (OS 162-1). The operated ARB relay and the operated code conversion relays operate the TCD1 and TCD2 (transfer code digits from the card to the code matching circuit) (OS 176-1). The code digits 216 registered in the sender and the code conversion punches enlarged to show the Cleveland area number 216 match. Consequently the marginal relays MCCH, MCCT and MCCU (match code conversion) operate. These three relays, and the AC relay, which operated when the decoder read the 3D card, place ground on the SK3 lead to the marker.

Registering Information on the Marker

2.37 The marker registers the following information from the decoder and directly from the AR card:

(a) SK3 Variable Spill Information - The marker SK3 (skip 3) relay operates when the SK3 lead from the decoder is grounded as a result of code matching (OS 176-1). The skip 3 information is later transmitted to the sender so that the first three registered digits will be skipped when outpulsing takes place.

(b) Code Conversion - The marker CCHN, CCTN and CCUN relays are operated to indicate that no digits are to be outpulsed in place of the three digits which will be skipped.

(c) Trunk Block Connector Number - The marker TCTO, TCU1 and TCU2 relays operate, indicating that the trunks appear on trunk block connector number 3.

(d) Trunk Block - The marker TB2 and TB7 relays operate, indicating that the trunks appear in trunk block number 9.

(e) Group Start - The marker GSTO, GSU4 and GSU7 relays operate, and in turn operate the GSO relay to indicate that the trunk test is to start at MS terminal 0.

(f) Group End - The marker GET1, GEU4 and GEU7 relays operate, and in turn operate the GE 21 relay to indicate that the trunk test is to end at MS terminal 21. (Although there are only ten trunks in the subgroup MS, terminals are provided for 21 trunks. This provides for future growth. MS terminals 11 to 21, reserved for future trunks, are made busy by grounding the MS leads from the trunk block connector at the distributing frame) (OS 203-1).

(g) Class - The CLTO, CLUO and CLU2 relays operate, and in turn operate the CL2 relay to indicate that the sender is required to outpulse on a multifrequency basis.

(h) CLDC - The CLDC relay is operated to indicate that the delay loop closure test is canceled.

Decoder Release - Common Grade Trunk Selected

2.38 When the marker has registered all of the information from the decoder and the AR card, as indicated by the operation of the RCK (read card check) relay, the marker places ground on the RCK lead which operates the RCD (read card and release decoder) relay in the decoder. The path for operating the RCD relay is prepared by the operation of relay FOF (follow-with-overflow) from the routing instruction on the 251 AR card. The decoder is released before the marker has completed its functions, because the routing instruction indicates that the decoder has no further instructions for the marker. Relay RCD operates the ARC relay in the home translator to restore the 151 AR card. (See Fig. 5 on SC 119-1.) The ARC relay operates the RLT relay, which releases the DC1 relay in the decoder connector. The DC1 relay operates the CHK and RLT1 relays. The RLT1 relay releases the DP relay and in turn the DC relay. The leads from the sender to the decoder are opened. However, the sender remains connected to the marker through the contacts of the operated MC relay which locked when the RLT relay operated.

Marker Operations and Release - Common Grade Trunk Selected

2.39 The marker selects and seizes an idle outgoing intertoll trunk, closes and tests the crosspoints, transmits to the sender the class, variable spill and digit control information, and requests a release signal from the sender in the manner described in Section A828.121.2.

3. OUTPULSING DIGIT INFORMATION TO CLEVELAND 4A TOLL OFFICE

(A) General

3.01 Seizure of the outgoing trunk in the Pittsburgh 4A toll office causes the operation of the OS (out-sleeve) relay in that circuit (OS 203-1). A connect signal is then sent to the Cleveland 4A toll office where an MF incoming sender is seized. During sender seizure, the Cleveland 4A office maintains a stop pulsing signal back to the Pittsburgh 4A toll office. When the sender at the Cleveland 4A toll office is ready to receive pulses, the stop pulsing signal is changed to a start pulsing signal.

3.02 In the description of this call it is assumed that the connect signal and the stop and start pulsing signals are transmitted over the trunk between the two toll offices by means of single frequency signaling. Upon receipt of the start signal and the completion of certain other operations, the DP incoming sender in the Pittsburgh office begins to send out multifrequency pulses over the trunk to an MF incoming sender in the Cleveland office. When the last digit has been sent, the sender in the Pittsburgh office completes the connection, thereby closing the transmission leads between the incoming and outgoing trunks, and releases itself.

(B) SF Signaling

Connect Signal to the Cleveland 4A Toll Office

3.03 SF signaling circuits are used to transmit the connect signal from the Pittsburgh 4A toll office to the Cleveland 4A toll office. The connect signal causes the 2-way intertoll trunk in the Cleveland 4A toll office to be connected to an MF incoming sender.

3.04 The operated OS relay (OS 128-1) in the Pittsburgh 4A toll office furnishes battery over the M lead to the SF signaling circuit in the Pittsburgh 4A toll office. (See Fig. 5, attached.) Battery over the M lead reduces to an insignificant value the level of tone furnished by the SF transmitter over the T and R leads to the SF receiver in the Cleveland 4A toll office. Reduction of the single frequency current causes the RG relay to release in the SF receiver located in the Cleveland 4A toll office. Release of the RG relay grounds the E lead and operates the LC relay in the trunk circuit. The SVP relay (OS 128-1) in the Cleveland

4A toll office also operates from ground furnished over the E lead. Detailed circuit operation of the signal frequency system is described in A820.256.

3.05 Operation of the LC relay causes the intertoll trunk at the Cleveland 4A toll office to seize a sender. Operation of the SVP relay causes a stop pulsing signal to be returned to the Pittsburgh 4A toll office.

Stop Pulsing Signal Returned to the Pittsburgh 4A Toll Office

3.06 SF signaling circuits return the stop pulsing signal from the Cleveland 4A toll office to the Pittsburgh 4A toll office. This signal notifies the sender in the Pittsburgh 4A toll office to delay outpulsing until the sender in the Cleveland 4A toll office is ready. Release of the RG relay in the SF signaling circuit in the Pittsburgh 4A toll office is accomplished in a manner similar to the operations described in the preceding paragraphs. Release of the RG relay grounds the E lead which operates the SVP intertoll trunk relay in the Pittsburgh 4A toll office and the OF relay in the sender (OS 128-1). Operation of the OF relay in a sender delays outpulsing until the start signal is returned.

<u>(C) Seizing of the MF Sender in the Cleveland 4A Toll Office</u>

Sender Seizure

3.07 The intertoll trunk connects to a multifrequency sender in the Cleveland 4A toll office through the operation of the controller connector, link controller, and sender link circuits.

3.08 Operation of the LC relay in the intertoll trunk grounds the start lead to the ST relay in the sender link (OS 101-1). Seizure of the multifrequency sender and closure of crosspoints on the sender link and controller frame are similar to operations described in Section A828.121.2.

<u>(D) Sending Start Pulsing Signal to the Pittsburgh 4A Toll Office (SC 107-1)</u>

3.09 Operation of the hold magnets in the sender link and connector circuit closes leads from the incoming trunk circuit to an MF incoming sender and operates the S relay in the sender (OS 134-1). The operation of the S relay closes the SP lead, thus connecting the winding of the SP relay in the sender circuit in series with the winding of the SP relay in the trunk circuit. The SP relay in the sender operates but there is insufficient current at this time to operate the SP relay in the trunk circuit. Operation of the SP relay in the sender operates the SP1 relay. Operation of the SP1 relay operates the ON and ON1 relays which provide off-normal grounds to the sender. The S1 relay also operates from the SP1 relay. The CO relay in the trunk circuit operates to contacts on the SP1 relay which locks.

3.10 The operation of the S relay also operates certain sender class relays depending upon the wiring options used on the KT and KT1 leads. (See table on OS 134-1.) Assuming that the TS relay is operated over the KT lead, the CTS relay operates and furnishes a path to operate the FT relay. The operated FT relay closes a path to operate the FT1 relay, which is sufficiently slow in operating to insure that all class relays expected to operate have time to do so. At this time the operated FT1 and SP1 relays short-circuit the secondary winding on the SP relay and the BD resistor, which permits the marginal SP relay in the trunk circuit to operate. The operation of the SP relay removes the class indication on the KT and KT1 leads causing the TS relay to release and remove the shunt from the winding of the RT relay, which operates in series with the FT relay. Operation of the RT relay releases the trunk SVP relay to return a start pulsing signal to the sender in the Pittsburgh 4A office by grounding the M lead (OS 128-1).

<u>(E) DP Sender - MF Outpulsing to the Cleveland 4A Toll Office (SC 105-1)</u>

General

3.11 The call described in this part requires the dial pulse sender to outpulse on an MF basis. Detailed operations for simplex dial outpulsing are described in Section A828.121.2. The operations involved in MF outpulsing are similar to those of simplex dial outpulsing up to and including RTT timing. Thus the detailed description of MF outpulsing in this part begins with the operations which follow RTT timing.

3.12 Sender relays MF, SK3 and LPS, operated by the marker, direct the sender to outpulse on an MF basis, after a 375-millisecond delay for round trip transit timing, sending a KP pulse and then starting the outpulsing with the D digit and sending an ST pulse after the K digit is outpulsed.

Synchronization of Sender in the Pittsburgh 4A Toll Office with Sender in the Cleveland 4A Toll Office

3.13 RTT timing permits the sender in the Pittsburgh 4A toll office to mark time while the sender in the Cleveland 4A toll office is seized and prepared to receive pulses. Upon completion of RTT timing, the operation of the OF relay indicates that the stop pulsing signal from the Cleveland 4A toll office is still effective. A start pulsing signal must be present before outpulsing can begin.

3.14 The detailed circuit operation is as follows. The marker release and the end of RTT timing are indicated by operation of the TCA relay (OS 125-1) in the sender. The TCA relay operates from ground on the operated MRL relay through operated contacts on the TC3 and MF1 relays. The TCA relay also operates the KP relay which prepares paths for the sender to transmit MF key pulsing to the Cleveland 4A toll office (OS 130-1).

3.15 A preliminary SL check is made when the TCA relay operates. The SL relay (OS 128-1) in the sender operates through its high resistance winding in series with the LO and SL relays in the trunk circuit. Due to the high circuit resistance, the SL relay in the trunk circuit is marginal and does not operate at this time. The SL1 relay operates from ground on the operated MFT relay, and prepares a path to operate the SL relay on the trunk through the low resistance winding of the sender SL relay. This path is completed when the OF1 relay releases under control of the OF relay, which releases when the start signal is received from the Cleveland 4A toll office.

3.16 At this point the sender waits for the release of the OF and OF1 relays caused by the receipt of the start pulsing signal from the Cleveland 4A toll office. The start pulsing signal may already be effective when the sender SL relay operates; therefore the sender may begin outpulsing without delay, provided the D digit has been registered.

SL Check

3.17 Receipt of the start pulsing signal releases the OF and OF1 relays (OS 128-1). Release of the OF1 relay completes the path from ground on the MRL1 relay through the low resistance winding of the SL relay in series with the LO and SL relays in the trunk circuit. This operates the marginal SL relay in the trunk circuit which locks to ground on the G relay. Operation of the SL relay in the trunk circuit releases the SL relay in the sender indicating a satisfactory trunk check.

Outpulsing KP Signal

3.18 The KP signal is the first pulse forwarded to the MF receiver in the distant 4A toll office. This is a pulse of 100 milliseconds duration consisting of 1100 and 1700 cycles, and is a signal to the MF receiver to prepare for reception of shorter pulses representing the various digits and the start pulsing signal. The KP signal is sometimes called the gate opener pulse.

3.19 The KP signal is transmitted after the following circuit operations. The release of the SL relay in the sender permits the OP relay (OS 128-1) to operate in the sender. The OP relay contacts operate the OP1 relay which transfers the simplexed KT and KR leads from the SL relay to the windings of relays OF and TG in series for recognizing stop and start pulsing signals from the Cleveland 4A toll office. Operation of the OP1 relay also starts the release of slow-release MFT relay.

3.20 This slow-release feature allows time for the OF relay to operate on calls using guarded MF trunks. On these calls, the SL check is completed as long as relay OF1 is normal regardless of whether it is normal because a start pulsing signal is present or because a stop pulsing signal has not been sent. After waiting the additional time allowed by relay MFT it is assumed that a start pulsing condition exists or that the stop pulsing signal was too short to be recognized. With relays MFT and OF normal, the OP2 relay operates and transfers the KR1 and KT1 leads to the contacts of relay PG1 (OS 128-1 and OS 130-1). Transmission of the KP pulse now awaits the operation of the PG1 relay (OS 125-1).

3.21 The operation of the PG1 relay is dependent on the registration of the first digit to be outpulsed on the recapture relays (OS 125-1). Ten digits have been or are being inpulsed, but only seven are to be outpulsed for this call. Outpulsing is to begin with the D digit as indicated by the operation of the SK3 (skip 3 digits) relay under control of the marker.

3.22 The D digit is registered in the outsteering circuit as follows. When the MRL1 relay operates upon marker release, the DSO relay operates through the operated SK3 relay and locks to the off-normal ground. The EVO relay operates through the operated contacts on the DSO relay through the operated ON1 relay contacts. Operation of the DSO and EVO relays connect the leads from the $D\frac{2}{5}$ relay contacts to the windings of the RR and RT recapture relays (OS 125-1). On this call, the first digit to be outpulsed is 5, therefore the RR1 and RR4 and RT1 and RT4 relays operate. The four recapture relays close the path to operate relay OSC (outsteering cock), which in turn operates the SY (synchronizing) relay as an indication that all circuits are in step for sending out a pulse (OS 126-1).

3.23 This first operation of the SY relay operates the PS (pulse start) relay which permits the self-interrupted capacitor-timed PG (pulse generator) relay to begin its operating cycle (OS 125-1). The operation of the pulse generator is described in Section A828.121.2. The operation of the PS relay releases relay P (pulsing) which operates the PG1 (pulse generating auxiliary) relay (SC 105-1).

3.24 Relay PG1 operates the PP (preliminary pulse) relay and closes leads which transmit the 1100- and 1700-cycle KP frequencies simultaneously to the network connected to leads KT1 and KR1. This pulse lasts as long as the PG1 relay is operated.

3.25 Relay PG1 is released to stop the pulse when relay PG operates. The PG relay was energized when the SY relay operated, but the action of the PG capacitor and KP network prevents its operation for 100 milliseconds (OS 125-1).

3.26 When the PG relay operates, it operates relay P which releases the PG1 relay. The normal PG1 relay, in addition to terminating the KP pulse, operates the PP' relay which modifies the network associated with relay PG so that further pulsing will be at a 68- rather than a 100-millisecond interval. Relay PP' also closes path through the recapture relays, $RR\frac{2}{5}$ and $RT\frac{2}{5}$, for outpulsing the regular digits (OS 130-1).

Outpulsing Digits to the Cleveland 4A Toll Office and Release of Sender

3.27 The next release of the PG and P relays and the operation of the relay PG1 sends out the digit 5 already recorded on the recapture relays. Relay PG1 closes the leads between the operated recapture relays, with two frequencies standing on their contacts, and the network connected to the KT1 and KR1 leads. It also operates relay ESO (E digit outsteering) in preparation for sending the next digit (OS 126-1).

3.28 The next operation of the PG and P relays and the release of the PG1 relay end the pulse. Relay PG1 releases the DSO relay which releases relays RT1, RR1, RT4, RR4 and ODO. The SY relay also releases and, when the PG and P relays release, the pulse ends and relay EVO (even outsteering) operates. This closes a path to transfer the next digit on the register relays to the recapture relays. When this is done, relay SY reoperates, the pulse generator starts again, and the digit is outpulsed.

3.29 Transmission of the remaining digits is a repetition of the action just described. The recapture relays $RT\frac{2}{5}$ and $RR\frac{2}{5}$, and the pairs of frequencies used, will vary to fit the digit being outpulsed.

3.30 The call described in this part requires outpulsing a national office code and four numerical digits; therefore an ST (start) pulse signal is transmitted after the outpulsing of the seventh digit to indicate that no more digits should be expected.

3.31 This is accomplished in the following manner. While the seventh digit is being outpulsed, the LSO relay (OS 126-1) operates. Ground on the operated contacts on the LSO relay, through operated contacts on the LPS relay, operates the SST relay (OS 127-1). The SST relay operates the SST1 relay which connects 1500- and 1700-cycle frequencies to the contacts of the PG1 relay (OS 130-1) for outpulsing as soon as the pulse generator is started again. The SST relay also operates relay SY to start the generator (OS 126-1) and send the ST pulse to the sender in the Cleveland 4A office, indicating that all digits have been transmitted. Relay SST1 also completes a path which, when PG1 operates to transmit the ST pulse, operates relay FP (final pulse). The FP relay closes a path, which is completed upon release of the PG1 relay, to operate the AV (advance) relay (OS 126-1).

3.32 The AV relay operates the AV1 (advance auxiliary) relay which starts the release of the sender (SC 105-1). One of the first steps in the release procedure is to release the SP (splitting) relay in the incoming trunk at the Pittsburgh office, in order to disconnect the transmission leads from the sender and connect them through to the outgoing trunk. The sender releases and may now handle other calls.

4. INPULSING TO MF RECEIVER ASSOCIATED WITH MF INCOMING SENDER

(A) General

4.01 This part describes the operation of two different types of multifrequency receiving circuits that can be associated with an MF incoming sender. The operations of the MF receiving circuit shown on OS 135-2 are described in Par. 4.06 to Par. 4.38. This type of receiver is installed at all new 4A offices. It represents an improvement in design over the older type of receiver shown on OS 135-1, which is installed at No. 4 and No. A4A offices. The newer type receiver design makes possible a large reduction in unit size, initial cost, and operating power. Even though manufacturing of the older type receiver has been discontinued, its operations are discussed in Par. 4.39 to Par. 4.67, since this type will not be replaced when No. 4 and No. A4A offices are converted to 4A operation.

4.02 While the design of the two receiving circuits is different, they perform the same function. These circuits translate incoming MF signals into d-c indications suitable for operating register relays in the MF incoming sender. Each incoming signal is in the form of a pulse at least 27 milliseconds long, containing two voice-frequency a-c currents. Different digits and signals are recognized on the basis of the frequencies combined in the pulse. Six frequencies (700, 900, 1100, 1300, 1500 and 1700) are used, and any two out of the six represent a particular digit as shown on the tables of OS 135-1 and OS 135-2.

4.03 Neither of the two types of receivers is prepared to receive digit pulses until the KP (key pulse) signal has been received. The KP signal, consisting of frequencies 1100 and 1700, must be maintained for at least 55 milliseconds. This minimum is about twice as long as the 27 milliseconds required in the reception of the other digits. The long KP signal is necessary to keep voice frequencies, noise and other transients from being interpreted as digit pulses by the receiver. In addition, a ST (start) pulse consisting of frequencies 1500 and 1700, is required at the end of pulsing to indicate to the sender that no more multifrequency pulses can be expected. Each type of receiver is designed to receive pulses from an operator using a keyset (pulsing at the rate of two digits per second) or from a sender (MF outpulsing at the rate of 7 digits per second).

4.04 The older type of receiver will operate satisfactorily on power inputs ranging from 2 db above one milliwatt to 27 db below one milliwatt, provided the difference in power between two frequencies making up a signal does not exceed 6.5 db. The newer type of receiver will operate satisfactorily on power inputs ranging from 1 db above to 22 db below one milliwatt, provided the difference in power between two frequencies making up a signal does not exceed 8.5 db.

4.05 If a second KP pulse or a pulse containing three frequencies is received, or if an ST pulse is received at a time other than the expected time, each type of receiver will cause the sender to route the call to reorder.

(B) MF Receiver Operations per OS 135-2

Receiving KP Signal

Receiving KP Signal in Input Circuit

4.06 When the MF sender is seized at the Cleveland 4A office, the operation of the SP relay places battery on the BAT1 and BAT2 leads to the MF receiving circuit (OS 135-2). The battery on the BAT2 lead energizes the primary winding of the KP (key pulse) relay and holds the relay on its back contacts. The BAT1 lead connects battery through the windings of the KP1 and KP2 relays to prepare them for future operation. The RT relay operates during sender seizure and removes ground from the T and R leads (OS 134-1). When the above operations have taken place, the MF receiving circuit is prepared to receive the KP signal via the IN repeat coil.

4.07 The first signal received from the sender at the Pittsburgh 4A office is the KP signal, which consists of a relatively long pulse of frequencies 2 and 10. The KP signal is received from the incoming trunk circuit via the T and R leads. This signal is transmitted through the input portion of the receiving circuit, consisting of the IN repeating coil, an impedance correcting network having a loss of 7 db and an IN input transformer (OS 135-2).

4.08 The IN repeating coil is a well-balanced shielded coil and is used in reducing the effect of longitudinal currents which might cause false operations in the receiving circuit. Longitudinal currents in telephone circuits are the result of electrostatic and electromagnetic induced differences in foreign potentials which cause current flows, equal and in the same direction, on both the tip and ring of the trunk.

4.09 The impedance correcting network is made up of resistors P1, P2 and P3. The network causes a loss of approximately 7 db to the incoming KP signal. The grounded midpoint of resistor P3 is a balanced circuit point and is provided for the removal of longitudinal currents. The high ratio step-up input transformer is used to increase the voltage of the incoming signal.

Receiving KP Signal in Volume Limiter

4.10 From the secondary of the IN transformer, the KP signal is placed on the grids of vacuum tubes L1 and L2 of the volume limiter, which serves to amplify weak signals or to limit strong signals to such a value that they will not cause interfering signals in channels other than 2 and 10.

4.11 The limiting action is obtained by means of the control grid resistors L1 and L2, and capacitors L1 and L2. These RC networks cause the grid bias to become more negative when the a-c on the grids becomes large enough to cause them to draw current during the positive half cycles. When this occurs, the power output increases very slowly with further increases in the grid voltage. The actual point at which limiting occurs is controlled by the voltage on the screen grids and on the cathode as well as by the voltage on the control grids. The voltage on the screen grids can be adjusted by potentiometer P, in order to control the receiver sensitivity. A fixed bias on the grids of tubes L1 and L2 is obtained from the voltage drop in resistor L3.

4.12 The limiting action results in the generation of a relatively high harmonic content in the output. However, the even harmonics are eliminated since the L1 and L2 tubes are arranged for push-pull operation. All of the odd harmonics lie beyond the maximum multifrequency signal of 1700 cycles.

4.13 The greater part of the limiter output passes through the step-down OUT transformer to the 6 db pad which is composed of resistors A, B and C. The input terminals of the SP band-pass filter are connected across resistor C of the pad. The common input circuits to the channel filters are connected across resistors B and C. A small part of the output of the volume limiter is supplied to the variable bias circuit via a lead connected to the plate of the L1 tube. The following paragraphs describe the effect of supplying energy to the SP filter, the channel filters, and the variable bias circuit during the reception of the KP signal.

Input to SP Filter

4.14 At the output of the volume limiter the voltage (caused by the KP signal) across the 600-ohm resistor of the 6 db pad is applied through the 201D band-pass filter SP, and input transformer SP, to the No. 3 grid of tube BR in the signal present circuit. This performs no useful function during the reception of the KP signal since the cathode output circuit (from No. 2 terminal on BR tube) is open at the normal KP2 relay contacts. In addition, the No. 3 BR tube grid is given a high negative bias (-48 volts) through normal contacts of the KP1 relay. This negative bias keeps the triode cut off, thus avoids placing a positive change on capacitors C and H during the reception of the KP signal. The time constant of the P resistor and the H capacitor combination is later used during the reception of digit signals to delay the recognition of the signal 14 milliseconds until the shock transient set up in the filters is dissipated.

Input to Channels 2 and 10

4.15 The voltage across the B and C resistors in the 6 db transmission pad (formed by resistors A, B and C) is applied to the six channel filters. The 6 db pad acts as an impedance smoothing device between the varying output of the volume limiter and the input to the filters. It also has an attenuation effect on filter reflected transients which might adversely affect the signal present (SP) circuit.

4.16 Each of the six channels consists of a channel filter, half of a tube connected as a diode rectifier, a thyratron tube, and a channel relay. There is one channel for each of the frequencies used in MF signaling, namely 700 cycles, 900 cycles, 1100 cycles, 1300 cycles, 1500 cycles and 1700 cycles. These frequencies and their associated channels are numbered 0, 1, 2, 4, 7 and 10 respectively for convenience in digit coding.

4.17 The filters are assembled with elements for two frequencies under a common cover. Common input terminals for both filters are 1 and 2, while 3 is the output terminal for the lower frequency and 4 for the high. Two other filter elements appearing on terminals 4 and 5 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 appreciable improvement in the 700- and 1700-cycle wave shape at the output of those filters.

4.18 The KP signal passes through the 1100- and 1700-cycle filters. At the output of these filters the signal is changed to positive d-c potential by means of the rectifier tubes for channels 2 and 10. The resulting positive potential added to a negative variable bias and a fixed bias is placed on the grids of the associated channel thyratrons and the suppressor and control grids of the SP tube. This action is further described in the following paragraphs.

Input to the Variable Bias Circuit

4.19 A small amount of energy from the plate of the L1 tube of the volume limiter is used in the variable bias circuit which consists of the left half of the BR tube, the grid bias control apparatus connected to terminal 7 of the BR tube, and the voltage doubler apparatus connected to terminal 6 of the BR tube.

4.20 The variable bias circuit operates in the following way when the KP signal is received. Energy from plate terminal 5 of the L1 tube is connected via capacitor AA, resistor AC and potentiometer BIAS to the number 7 grid terminal of twin triode BR. This grid is biased negatively 10 volts through the connection to the potentiometer formed by resistors AD and AE.

4.21 The amount of signal voltage applied to grid 7 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 the BR tube 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 polarity of the varistors is such that a negative potential is produced. Its value increases as the value of the input signal increases. The negative d-c voltage derived from the rectified signal appears across resistor N and is here added to the negative 18-volt fixed bias potential derived from the potentiometer formed by resistors D, E and F. This negative potential is applied through the normal KP2 relay and the SP5 and SP6 one-megohm resistors to the suppressor and control grids of the SP tube. In addition to the above path, this negative potential is applied through the BA and BB one-megohm resistors to a point in each channel at the output of the channel rectifier tube. Here the negative potential is applied to the grids of channel thyratron tubes 2 and 10 and through the normal KP2 relay to the suppressor and control grids of the SP tube.

4.22 Both the positive potential from the rectifier tubes in channels 2 and 10 and the negative potential from the fixed and variable bias circuits appears on the grids of the SP tube. The SP tube, a 415A, has a characteristic such that it will conduct when both the grid and suppressor elements approach a positive potential. Thus as the grid is connected to the output of channel 2 and the suppressor is connected to the output of channel 10, 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 the SP relay which removes ground from the No. 7 contact of the KP relay and connects ground to lead J to the MF incoming sender circuit. In the sender the J and L leads are connected together so that the operation of the SP relay in turn operates the LK relay which supplies positive 130-volt plate battery to all thyratron tubes except 2 and 10.

4.23 The KP relay, which has been held on its back contacts from battery through the secondary winding to ground on the back contact of the SP relay, remains in this condition for approximately 50 to 55 milliseconds after the SP relay operation, due to the charging current through capacitors E, F and G to ground at the K resistor. At the end of this interval the current in the secondary has decreased to such an extent that the primary winding takes control and operates the KP relays to its front contacts. Relay KP remains operated to its front contacts for the duration of the digits reception.

4.24 If a third frequency accompanies the KP signal, a positive potential will be placed on a channel thyratron grid other than 2 and 10. This thyratron will immediately become conducting, operating its associated channel relay. Ground from the contact of this channel relay via a back contact of the KP2 relay will be connected through the back contact of the KP relay to stop the tuning capacitor charge and to continue holding the KP to its back contacts. Thus no recognition takes place.

4.25 When a normal KP signal consisting only of frequencies 1100 and 1700, and lasting a minimum of 55 milliseconds has reduced by one db, the SP tube again becomes nonconducting and the SP relay releases. The normal SP relay releases the LK relay and again connects ground through the front contacts of KP relay to operate the KP1 and KP2 relays.

4.26 The operation of the KP1 and KP2 relays at the end of the KP signal conditions the receiver for the reception of digit signals by the following changes:

(a) In the SP circuit the negative voltage on grid 3 of the BR tube is removed. Also, the cathode output circuit of this tube is connected to the grid and suppressor elements of the SP tube. At the same time, these elements are disconnected from the filter outputs of channels 2 and 10.

(b) The plates of channel thyratrons 2 and 10 are connected via their associated relays and resistors to the contacts of the LK relay. When the LK relay is reoperated 130 volts will be connected to the plates of all thyratron tubes so that subsequent operation will be the same in all channels.

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

Receiving and Registering the A Digit

4.27 On this call the first digit transmitted is assumed to be 5. Therefore frequencies 900 and 1300 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.

4.28 At the output of the volume limiter the voltage across the 600-ohm resistor in the shunt element of the 6 db pad is applied through the 201D band-pass filter, SP and SP input transformer to the No. 3 grid of the BR tube. This voltage is rectified and the resulting d-c voltage is taken from the BR tube cathode terminal 2, and is applied through the smoothing filter (consisting of the C and H capacitors and P resistor) and through the make contacts of the KP2 relay to the grid and suppressor elements of the SP tube. After 14 milliseconds, the H capacitor becomes sufficiently charged so that the current flow in the plate circuit of the SP tube operates the SP relay, which in turn operates the LK relay. The operation of the LK relay connects 130-volt battery to the plate circuits of all six channel thyratrons.

4.29 Part of the energy from the digit 5 signal is taken from the plate of the L1 tube for the operation of the variable bias circuit. The a-c voltage from the L1 tube is connected to grid No. 7 of the BR tube, is amplified therein and is passed to a rectifier circuit. The negative d-c voltage derived from the rectifier is added to the negative 18-volt bias on the grids of the thyratron tubes.

4.30 The a-c voltage across the B and C resistors in the 6 db pad is applied to the rectifier tubes of channels 1 and 4 via the 900- and 1300-cycle filters. The rectified positive potential is added to the 18-volt fixed negative bias augmented by the negative potential that varies with the incoming signal amplitude and is then applied to the grids of thyratron tubes B1 and C2. With the incoming signal voltage on the grids of thyratron tubes 1 and 4 and with battery on the plates of all thyratron tubes, tubes B1 and C2 conduct current. Since a strong positive signal from the channel rectifier tube must overcome both the variable negative bias and a fixed bias in order to fire a channel thyratron, the variable negative bias guards against firing thyratron tubes in unwanted channels.

4.31 The current flow through tubes B1 and C2 operates channel relays 1 and 4. In addition, the CK2 relay operates when the two thyratron tubes conduct. The operation of the CK2 relay:

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

(b) Connects ground to the H lead.

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

Operation of Sender Insteering Circuit and Registering of the A Digit

4.32 At this time the AS, OD and OD1 relays are operated in the insteering circuit and the paths for operating the A register relays are cut through to the digit leads from the receiver circuit. The operation of channel relays 1 and 4 in the receiver grounds the 1 and 4 digit leads, thereby operating the A1 and A4 relays. At the same time the SYN relay operates from ground on the Q lead, and the RA relay operates from ground on the H lead. The operated RA relay extends the grounded K lead through a back contact on the EV1 relay and a front contact on the AS relay to operate the BS relay. The BS relay operates the EV relay, and it in turn operates the EV1 relay. Also the ADR (A digit registered) relay operates, opening the original operating path for the AS relay.

4.33 With the OD and the EV relays both operated, the J-L loop is opened as an indication to the MF receiver that the digit has been registered in the sender. With the registration complete, the SP and LK relays release when the signal for digit A ends. The C, D and E varistors in the SP circuit are poled so as to reduce the time constant of the P resistor and H capacitor at the end of a signal. This shortens the release time of the SP relay. The thyratron tubes are extinguished when the LK relay releases. This causes the release of channel relays 1 and 4 and the CK2 relay, leaving the circuit ready to receive the next digit.

4.34 While the first digit is being received, the CK3 relay will operate if three thyratron tubes conduct current due to the presence of a third frequency. When the CK3 relay operates, it removes ground from the K lead to the sender and grounds the RO lead to the sender. The grounded RO lead operates the ROR relay and the call is routed to reorder.

Receiving and Registering the B and Succeeding Digits

4.35 The B digit (2) and succeeding digits (5-6358) 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.

Receiving and Registering the Start Signal

4.36 The start signal ST, consisting of frequencies (7) and (10), is sent out after all digits (525-6358) have been transmitted. In 4A operation, the number of digits varies from call to call and it is necessary to indicate when all digits that are necessary have been received.

4.37 The ST signal is received the same way as described for the first digit except that the 7 and 10 leads are grounded to the sender. On this call the last digit (8) is registered by the operation of the G7 and G1 register relays. Thus the grounded 7 lead operates the H7 relay. The grounded 10 lead operates the TEN relay, removing ground from the spring on the RA relay before the RA (register advance) relay can operate. The TEN relay operates the 10A relay, releasing the RA relay if it has operated from ground on the H lead.

4.38 The RST (received start) relay operates from ground on the 7 lead through front contacts of the 10A relay operating the RST1 relay, which in turn operates the RST2 relay. The RST2 relay connects off-normal ground through the back contacts of the EV1 relay and the front contacts of the HS relay to operate the JS steering relay. The JS relay operates the EJ relay. With both the OD and EV relays operated, the J-L loop is opened indicating to the receiver that the ST pulse has been registered. The SYN relay remains locked up to the RST1 relay, preventing the registration of further digits.

(C) MF Receiver Operations per OS 135-1

Receiving KP Pulse

Receiving KP Pulse in Input Circuit and Volume Limiter

4.39 Following the seizure of a multi-frequency incoming sender at an office equipped with older type MF receiving circuits, the operation of relays SP and S1 (OS 134-1) connects 48-volt signal battery to receiver leads BAT1, BAT2 and BAT3 (OS 135-1). The operation of relay RT removes ground from leads T1 and R1 (OS 134-1). The MF receiver is now in a position to receive incoming pulses beginning with a KP pulse.

4.40 The KP pulse, a combination of 1700 cps (10) and 1100 cps (2) appearing on the secondary of the IN repeat coil is applied through the IN pad and the input IN transformer to the grids of the volume limiter tubes L1 and L2.

4.41 The IN repeating coil is a well-balanced shielded coil provided to reduce the effect of longitudinal currents on the receiver. Longitudinal currents in telephone circuits are the result of electrostatic or electromagnetic induced differences in potential that cause current flows, equal and in the same direction, on both the tip and ring over the trunk loop.

4.42 The IN pad, an 89-type resistor plug in arrangement, is used to reduce the sensitivity of the receiver to a minimum value required by the installation. Pads resulting in losses of 0, 5, 10 and 15 db are provided, depending on the input power from the longest trunk having access to the sender. This reduces the effect of background noise and speech on the receiver.

4.43 The IN resistor supplies a termination for the trunk and a balanced midpoint to which ground is connected to assist in draining off longitudinal currents.

4.44 All the tubes in the receiver are pentode (five-element) 375A-type. The L1 and L2 tubes of the volume limiter are arranged for push-pull operation, their grids being connected to opposite ends of the secondary winding of the input transformer so that the signal on one grid is 180 degrees out of phase with the signal on the other. The vacuum tube action introduces another 180-degree phase shift so that the signal voltages appearing at the ends of the 54W-retard coil L are still 180 degrees out of phase. The output of L2 appears across one half of the retard coil (grounded at its midpoint) which induces an in-phase component in the other half of the coil. This voltage is then combined with the output voltage of the L1 tube and is applied via the coupling capacitor L to resistors N1 and N2 connected in series and acting as a voltage divider. The voltage across N1 is applied to the grid of the SP (signal present) tube, and the voltage across N2 is applied to the grids of the channel tubes through the channel filters.

4.45 The grid bias of tubes L1 and L2, with no signal present, is obtained from the voltage drops across the 100-ohm cathode resistor. The current flowing through this resistor is the sum of the plate and screen currents.

4.46 The limiting action of the L1 and L2 tubes is obtained by means of the control grid resistors and capacitors L1 and L2 which cause the grid bias to become more negative when the signal on the grids becomes large enough to cause them to draw current during the positive half-waves. When this happens the power output becomes practically constant regardless of further increases in the signal voltage. In other words, weak signals that do not overcome the negative grid bias are amplified but strong signals that cause grid current to flow are limited. The resulting voltage drop across the grid resistors, in effect, cuts off the positive peaks in the signal voltage with the final result that the output power is constant for strong and weak signals. In order to compensate for variations in tubes the screen voltage is made variable. This potential is obtained from a voltage divider consisting of resistances P1, P2 and P6 and potentiometer P.

Receiving KP Signal in Signal Present Circuit and Channel Units

4.47 The KP signal voltage across the N1 resistor is applied through N5, the IN (128E) filter, and the SP (603A) input transformer to the grid of the SP tube. Resistor N5 is connected in series with the filter input in order that the filter provide the correct terminating impedance. The IN (128E) filter is a high-pass filter, used to suppress low-frequency noise and speech currents which might cause false operations. It offers considerable attenuation to frequencies below 700 cycles and little or none to the working frequencies between 700 and 1700 cycles. The SP (603A) input transformer steps up the signal voltage applied to the grid of the SP tube.

4.48 The KP signal voltage across N2 is applied through the T network composed of resistors N3 and N4, and band-pass filters 0, 1, 2, 4, 7, 10 to the grids of channel tubes 2 and 10. The T network serves three purposes: (1) provides attenuation to afford the desired relationship between channel sensitivity and the output of the volume limiter; (2) it affords a relatively constant impedance match between the filters and the varying output impedance of the limiter; and (3) it attenuates transients reflected from the filters which might cause objectionable chatter of the SP relay.

4.49 The band-pass filters separate the signaling frequencies into channels 0 to 10 corresponding to bands 700 ± 45 cycles, 900 ± 45 cycles, etc., to 1700 ± 45 cycles. They offer low attenuation to the band to which they are tuned and high attenuation to frequencies above or below. Thus a 700-cycle signal affects only channel 0, an 1100-cycle signal channel 2, and a 1700-cycle signal channel 10. The compensating filter CF improves the characteristic of the 700- and 1700-cycle filters by simulating the effect which would be produced by adjacent filters tuned to 500 and 1900 cycles.

4.50 The plate of the SP tube is connected to ground through the secondary (bias) winding of the SP relay and the plates of the channel tubes are connected to the secondary (bias) windings of the associated channel relays. The cathode potential on the channel tubes is obtained from FLT battery and on the SP tube from the same source through the 103.5-ohm L4 resistor. The plate current in these tubes acts to drive the armatures of the associated relays to their back contacts.

4.51 The screen grids of the SP and channel tubes are connected to ground through resistors shunted by capacitors that serve to by-pass the signal currents present in the screen grid circuit. Control grid bias for the SP and channel tubes is provided from the voltage divider composed of resistors P3, P4 and P5. The pick-off point, between resistors P3 and P4, is at approximately minus 41 volts as compared with minus 48 volts on the cathodes of the associated tubes. The grids of the SP and channel tubes are thus operated at a slight positive bias as compared with their cathodes.

4.52 Capacitor P serves to by-pass the signal currents present in the grid return circuit around resistor P3. The filter in the plate circuit of the SP tube, consisting of the (54C) retard coil SP and shunt 4-mf capacitor SP1, reduces modulation products which would cause the SP relay to chatter and slows down the operate and release of the SP relay. These effects compensate for the fact that there is no band-pass filter in the SP grid circuit as compared to the channel circuits.

4.53 The chatter of relay contacts during the outpulsing of the signal frequencies at the originating end and the building up of the signals in the filters cause relatively large transients at the beginning of the signal pulses. In order to minimize the effect of these transients on the channel tubes and relays, the limiter output is reduced to a lower value at the beginning of a pulse, rather than at the end. As long as the SP relay is on its back contact, ground is connected through the 120-ohm resistor L6 and the 420-ohm portion of L5 to the junction points of the L3 resistors and through the 410-ohm section of resistor L5 to the L4 resistor. This shunt ground causes an increased voltage drop across the 220-ohm section of L3 and the 103.5-ohm L4 resistor. This in turn causes a reduction in the cathode potential applied to the limiter and SP tubes. In the limiter tubes this is equivalent to a reduction in their plate and screen voltages and results in a reduction of about 6 db in the limiter output. In the SP tube, operating at a fixed positive bias on the control grid, the reduction of the cathode potential acts to reduce the grid bias and thus increase its sensitivity. When the SP relay leaves its back contact, the normal output of the volume limiter is attained and the sensitivity of the SP channel is reduced. Resistor L6 (122-ohm section) and capacitor L3 serve to slow down this change in sensitivity.

4.54 The SP and channel tubes are arranged to operate as detectors in the sense that they respond differently to the positive and negative half-cycles of the incoming a-c signal voltages. As pointed out, their grids are operated at a slight positive bias with respect to the cathodes. Thus, current flows through the half-megohm resistors in the grid circuits and causes a voltage drop across the grid resistors. During the positive half-cycles of an a-c signal voltage applied to the grid, the signal voltage tends to increase the positive bias and the grid current but the resulting greater voltage drops across the grid resistor reduces the actual voltage change on the grid. During the negative half-cycles of the a-c signal voltage, the signal voltage overcomes the positive bias on the grid and, depending on the peak value of the signal voltage, drives the grid negative with respect to the cathode. The plate current of the tube is controlled by the grid and this change from positive, through zero, to increasing negative values in relation to the cathode of the grid results in decreased plate current.

4.55 When no signal is present, the plate current of the SP and channel tubes flows through the secondary winding of the associated relay in bias direction and tends to keep the relay on its back contact. When the KP signal is received, a resulting decrease in plate current reduces the current through the secondary windings of the SP relay and the 2 and 10 channel relays. Then the current through the primary windings operates the SP relay and the 2 and 10 channel relays to their front contacts.

4.56 When the SP relay operates to its front contacts, it closes ground over the J-L loop to the sender and back to the primary (operate) windings of the channel relays. It also operates relay SYN in the incoming sender. With channel relays 10 and 2 operated and the other channel relays normal, ground is removed from the secondary (bias) winding of the KP1 relay and from capacitors KP1 and KP2. After a delay introduced by the charging time of these capacitors, the current flow through the secondary bias winding of the KP1 relay is reduced and current through the primary winding operates the KP1 relay to its front contact.

4.57 After the operation of the KP1 relay, the end of the KP pulse and the release of either the 10 or 2 channel relays cause the operation of the KP2 and KP3 relays. The operation of the KP3 relay closes the tertiary bias windings of the channel relays. These windings supply some additional bias to the channel relays when the receiver is prepared to receive digits or the ST signal. It insures the release of the relays after they have been locked up on digit codes. The operation of the KP2 and KP3 relays transfers the front contacts of the channel relays from the KP circuit to the incoming sender. The receiver and sender are now prepared to receive and register the first digit pulse.

Receiving and Registering Digit Pulses

4.58 Assuming that the first digit is a 5, then the first pulse received is a combination of frequencies 700 and 1100. These frequencies pass through the volume limiter to the SP tube, operating relay SP and a little later channel relays 1 and 4. These operations take place as described for the KP signal reception.

4.59 The operated channel relays ground the 1 and 4 leads to the sender. At this time the sender is prepared to register the first digit. Both the ON and AS relays have operated during sender seizure. The AS relay has operated the OD relay, which in turn has operated the OD1 relay. Thus ground on the 1 and 4 leads operates the A1 and A4 register relays in the sender. The operated 1 and 4 channel relays also cause a current to flow in the primary operate windings of the CK1, CK2 and CK3 (check) relays proportional to the number of channel relays operated.

4.60 These check relays do not function on the KP pulse because at that time they are shunted through normal contacts of the KP2 and KP3 relays. The operate and bias currents through the CK1 to CK3 relays are such that none will operate if one channel relay is operated; CK1 and CK2 operate if two channel relays are operated; and all three will operate if three channel relays are operated.

4.61 Relay CK3 operated grounds lead RO to the sender which starts a reorder call for returning a reorder signal to the originating office. If none of the CK- relays operate, the same result is obtained when the sender times out.

4.62 Relay CK2 operated grounds lead H to the sender and operates relay RA (register advance) to operate the steering relay for the next register, relay BS in this case. Relay BS operates relays ADR (A digit registered) and EV (even register).

4.63 Relay EV operates relay EV1 and releases the channel relays and relay AS. The channel relays release relays CK1 and CK2. Relay CK2 releases relay RA and when the frequencies are terminated the SP relay in the MF receiver releases. With relays SP, CK1 and RA normal, relay SYN releases, releasing relays OD and OD1. The insteering circuit is now ready to receive the next digit.

4.64 The operation of the sender and MF receiver in registering the remaining digits is similar to that for the A digit just described. The reception of the ST pulse after the digits is an indication to the sender that no more MF pulses will be received.

Receiving and Registering the Start Pulse

4.65 The ST pulse is outpulsed after all digits have been transmitted. The ST frequency 7 for the call described registers on the H7 relay. The ST frequency 10 operates the TEN and 10A relays in the sender.

4.66 Operation of the TEN and 10A relays provides paths to operate the RST, RST1, and RST2 relays. The RST- relays lock the HS and JS relays to prevent further advance. The ODO relay also locks and operates the OD1 relay. At the end of the ST pulse the 10 and 7 channel relays, CK1 and CK2, SYN and the TEN and 10A relays release.

4.67 The national office code and the four digits dialed by the originating operator are now registered in the sender.

5. DECODER OPERATIONS - CLEVELAND 4A OFFICE

(A) General

5.01 As soon as the C digit is registered in the MF incoming sender at the 4A office at Cleveland, a decoder connector is called in. This connects the sender to a decoder into which the sender transmits the A, B and C code digits, trunk class mark VO or NVO, and a 3D mark.

5.02 The decoder uses this information to select a card in its home translator. Since there are 50 trunks to the LA5 local office on this call, two cards are available. The first card dropped contains card-to-card routing instruction. (See Fig. 6.) A marker is called in, and if the marker finds all the trunks on the first card busy, the second card is dropped. This call assumes that a trunk indicated on one of these two cards is idle and can be seized.

(B) Dropping 3D Card

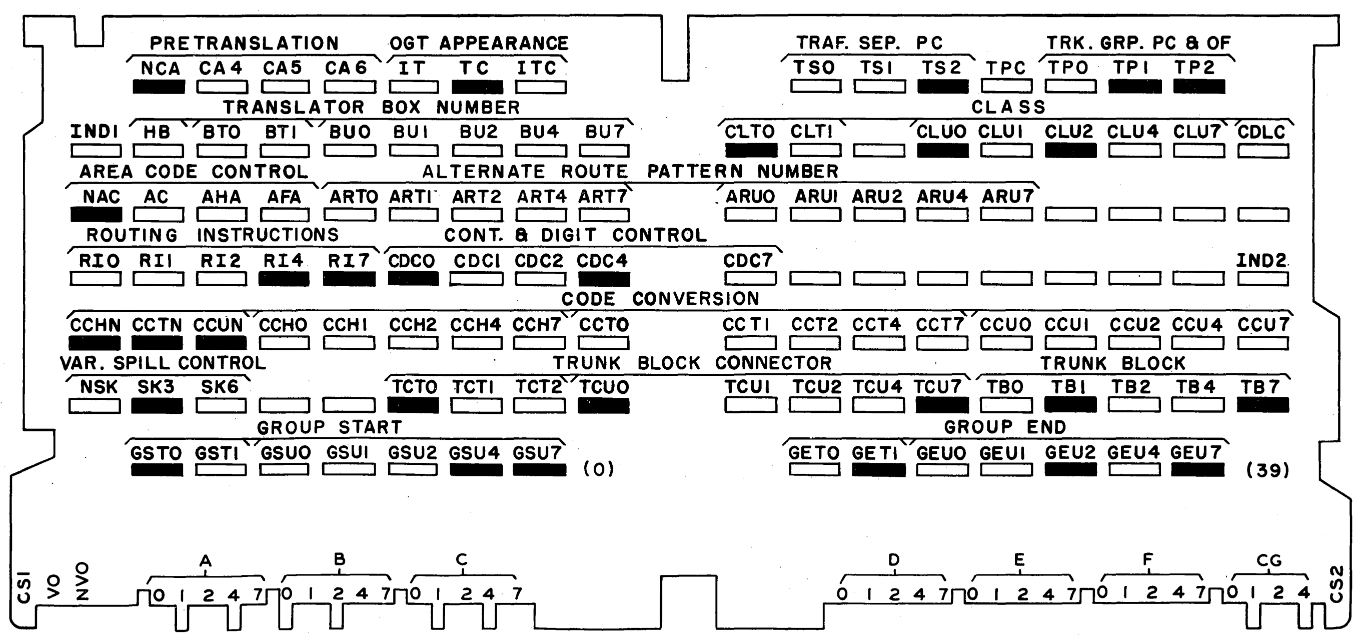
5.03 As described in Section A828.121.2, the seizure of a decoder results in the operation of relays HC1-HC16 (OS 161-1). These relays connect leads from the sender, through the decoder, to operate relays in the home translator.

5.04 On this call, the national office code is LA5, which means that code bars corresponding to the A, B and C digits (525) are actuated on a two-out-of-five basis. Information on the associated 3D card:

(a) Directs the decoder to seize a toll completing (TC) marker.

(b) Indicates card-to-card routing instruction.

(c) Indicates that outpulsing by the sender should start with the D digit on an MF basis.



NOTES:
1. VIEWED FROM LIGHT SOURCE.
2. ENLARGED PUNCHES SHOWN IN BLACK.

FIG. 6 – 525(LA5)-3D CARD AT CLEVELAND FOR FIRST 40 TOLL SWITCHING TRUNKS TO THE LA5 OFFICE

(C) Connecting to Idle Toll Completing Marker (SC 113-1)

5.05 This call assumes a 2-train arrangement at the Cleveland 4A toll office; therefore a toll completing marker is required to complete the call to a toll switching trunk. Selection of such a marker is slightly different from the marker selections previously described and is outlined in detail in the following paragraphs.

5.06 When the connection between the sender and the decoder is established, ground on leads SMI and SMC, originating at the incoming trunk operates decoder relays to indicate whether the trunk is located on one or both trains.

5.07 A terminal grade trunk located only on the toll completing train supplies low resistance ground to lead SMC and high resistance ground to lead SMI. This operates relays SMC, SMC1 (select magnet completing) and SMI1 (select magnet intertoll). SMC closes a path for operating SMC2 (OS 168-1).

5.08 A common grade trunk located on both trains places low resistance ground on both leads. This would operate relays SMI, SMI1, SMC and SMC1 which close paths for operating relays SMI2 and SMC2.

5.09 Since this call is to be completed via a toll switching trunk located on the toll completing train, the card operates the TC (toll completing marker) relay in the decoder (OS 164-1). The SMC2 relay, operated in either case above, operates the TC1 relay in combination with the operated TC relay (OS 168-1).

5.10 The TC1 relay operates relay SMCO (select magnet cut-off) which opens the SMI and SMC leads, releasing the SMI and SMC relays and operating the TC2 relay. The TC2 relay places battery on the STC lead to the marker connector, thus starting selection of a marker in the manner described in Section A828.121.2 except that on this call a toll completing marker is seized.

6. MARKER OPERATIONS - CLEVELAND 4A OFFICE (SC 122-1)

6.01 Many of the operations of the marker on this call are the same as those for the call described in A828.121.2. Details of the operations not the same as those already described are included in the following summary.

6.02 The marker records information transmitted by the decoder and card translator and checks that it is complete. While this is going on, the marker identifies the incoming frame and calls in a trunk block connector where it operates the proper trunk block relay as soon as this information is received. Then the marker selects a toll switching trunk and identifies the outgoing frame on which it appears.

6.03 When the first of the two available cards is dropped, the marker holds the decoder while a test for the idle trunk is made. Selection of an idle trunk is indicated by the release of marker relay TKE (OS 201-1) followed by the operation of decoder relay TKS (OS 202-1).

6.04 If the trunks indicated on the first card are busy, the second card is dropped. (See Fig. 7.) Since this card contains follow-with-reorder routing instruction, the marker releases the decoder as soon as the marker RCK (register check) relay is operated (OS 197-1).

6.05 As soon as the incoming and outgoing frames have been identified, the marker can connect to them, seizing the out frame first. Then it connects to groups of A, B and C links on the frames and selects a set representing an idle channel. Next, the marker transmits information to the sender as to how the call is to be handled and closes the crosspoints connecting the intertoll incoming trunk to the toll switching outgoing trunk.

6.06 If a successful crosspoint check is made, relay SRL (start release) operates to start the release of the marker and the connectors it is holding and to signal the sender to release the decoder connector (OS 217-1).

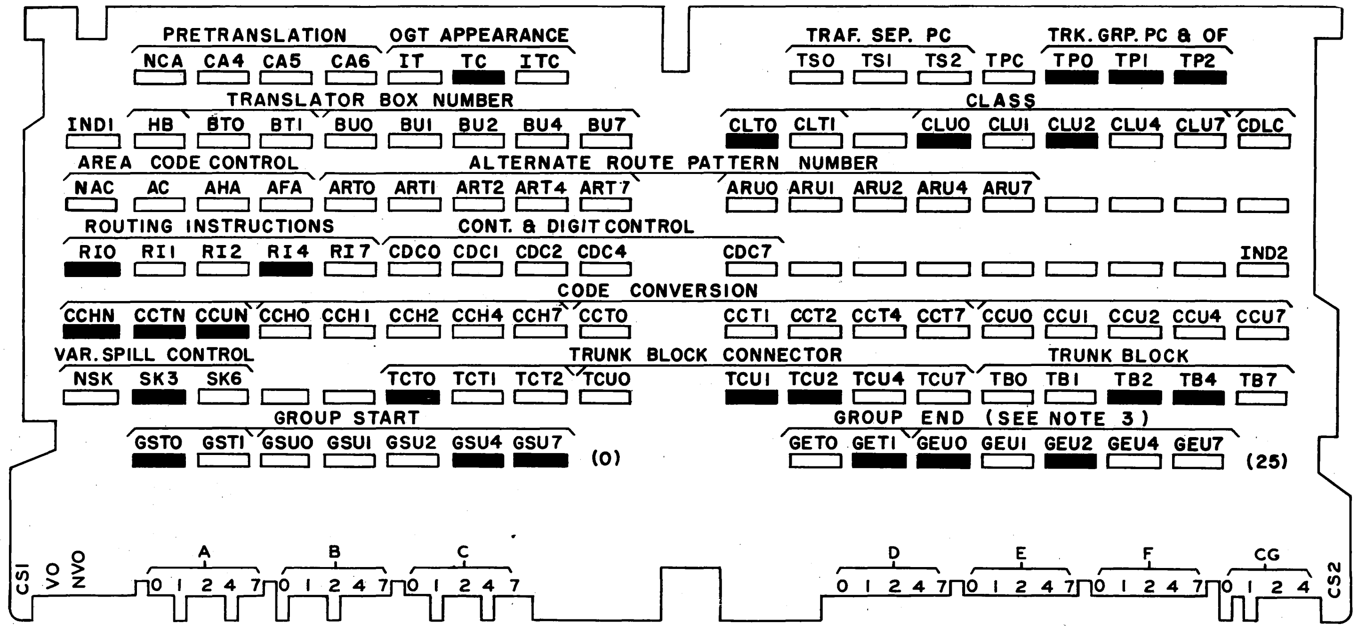
7. SUPERVISION - NO. 1 CROSSBAR OFFICE

(A) General

7.01 At this point a connection has been established at the Cleveland 4A toll office between the intertoll incoming trunk with an MF incoming sender attached and the outgoing toll switching trunk which terminates in an MF incoming trunk circuit at an LA5 No. 1 crossbar office.

7.02 The next step is to transmit the numericals 6328 to the LA5 office so that equipment there can connect the incoming trunk to the called subscriber line.

7.03 After marker release and the completion of the SL check by the sender, the toll switching trunk at the Cleveland 4A toll office signals the incoming trunk at the No. 1 crossbar office. This causes the No. 1 trunk to be connected to an MF terminating sender which returns a start pulsing signal.



NOTES:
1. VIEWED FROM LIGHT SOURCE.
2. ENLARGED PUNCHES SHOWN IN BLACK.
3. 16 SPARE TERMINALS PROVIDED FOR GROWTH OF TRUNK GROUP.

FIG. 7 - 525 (LA5) RAI CARD AT CLEVELAND FOR 10 TOLL SWITCHING TRUNKS TO LA5 OFFICE

7.04 The start signal causes the MF sender at the Cleveland 4A office to send out a KP pulse, pulses for four digits, and an ST pulse. The MF sender then releases and releases the SP relay in the incoming intertoll trunk at Cleveland and the hold magnets in the sender link.

7.05 The equipment at the No. 1 office now connects the incoming trunk to the line and rings the subscriber's bell.

(B) Called Party Answers

7.06 When the called party answers, ringing is tripped in the incoming trunk circuit at the No. 1 crossbar office and the supervisory relay operates. This reverses the battery and ground on the T and R leads to the toll switching trunk at the Cleveland 4A toll office and operates relay S (supervisory).

7.07 Relay S (OS 139-1) grounds the simplexed OT and OR leads back through the crossbar switches to the simplexed IT and IR leads of the incoming intertoll trunk in the same office. This operates relay SVP (OS 128-1).

7.08 When relay SVP operates it places battery on lead M to the associated single frequency signaling circuit. This returns a signal to the outgoing trunk at the Pittsburgh 4A toll office, similar to the stop pulsing signal described in (B) of Part 3 under SF Signaling. (See Fig. 5.) The only difference is that relay SV (supervisory) in the incoming tandem trunk at the Pittsburgh office is operated instead of relay OF in the sender which has been dismissed (OS 222-1).

7.09 Placing battery on lead M of the SF signaling circuit at the Cleveland 4A toll office causes the SF receiver at the Pittsburgh office to ground lead E going to the outgoing trunk. This ground is passed through the operated contacts of relays OS1 and SL and the windings of relay LO (lockout) to the simplexed OT and OR leads.

7.10 The path continues through the crosspoints to the simplexed IT and IR leads of the tandem trunk and on to the winding of relay SV which operates and reverses the loop to the switchboard cord circuit. Assuming that the outward switchboard cord circuit is like the one shown on OS 221-1, battery and ground through the windings of the trunk L relay now operate relay P in the cord circuit. This operates relay CH which extinguishes the calling cord lamp. The operator now knows that the called party has answered.

(C) Disconnect

7.11 When the called subscriber hangs up, an on-hook signal is transmitted to the operator by the release of the relays which were operated to give the off-hook signal. This relights the lamp associated with the calling cord and when the customer who originated the call hangs up, the answering cord lamp lights. The operator now may release the connection.

7.12 Removing the cord from the tandem trunk jack releases relays SL and L in the trunk. Relays H, CO and LU follow the L relay down in sequence. Relay CO removes ground from lead IS to the incoming and outgoing link hold magnets which release (OS 222-1).

7.13 The release of the outgoing frame secondary hold magnet starts the release of the outgoing trunk at the Pittsburgh office. OS is the first relay to release and it removes battery from the M lead, replacing it with ground. This causes the SF signaling circuit to remove ground from the E lead to the incoming trunk at the Cleveland 4A toll office.

7.14 The first relay in the incoming trunk to release is LC (OS 222-1), which prepares a path that fires tube TM as soon as the timing capacitor charges. The circuit for the TM tube is similar to the circuit shown for the DP incoming trunk (OS 101-1). Firing the TM tube releases relay G which opens the locking path for the CO relay, allowing it to release. The normal CO relay removes ground from lead IS to the incoming and outgoing link hold magnets (OS 222-1). Release of the outgoing frame secondary hold magnet opens lead OS to the toll switching trunk and starts its release by releasing the SC relay. The SL relay opens the circuit across the T and R leads to the No. 1 crossbar incoming trunk circuit, starting the release of the circuits in that office.

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Attached:
Fig. 5

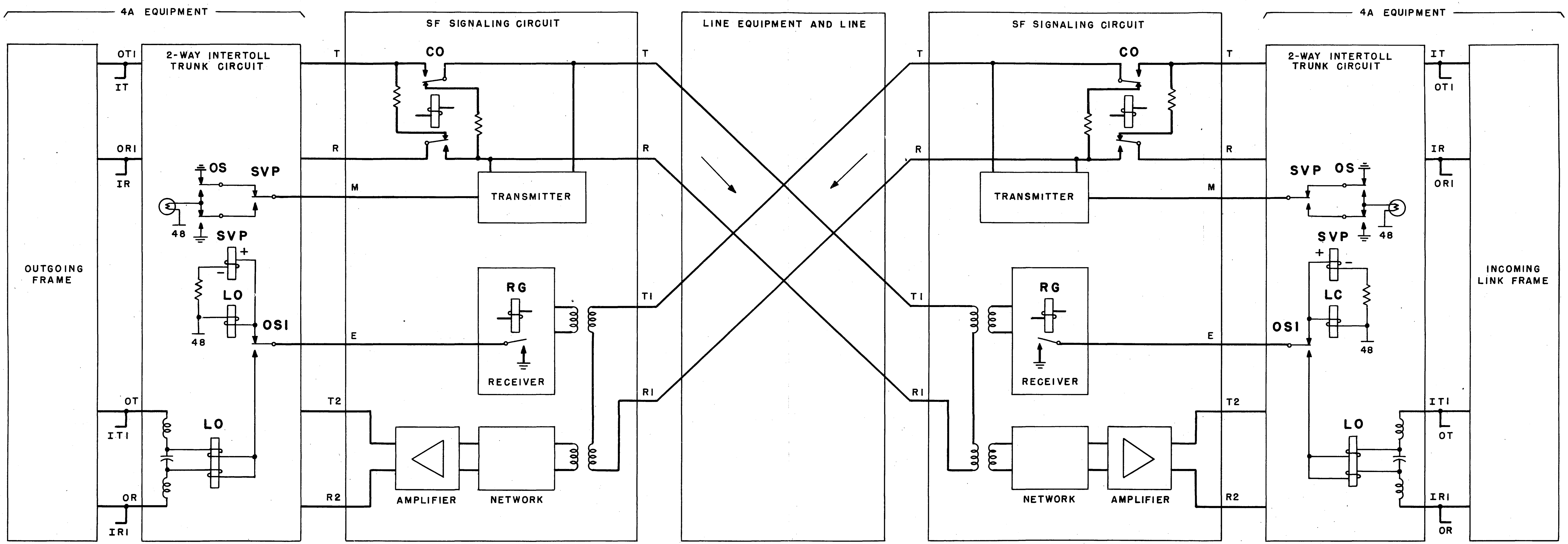

FIG 5.- SF SIGNALING SYSTEM ON 4 WIRE TOLL CIRCUIT

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