GENERAL DESCRIPTION

NO. 4A TOLL SWITCHING SYSTEM

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1. INTRODUCTION

(A) General

1.01 This section describes the No. 4A toll switching system. The 4A system performs the switching functions required at important switching centers under the operator nationwide toll dialing plan.

1.02 This section includes six parts as follows:

1. INTRODUCTION
2. SWITCHING PRINCIPLES
3. FUNCTIONS OF PRINCIPAL EQUIPMENT ELEMENTS
4. METHOD OF OPERATION ON TYPICAL CALLS
5. MAINTENANCE FEATURES
6. EQUIPMENT

1.03 Detailed descriptions are covered in several sections with the base number A828.121. Detailed engineering information will be covered in sections in the AA400 series.

1.04 The INTRODUCTION is covered in five broad divisions:

(1) (B) Automatic Toll Switching: A short discussion of the beginnings of automatic toll switching, and the limitations of the early systems.

(2) (C) No. 4A Toll Switching System - Nationwide Operator Toll Dialing: A highlight picture of the 4A system, which includes a partial story of the numbering plan used in nationwide toll dialing.

(3) (D) Existing Toll Systems: Features of toll systems in use prior to the introduction of the 4A system. A typical call is traced through each of these systems.

(4) (E) No. A4A Toll Switching System: A broad description of the A4A system, (the advance model of the 4A system), which includes a more complete story on the nationwide numbering plan.

(5) (F) No. 4A Toll Switching System: A description of the 4A system in more specific terms, with typical calls.

(B) Automatic Toll Switching

1.05 The benefits realized from applying dial operation to the toll system are of the same nature as those obtained from dial operation of the local exchange plant. Broadly, these benefits are realized in improved service, due to greater speed and accuracy, and in reduced cost of providing service.

1.06 Many of the problems encountered in introducing dial operation on toll calls and on local calls are similar. However, the toll problems are more extensive, some of the principal ones being:

(a) Numbering plan. The number of digits used to reach any of the approximately forty million telephones in the nationwide system should be held to a minimum (not more than eleven).

(b) Adaptability. Must be able to introduce the new switching units without major modifications in existing systems. Also must make efficient use of the existing toll network.

(c) Supervision and signaling range. The system must have the equivalent of local common battery supervision, (switchhook supervision from calling and called subscribers), and have a range equal to the ringdown system used in manual toll switching.

(d) Transmission. The system must be able to automatically provide the proper transmission levels on different types of connections.

1.07 The first step in the direction of automatic toll switching was the provision of dial intertoll trunks from one toll center to another toll center with step-by-step equipment. This enables an outward operator in one toll center area to dial a called subscriber's number in another toll center area and complete the call without the aid of an inward operator. The composite or simplex signaling circuits used on these dial intertoll trunks resulted in a practical limitation of 300 miles in the length of the trunks. This restricted the number of toll centers which could be dialed directly from any particular toll center. Most traffic was limited to calls direct from the outward operator to the switches in the distant city, and there was little through switching.

1.08 The advent of the crossbar switch led to the study of common control systems for toll dialing and this resulted in the development of the No. 4 Toll Switching System. This system introduced several important improvements into the toll network. It is the first system capable of switching a four-wire talking connection. It is also the first to use multifrequency pulsing which considerably shortens the time required for transmitting the pulses which control the switching equipment. Being a common control system, it greatly enlarged the scope of automatic toll switching over that provided by step-by-step toll dialing, because it made toll dialing benefits available to the large metropolitan areas where panel and crossbar equipment is installed.

1.09 The introduction of the No. 4 system and the extension of the range of the step-by-step toll dialing system, (by use of single-frequency signaling), brought many benefits into the toll system. However, these systems do not have the features necessary for full nationwide dialing.

1.10 The basic reason for the inadequacy of these systems is that each of them operates on a trunk route basis rather than on a destination basis. This is to say that on a toll call that is switched through several toll centers, each toll center knows only the route to the next one in line - it doesn't know the destination of the call. Therefore, a directing code is required for every switching point in the connection. For example, on a call from Cleveland to New Castle, Delaware, the call is routed through toll centers in Cleveland, Philadelphia, and Wilmington. Eight code digits are required in addition to the subscriber's telephone number. Code 215 is the trunk group code from Cleveland to Philadelphia, 302 is the code from Philadelphia to Wilmington and 17 is the trunk group code from Wilmington to New Castle. Therefore, to reach a subscriber in New Castle, whose telephone number is 2345, the originating toll operator must dial 215-302-17-2345. Obviously systems using such unwieldy digit combinations are not suitable for full nationwide dialing, and a different system was required.

1.11 The first step in designing an adequate system was the development of a nationwide numbering plan requiring a maximum of ten digits, plus an added digit for party lines, to route a call to any subscriber in the nation. The 4A system is built around such a numbering plan. With this plan all of the 4A systems in a built-up connection know the destination of the call. Therefore, on a call such as the one just described, only one 3-digit code is needed in addition to the called subscriber's telephone number. Furthermore this is all that is required to route a call to any point in the nation, (some calls may be routed through as many as seven No. 4A installations). The originating toll operator's job is considerably simplified because no matter how many switching points are used on a call, she prefixes only one three-digit code to the called subscriber's telephone number - the code of the numbering plan area where the call terminates.

1.12 One other point should be mentioned. The development of single-frequency signaling removed the 300-mile limitation on the length of intertoll trunks by employing voice frequencies. This had to be done before nationwide dialing could be accomplished. Since single-frequency signaling does not directly affect the switching equipment it is not covered in this Section.

(C) No. 4A Toll Switching System - Nationwide Operator Toll Dialing

1.13 The No. 4A system is a part of the long range Nationwide Toll Dialing Plan which has for its ultimate goal extensive application of customer dialing of toll calls. Nationwide Operator Toll Dialing is the first step in this long range plan. At this stage of the plan long distance operators dial or key the information for routing a call into the switching equipment which then automatically completes the call without further operator assistance. The customers still place their toll calls with an operator as they do now. Ultimately, a customer will dial his toll calls the same as he now dials local calls wherever local office facilities can be economically provided to enable him to do so.

1.14 Fig. 1 shows how the 4A toll switching system fits into the general over-all toll switching plan.

1.15 As shown in this figure, the 4A system starts with the trunk relay equipment on an incoming intertoll or toll tandem trunk and ends with the trunk relay equipment on an outgoing intertoll or toll switching trunk.

1.16 (The primary purpose of this section is to tell how the 4A switching system works. However, to aid in presenting this story, selected general material is also included on the workings of the whole crossbar toll system.)

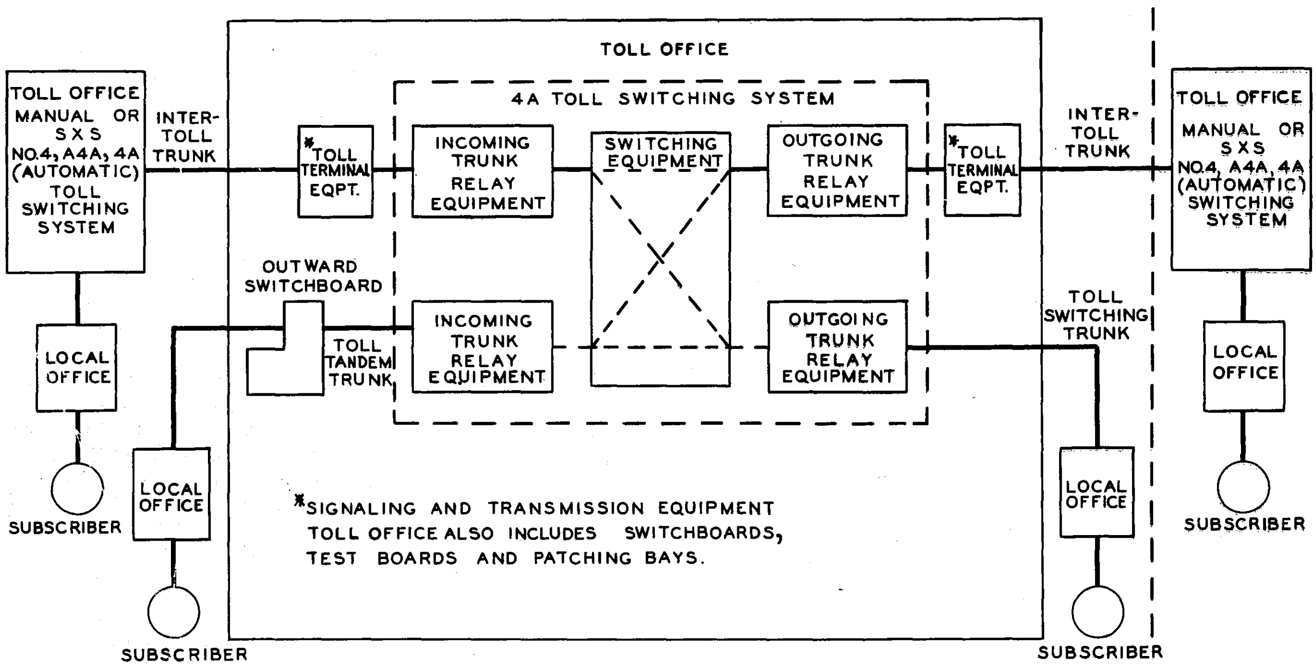


FIG. 1 - RELATIONSHIP OF 4A TOLL SWITCHING SYSTEM TO GENERAL TOLL SWITCHING PLAN.

1.17 Toll calls come into the 4A toll switching system on toll tandem or intertoll trunks and are automatically switched to intertoll trunks or toll switching trunks going out of the system. These calls can come from local offices (on toll tandem trunks) and be routed to a toll office. Or they can come from a toll office (on intertoll trunks) and be routed to another toll office, or be completed to a local office (on toll switching trunks).

Nationwide Numbering Plan

1.18 An important requirement for a nationwide toll dialing system is an adequate numbering plan. This plan should be suitable for initial use with operator toll dialing, and should anticipate customer dialing of toll calls so that little or no changes will be necessary in it when the ultimate nationwide toll dialing system is introduced.

1.19 The plan must also meet other important requirements. Some of these are:

(a) Every one of the telephones in the system, which includes all of the United States and parts of Canada, must have a distinctive nationwide telephone number, different from every other telephone. (There are now about 42,000,000 telephones in this area.)

(b) The total number of digits in these numbers must be kept as small as possible (not more than 11), and the digits should fall into some easily recognized pattern.

(c) Wherever practicable, existing telephone numbers should be retained for making local calls.

1.20 The 2-5 numbering plan is used for local dialing in the numbering areas of most of the large cities and its use will be extended to many other areas. For nationwide dialing purposes, ultimately it will form the basis for numbering all telephones. The telephone numbers in this plan are made up of an office code with two letters and a single-digit number, plus four or five numericals. This provides a maximum of about 500 non-conflicting, suitable office codes. Suitable means that the letters in each of the codes are part of a pronounceable name with reasonable spelling. No local numbering area has used more than 400 office codes. The problem of the nationwide numbering plan is to retain these codes for local calls and also to use them in the nationwide plan for toll calls.

1.21 This objective is reached in the following way. The United States and parts of Canada are divided into 88 geographical subdivisions, called Basic Numbering Plan Areas. (See Fig. 2, attached.) Within each of these areas all conflicts between office codes are eliminated. Some of the areas cover as much as an entire state, while one covers a single city, New York. The size of an area is restricted to about 500 offices, because of the limitation in the number of suitable office codes, which has been discussed. Each basic numbering plan area is assigned a different 3-digit "area code".

1.22 In areas with the 2-5 numbering plan, the subscriber's local office code, in the great majority of cases, becomes his "national office code" as well. The area code is prefixed to this national office code and the numericals, and the result is the subscriber's "nationwide telephone number".

1.23 For example, a local telephone number in New York City may be MAin 2-1234. The national office code is MA2. The area code for the geographical subdivision that includes New York City is 212. Therefore the nationwide telephone number is 212-MA2-1234. This is the number that toll operators, (and ultimately customers), in distant cities will dial.

1.24 With this numbering plan, a maximum of 10 digits, plus a party digit, will be dialed by the outward operator who handles the call, to reach any subscriber in the United States and parts of Canada. These consist of three digits for the area code, three for the national office code and four or five numericals. No more digits are required even though the call may progress through several 4A switching systems on the way to its destination.

1.25 As has been indicated, the national office code is the existing office code in the great majority of cases. In some instances a new national office code is assigned for receiving toll calls and the present code will be retained for local calls.

1.26 A more complete discussion of the numbering plan is included later under the discussion of the No. A4A toll switching system.

Six-Digit Translation

1.27 Nationwide dialing requires that calls be switched on a destination basis rather than on a trunk route basis. (See paragraph 1.10.) This means that all of the toll switching systems through which a call progresses must know the destination of the call. To route calls on a destination basis with the nationwide numbering plan requires that the 4A system be able to examine and use (or translate) six digits. The No. 4A system is the first system capable of translating six digits.

All previous common control systems are limited to 3-digit translation which was adequate until the advent of nationwide dialing.

Automatic Alternate Routing

1.28 With manual toll switching, if a toll operator finds all the trunks busy on a given route to a distant city she can select other, alternate routes over which to complete the call. Alternate routing is done automatically in the No. 4A system. This system has the ability to rapidly make a choice from several alternate routes in its attempts to establish a connection.

Transition Period

1.29 Systemwide usage of the basic numbering plan, and the benefits of 4A operation will be realized gradually as new 4A offices are added to the toll network and as the existing toll crossbar installations are modified for full 4A operation.

1.30 The operating methods used will be continually changing as more and more 4A installations are placed in service. Therefore the numbering plan used during this period will undergo a gradual transition from the plans in use today in the various toll dialing networks to the ultimate plan for nationwide dialing.

1.31 During the transition period, of course, the 4A toll switching offices will be operating with all the existing types of toll offices. However, for simplicity the following general description of a call assumes that the full complement of No. 4A systems have been installed. A more complete description of a toll call through the system is given later in this part in the more detailed discussion of the No. 4A Toll Switching System.

Toll Call - 4A System

1.32 The calling subscriber reaches a long distance operator through switching facilities in his local office and gives her his own telephone number and the called subscriber's name and city, or telephone number and city. The operator obtains from her routing instructions, the 3-digit area code of the basic numbering plan area in which the called subscriber lives and adds it to his national office code and numericals, which usually is his local telephone number. The resulting 10- or 11-digit number is the called subscriber's national telephone number.

1.33 The No. 4A switching equipment appears before the outward operator as a group of jack-ended trunks. She picks out an idle trunk in this group and plugs a cord into it. She then keys the called subscriber's national telephone number.

1.34 When the number has been keyed, the No. 4A network takes over, selects a route to the terminating local office, transmits the routing information, (through one or more intermediate toll offices where indicated), and follows the call to completion. The outward operator can work on other calls while this call is being set up because she has visual called party supervision. Where one route is busy, the 4A equipment automatically tries one or more other routes, until it finds an idle one.

1.35 The outward operator observes whether the connection is completed and takes care of timing and charging for the call.

(D) Existing Toll Switching Systems

1.36 As has been indicated, during the period of transition to full 4A operation, the 4A system will be operating with all of the existing types of toll switching systems. Therefore a brief description of these systems is given and a typical call is traced through each of them.

1.37 It should be understood that these typical calls are selected to illustrate a general operating procedure. In practice, the particular call chosen may not be completed in the exact manner described here.

Manual Toll Switching System

1.38 With manual operation of the toll system there is no need for a nationwide numbering plan. All the switching is done by operators and the toll offices are designated by the names of the cities in which they are located. There is, however, a systematic classification of toll offices to meet traffic and transmission requirements.

1.39 The offices in the manual toll system are classified as follows:

(a) Toll Center (TC). A toll center is a toll office which switches toll calls between a group of local exchanges located in nearby cities and towns, and the long distance network. It also is the original toll switching point for calls going outside the area and the final toll switching point for calls from outside toll areas. It is the basic switching unit in the toll system. There are about 2300 toll centers.

(b) Primary Outlet (PO). A primary outlet is the next larger switching unit; larger in this sense means that it serves a more extensive area.

It is a toll center which switches calls between groups of toll centers. Because calls pass through it going from one toll center to another, it includes facilities for raising the transmission level on those connections which require it. In addition it acts as a toll center to its own group of local exchanges located in nearby cities and towns. There are approximately 150 Primary Outlets. Newark, New Jersey and Kansas City, Missouri are examples of PO's.

(c) Regional Center (RC). A regional center is the most extensive of the switching units. It is a toll center which switches calls between a group of PO's. Like the PO's it includes facilities for raising the transmission level on connections which require it. It also acts as a toll center to its own group of local exchanges in nearby cities and towns. There are 8 Regional Centers. For example, New York City and Oakland, California are RC's.

1.40 Figure 3 shows an elementary (TC), (PO) and (RC) network. The circuits between these centers are called intertoll trunks. In examining the network it should be understood that if traffic volume warrants it, any office may have direct circuits to any other office.

1.41 Some calls are routed through a number of switching points (RC, PO, or TC) to reach the called subscriber, while others may go through one intermediate toll center, or be completed directly from one to another.

Typical Manual Toll Call

1.42 The calling subscriber places his call with an outward operator. If the call is completed directly from one toll center to another, the outward operator signals an inward operator at the distant toll center by ringing over the toll line. She passes the called number to this operator, who completes the call.

1.43 On a typical built-up connection, that is, one in which there are one or more through, (intermediate), toll centers, the outward operator may consult her bulletin or a route operator for routing instructions. From one of these sources she obtains the names of the first through toll center and the terminating toll center. She rings the first through toll center and tells the through operator the name of the terminating toll center. This operator sets up a connection to the next through toll center, if there is one, or to the terminating toll center. She rings and then leaves the connection. Where there is more than one through toll center the procedure is the same at each center. When the terminating toll center is reached the originating operator gives the called number to the inward operator, who completes the call to the local office.

1.44 The originating operator follows the call through each toll center and remains on the connection until the called subscriber answers, then she takes care of timing and ticketing the call.

1.45 Figure 4 shows a typical built-up connection between a subscriber in Oakland, California and a subscriber in Cleveland, by way of Chicago, as it would be handled in the manual toll switching system. (This same call is described later, as it would be handled in the No. 4, No. A4A and No. 4A systems.)

1.46 Subscriber A reaches the outward operator in the Oakland toll office through switching facilities in the local central office. The outward operator obtains from the calling subscriber his own

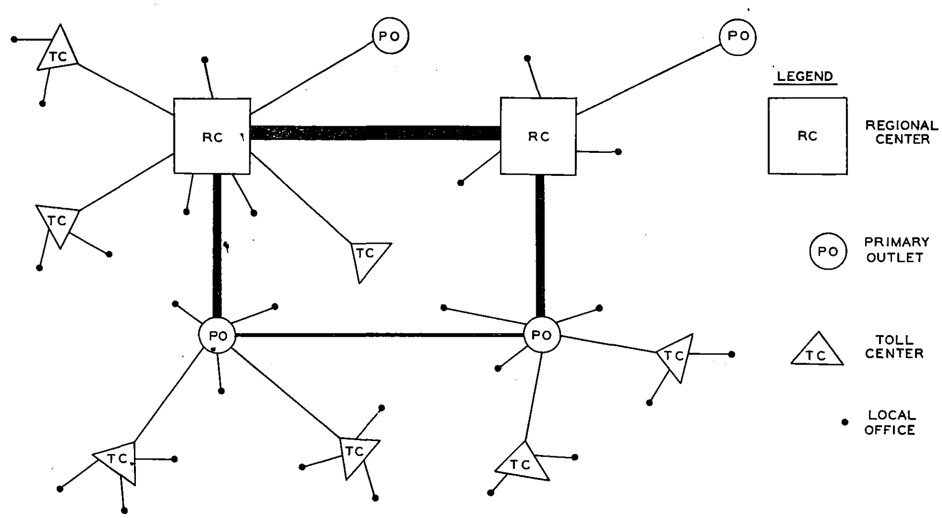


FIG.3 - MANUAL TOLL SWITCHING - LAYOUT AND CLASSIFICATION OF TOLL OFFICES

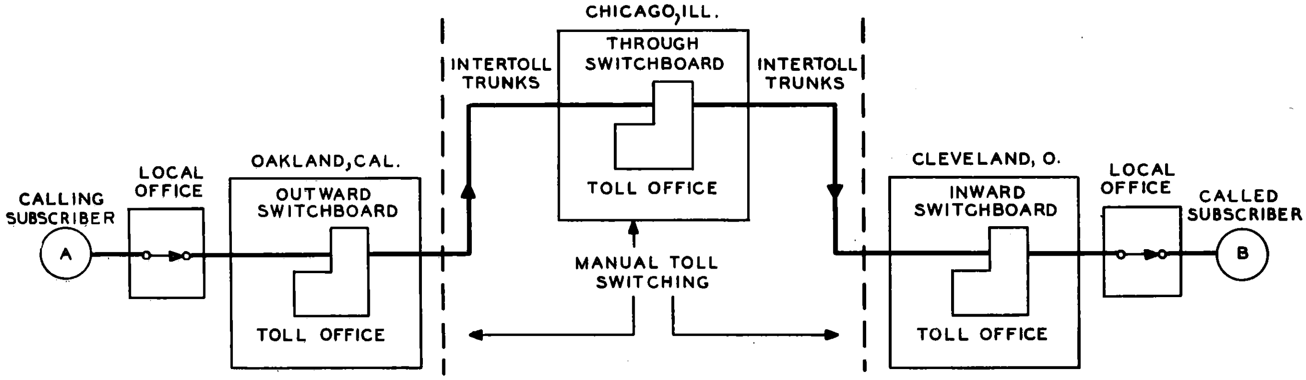


FIG. 4 - MANUAL TOLL SWITCHING

telephone number and the name or telephone number of subscriber B in Cleveland. (If the name is given, the distant information operator supplies the telephone number.) She then determines the routing of the call from her position bulletin or from a route operator. Part of this information tells her whether she must signal the next office manually, or whether it will be done automatically.

1.47 The operator finds that she must route the call through Chicago because there are no direct trunks to Cleveland.

1.48 She selects an idle intertoll trunk to Chicago, which terminates on the inward switchboard at Chicago, and rings. The Chicago inward operator challenges and is told by the Oakland operator that this call is to Cleveland. The Chicago inward operator transfers the call to the Chicago through operator who then selects an idle intertoll trunk to the Cleveland toll office and rings.

1.49 The Cleveland inward operator challenges and the Oakland operator gives her the called subscriber's telephone number. The Cleveland operator completes the call to subscriber B over a toll switching trunk and the facilities in the local office in Cleveland. The Oakland operator remains on the call until the called subscriber answers and takes care of timing and ticketing the call.

1.50 When subscriber A replaces the receiver on the switchhook upon completion of the call, the Oakland operator signals the Chicago operator to take down her cords and then takes down her own. When subscriber B disconnects, the Cleveland operator takes down her cords. The trunks and switching equipment are now available for other calls.

1.51 In small toll offices the inward functions and the through functions may be handled at the same switchboard in which case they are performed by the same operator.

Automatic Toll Switching - Types of Connections

1.52 There are three general types of toll connections in automatic toll switching. Since these connections are referred to in this section they are described now.

1.53 In a terminal connection, a call is completed from an outward position of a toll switchboard over a direct circuit to automatic switching equipment in the distant city where the called subscriber is located. The call may go directly from the outward position or it may go through automatic switching equipment, or through a manual toll tandem switchboard located in the originating toll center.

1.54 In a single switch connection there is one through (or intermediate) toll center between the originating toll center and the completing toll center in the distant city.

1.55 As the name implies, on a multi-switch connection there are more than one through toll centers between the originating toll center and the terminating toll center.

Step-by-Step Operator Toll Dialing

1.56 This is the earliest of the toll dialing systems. Most of the calls are terminal connections on which the operator dials from 4 to 8 digits, depending on the numbering plan in use in the distant city. The calls enter the toll center in the distant city on the step-by-step intertoll switches. These switches distribute the calls to the proper local offices.

1.57 On single switch connections the outward operator picks a group of trunks to the through toll center and dials a maximum of 10 digits (or 11 for party lines) depending on the number of digits required to select a trunk at the through toll center, as well as on the numbering plan used in the distant city. The number of digits used in the through toll center may be two or three; generally, it is three. Where the originating toll center has a No. 4 installation (described later) the outgoing calls may pass through this equipment on their way to the through toll center, in which case the operator may dial three more digits or a total of as many as 13 or 14 digits.

1.58 There are few multiswitch connections in this system because the number of digits required to go through more than one through toll center becomes too large and unwieldy to permit efficient operation.

Typical Toll Call - Step-by-Step Operator Toll Dialing

1.59 Figure 5 shows a single switch connection from Richmond, Virginia, to Allentown, Pennsylvania, via Harrisburg, Pennsylvania.

1.60 Subscriber A in Richmond, reaches the outward toll operator through facilities in the local office and gives his own telephone number and the name or telephone number of subscriber B in Allentown. B's telephone number is 2-1234. The outward operator finds from her routing information that there are no direct trunks to Allentown and that she must route the call through Harrisburg. It also tells her that she must dial 053 to get from Harrisburg to the Allentown intertoll switches.

1.61 She plugs into the Harrisburg group of trunks and dials 053, followed by B's telephone number, 2-1234. The first three digits, 053, pick a trunk out of Harrisburg to Allentown. At Allentown the digit 2 directs the intertoll switches to local office 2. The remaining digits, 1234, direct the switches in the local office to B's telephone.

1.62 When the subscribers replace their receivers on the switchhooks, the Richmond outward operator removes her cords. The switching equipment then restores automatically and is available for other calls.

1.63 Timing and ticketing are handled by the Richmond operator.

Operator Toll Dialing Through Crossbar Tandem

1.64 Crossbar tandem serves a purpose in toll dialing similar to that of step-by-step toll dialing equipment. Crossbar tandems are installed in large cities because of the economies which result in the local switching plant. They also find important use in the toll dialing plan because they permit toll dialing into these large cities. However, existing crossbar tandem systems, unlike step-by-step, are not used as through centers on single or multiswitch calls.

Typical Toll Call - Operator Toll Dialing Through Crossbar Tandem

1.65 Figure 6 shows how subscriber A in Miami, Florida, is connected to subscriber B in New York City via Gotham crossbar tandem in New York City.

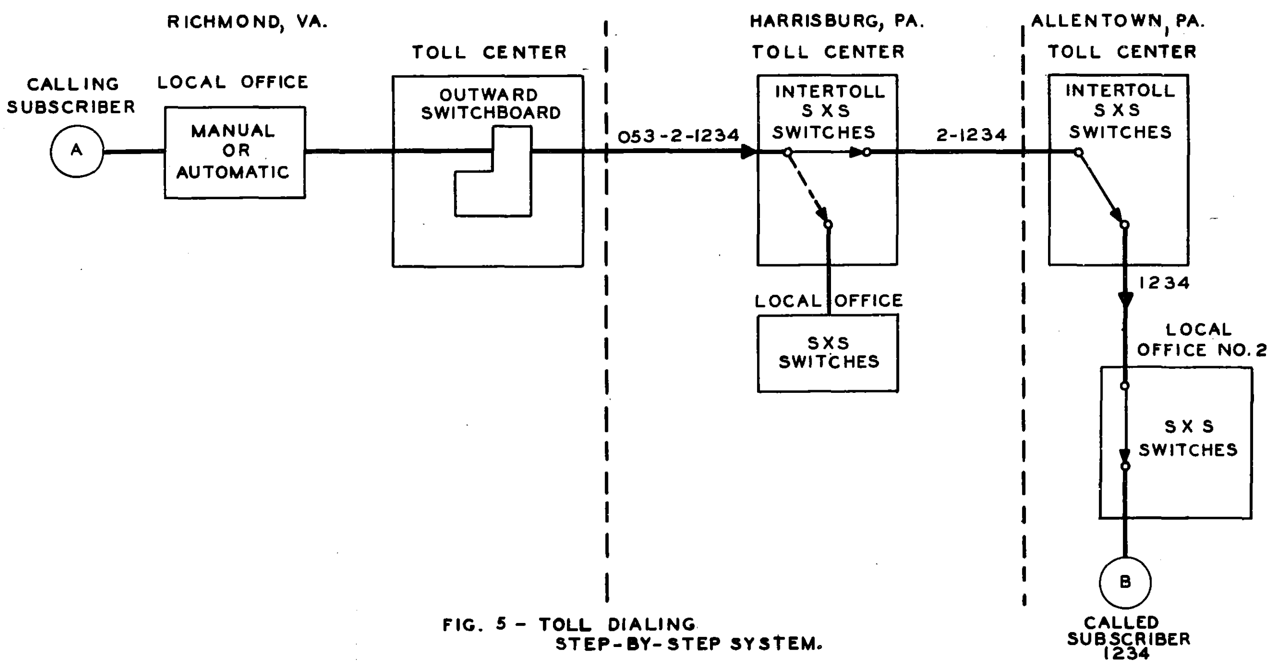


FIG. 5 - TOLL DIALING STEP-BY-STEP SYSTEM.

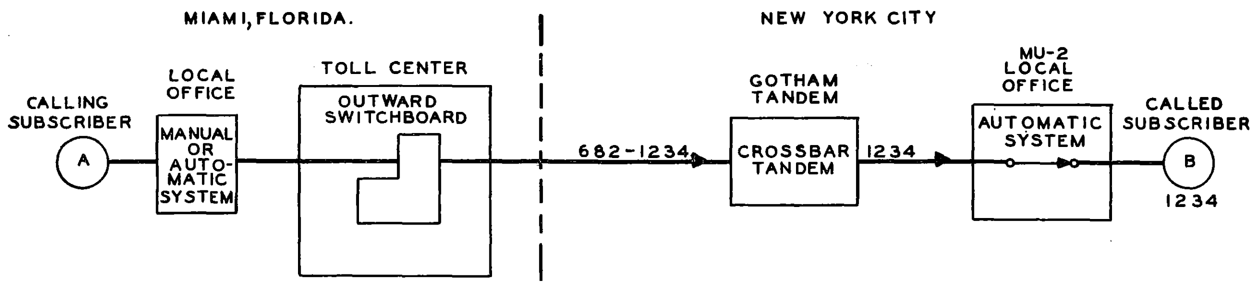


FIG. 6 - TOLL DIALING CROSSBAR TANDEM.

1.66 Subscriber A reaches the Miami outward operator in the usual way and places a call for subscriber B, whose telephone number is MUrray Hill 2-1234. There are direct intertoll trunks between the outward switchboard in Miami and Gotham tandem. The operator plugs into one of these trunks and dials MU 2-1234.

1.67 The automatic switching equipment in Gotham tandem examines and uses the first three digits, 682 (MU2 = 682), to select a trunk to the desired local office, MUrray Hill 2. The remaining digits, 1234, are sent by Gotham tandem to MUrray Hill 2, where the local switches direct the call to B's telephone.

1.68 When the subscribers disconnect, the Miami operator removes her cords and the switching equipment restores to normal automatically. Timing and ticketing are done by the Miami operator.

1.69 Step-by-step and crossbar tandem operator toll dialing are not suitable by themselves for any nationwide toll dialing plan. However, both of these facilities will be used to supplement the 4A Nationwide Operator Toll Dialing systems wherever they are economical.

No. 4 Toll Switching System

1.70 The No. 4 toll switching system was developed primarily to bring the economic and service advantages of operator toll dialing to the large multioffice areas like New York City. Its use considerably increases the scope of toll dialing.

Common Control

1.71 The No. 4 System is a marker type of common control system, and uses crossbar switches for all switching operations. "Common control" means that the switches in the talking connections are set up by certain equipment units which are common to all the switching frames in the office. A common control system has the ability to store and reuse digits which are pulsed into it by a dial or keyset. The marker is the major control unit of the common control equipment. One of its important functions is to make sure that there is an idle outgoing trunk available before attempting to set up a talking connection. The common control equipment is used on each call only long enough to set up a talking connection, after which it releases and is ready to serve another call.

Four-Wire Switching

1.72 In addition to being a marker type of common control system, the No. 4 system also differs from previous manual and automatic toll switching systems in that it is a 4-wire system. This means that two voice paths per trunk are provided through the switches - one for each direction of voice transmission. Prior to the development of the No. 4 system, toll switching systems were on a 2-wire basis the same as the local systems.

1.73 Before repeaters were developed, large gauge conductors and loading coils were used in outside toll plant to maintain proper transmission levels. A cheaper method of maintaining transmission levels was provided with the introduction of the vacuum tube repeater. The use of repeaters makes it possible to use smaller gauge conductors, and also economically extends the range of long distant telephone communication, but, as will be pointed out, four wires are required to get through the repeaters.

1.74 However, while the introduction of repeaters into the toll system brought many benefits, it introduced several problems and made necessary some changes in the existing toll systems. It is beyond the scope of this section to go into the details. However, the following discussion gives a general picture of the reasons for using 4-wire switching circuits and the advantages which result.

1.75 Because a vacuum tube amplifies in one direction only, repeaters are 4-wire circuits. Therefore, in 2-wire switching systems, when repeaters are used on a 2-wire trunk, the trunk must be connected to four wires where it enters the repeater and then back to two wires where it leaves the repeater. This conversion must be made at every repeater point.

1.76 These conversions from two wires to four wires and back again introduce certain undesirable transmission effects which limit the number of repeaters that can be provided on a toll line. It also limits the gain of each repeater.

1.77 The use of 4-wire trunks (or carrier), between toll offices eliminates these conversions with their undesirable effects. However, in 2-wire switching systems, conversion from four wires to two wires is still required at the ends of the 4-wire trunks where they enter and leave the switching equipment. Therefore, although 4-wire trunks eliminated the intermediate conversion points which are required whenever a 2-wire trunk goes through a repeater, conversions were still numerous when several 4-wire trunks were connected in tandem through 2-wire switching systems such as the manual and early toll dialing systems.

1.78 The four-wire switching feature of the No. 4 system eliminated many of these conversion points because four wires are provided through the switches. It is only necessary to convert the 4-wire trunks to two wires at the originating and terminating ends of the toll connection, so that they can be switched through the originating toll switchboard and the terminating local office. These are the only conversion points no matter how many switching offices and trunks are used to establish a connection.

Routing Plan and Code System

1.79 The routing plan used in the No. 4 system follows the general manual toll switching plan in which the basic unit is the toll center. As in the manual system, there is no nationwide numbering plan.

1.80 In the manual system, toll offices are designated by names. In the No. 4 system, arbitrary 3-digit codes are assigned to the intertoll trunk groups outgoing to other toll centers.

1.81 There are about 2300 toll centers in the United States and a 3-digit code system provides a maximum of only 1000 codes. Therefore some of these 3-digit codes must be repeated in the national network. However no repetitions occur in any of the toll centers reached by direct trunks from a particular No. 4 system. In other words, looking out from a given No. 4 installation, there are no conflicts in the codes of any of the trunk groups going directly to other toll centers. However, other toll centers may use the same codes for reaching their own trunk groups.

1.82 The No. 4 system does not have the ability to "spill" code digits forward. Therefore a separate set of code digits is required for each toll switching center in a built-up connection. For this reason the No. 4 system operates on a trunk route basis rather than on a destination basis. (See par. 1.10.)

1.83 The No. 4 system can register as many as fourteen digits. The first three digits received by a No. 4 office are used to select an outgoing trunk to the next office. The remaining digits are "spilled" forward. The second set of three digits are then used at the second office to find a trunk to the third office. The third set of three digits is used to select a trunk from this office to the local office in which the call terminates. The numericals are then spilled forward to this local office.

1.84 Three digits are used up or absorbed at each No. 4 office; therefore, using a maximum of 14 digits (three sets of 3-digit codes and 5 numericals) the number of toll switching points in a connection is limited to three. (The mechanical process of determining, from each of these sets of three digits, the equipment location of their associated groups of trunks is called 3-digit translation. Translation is one of the important features of common control systems.)

1.85 An automatic alternate routing feature is not included in this system. Instead, alternate routing is under control of the outward operator. Where the preferred route is busy at any switching point, (except the trunks to the local office), she selects an alternate route if one is indicated on her routing information. Of course, a different set of digits are dialed to select the chosen alternate route.

1.86 The No. 4 system considerably increased the scope of toll dialing and introduced many worthwhile features in the toll system. In addition to the important advantages of 4-wire switching and multifrequency pulsing, the No. 4 system has the advantages of high speed switching, self-checking circuits, precious metal contacts in all talking paths, and the ability to make more than one attempt to set up a call, (second trial feature). It has the further advantage of flexibility in assigning trunks and in changing the size of trunk groups. All these features were carried into the A4A and 4A systems.

1.87 Six No. 4 toll switching systems have been installed, located in Philadelphia, New York, Chicago, Boston, Cleveland and Oakland, California. It is planned to modify all these systems to the equivalent of the 4A system.

Typical No. 4 Toll Call

1.88 The manual call described earlier is completed on a fully automatic basis in the No. 4 system. Figure 7 shows how this call is handled by the No. 4 system when subscriber A in Oakland, California calls subscriber B whose telephone number is MAin 2-1234, in Cleveland. There are no direct trunks to Cleveland, so the call is completed via Chicago.

1.89 Subscriber A reaches the Oakland outward operator through switching facilities in the local office, and places the call with her. The outward operator obtains the routing information which tells her to add 312-216 to B's telephone number. She plugs into a trunk to the Oakland No. 4 system and keys 312-216-MA2-1234.

1.90 The first three digits, (312), are translated (examined and used), in the Oakland No. 4 system to select an intertoll trunk to the Chicago No. 4 toll system. The Oakland No. 4 system then spills forward the remaining digits, 216-622-1234 (MA2=622). The Chicago No. 4 system translates 216 to select an intertoll trunk to the Cleveland No. 4 toll system and spills forward 622-1234. The Cleveland No. 4 system translates 622 to select a trunk to the called local office, MAin 2, and spills forward 1234. The local (dial) office uses these digits to connect to subscriber B's telephone. The outward operator at Oakland times and tickets the call.

1.91 When the subscribers disconnect, the Oakland outward operator takes down her cords and the equipment returns to normal.

(E) No. A4A Toll Switching System

General

1.92 The toll dialing methods used in the systems just described require a 3-digit code to select a trunk group out of each switching point. As the number of switching points increases for a particular call, the string of digits keyed by the outward operator becomes unwieldy.

1.93 In addition, the code for a trunk route to a given switching point varies with the points of origin, and the use of automatic alternate routing, which is a must for nationwide dialing, would further multiply the number of codes which must be known to route a call. All of these codes, which are arbitrary, and have no significance in themselves, must be posted and kept up to date.

1.94 Altogether, the large number of digits required and the amount of information which must be posted make full nationwide dialing impossible with previous toll dialing methods.

1.95 It has been pointed out that to be suitable for nationwide toll dialing, a system should use a minimum number of digits and should not require more than ten or eleven digits to complete any toll call. Also the codes used in the numbering plan should have universal meaning, that is, the same code should be used to reach a given destination, regardless of where the call originates. This is necessary to keep the amount of routing information required by the outward operators at a minimum.

1.96 As has been indicated, the 4A system was specifically designed for operator nationwide toll dialing and anticipates future conversion to nationwide customer toll dialing. The A4A system, which is an advance 4A system, is the initial step in the general program for nationwide dialing. It has some of the 4A features in a limited form, and in order to realize the benefits of these features as soon as possible, several of these advance systems were installed while development of the 4A system was being completed. Since all A4A systems will ultimately be changed to 4A systems, the A4A design includes features which simplify the modification.

Numbering Plan

1.97 A brief story of the nationwide numbering plan has already been told. (Par. 1.18 and following paragraphs.) Since the features of the 4A system, and

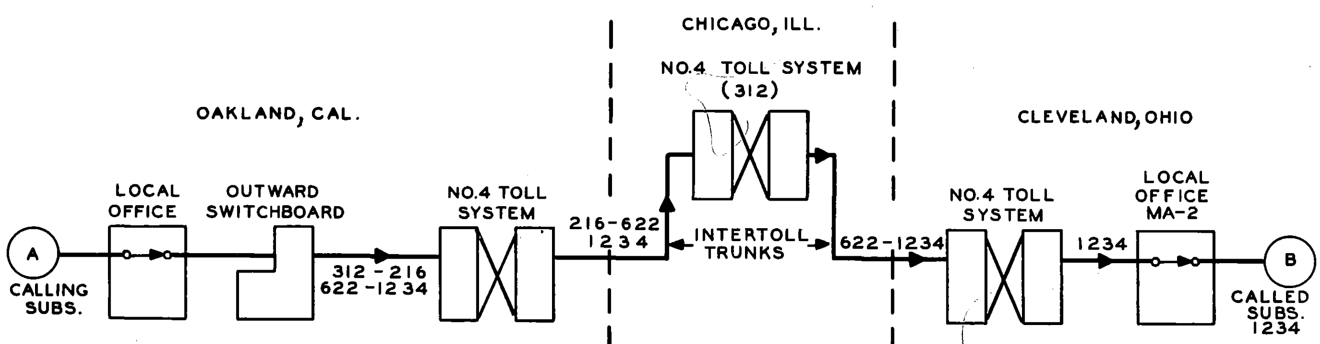


FIG. 7 - CALL USING NO.4 TOLL SWITCHING SYSTEM

to some extent those of the A4A system are built around the numbering plan, the numbering plan story will now be completed before going into the features of these systems.

1.98 As previously discussed, the United States and parts of Canada are divided into 88 basic numbering plan areas, each having a distinctive 3-digit area codes assigned to it.

1.99 Within each of these areas every local office has a distinctive 3-digit office code which is different from every other office code in the area. These are the national office codes and in 2-5 numbering areas they are the existing office codes. However, where two or more central offices in a basic numbering plan area had the same office code, new office codes were assigned to all but one of them to eliminate the conflict.

1.100 Also in some areas, new national office codes were assigned for receiving toll calls and the present telephone numbers retained for local calls. These are the cases where 2- or one-digit office codes, or no office codes are used. For example, Indianapolis, Indiana is a 2-digit office code area. The 2-digit codes are retained for receiving local calls, but for toll calls they are expanded to three digits. PLaza 2468, for instance becomes PLAza 2468 for receiving toll calls.

1.101 The three digits of the area code, together with the 3-digit national office code and the four or five numericals constitute the subscriber's national telephone number. These are the numbers which will be keyed by the outward operators to complete toll calls from one area to another when the full complement of 4A toll systems have been installed. (On calls completed within the same area, the area code is not used.) They are also the numbers that customers will dial in the ultimate customer dialing plan.

Nationwide Numbering Plan Codes

1.102 Five types of codes are used in the nationwide numbering plan.

1. National Office Codes
2. Area Codes
3. Service Codes
4. Delayed Call Operator Codes (TX Codes)
5. Toll Center Codes (TC Codes)

1.103 Figure 8, attached, shows the numbering plan for nationwide toll dialing in chart form. Reference to this chart will simplify the following discussion.

1.104 National Office Codes: There are 1000 possible 3-digit codes, 000-999. The national office codes are taken from the so-called ABX block in this series, that is, the first two digits can be any number from 2 to 9 and the third any digit from 0 to 9. This provides 640 codes (8x8x10). Of these about 500 can be used for codes containing a practical office name, and this limits the size of a basic numbering plan area to roughly 500 codes.

1.105 The remaining codes in the ABX block contain combinations which cannot be used to spell anything, or else spell names easily misunderstood. Some of these are used for TC codes, which are described in paragraph 1.112.

1.106 Area Codes, (A0X,A1X), are taken from the A0X and A1X block which means that the first digit can be any number from 2 to 9, the middle digit 0 or 1 and the last digit, any number from 0 to 9.

1.107 The area codes have full significance only in the 4A system. In the A4A system they are used in the same way as the arbitrary 3-digit codes - they designate a particular toll center.

1.108 Service codes are special codes used to reach Information, Rate and Route, and other assistance operators. They are in the 1D1 group where D means any digit except 1, for example, 131, 141, 181, etc. These codes are the same in all toll offices.

1.109 Delayed Call Operator Codes (TX) are used by toll operators to complete toll calls which are delayed due to inability to reach the called subscriber. They are the same as those used in the manual toll switching systems, and are used for the same purpose.

1.110 TX codes may be one-digit E, 2-digit EX, or 3-digit EXX. The E means any digit from 1 to 9 and the X any digit from 0 to 9. In the toll crossbar systems they are always preceded by dialing or keying a prefix 11. For example, a one-digit code might be 112, a 2-digit code 1124, and a 3-digit code 11375.

1.111 A familiar example of the use of TX codes is on a person-to-person call where someone else answers the telephone and is asked to tell the called subscriber to "call the Oakland, California long distance operator 375". The TX code is 375 and with a prefixed 11 it is used by the toll operator in the called subscriber's city to reach a team of TX operators in Oakland where the call originated. In Oakland there is a group of operators which is divided into teams of 4 or less, each team having a TX number assigned to it. An operator in the team with TX No. 375 completes the call to the calling subscriber.

1.112 A Toll Center Code (TC) is assigned to each toll center. With 4A operation, most of these are taken from the ABX codes referred to under National Office Codes, (par. 1.104) which cannot be used for office codes (approximately 140). These codes are used by toll operators in one office who wish to reach an operator in another toll office.

1.113 Since the service codes are the same in all toll offices, and TX codes will be repeated in some national numbering areas, a TC code is needed to select the particular toll office desired. This is then followed by an operator code. Calls to an assistance operator or to a service desk use the service codes, and calls to a TX operator use the TX codes just described. For example, the TC code for the Newark, N.J. toll office may be 899. Therefore, the nationwide number to reach the 121 assistance operator in the Newark toll office is 201 (New Jersey area code), 899 (TC code) and 121 (Service code), or 201-899-121.

1.114 Toll center codes are not required under A4A operation since the routing codes used will always direct the call to the proper toll center in the same manner for reaching operators as for reaching subscribers.

1.115 The arbitrary 3-digit systems codes used to identify toll centers in the A4A system are taken from the OXX, 1XX, XOX and X1X group of codes. In addition to these systems codes, which have nationwide significance, there are other codes of limited use taken from this block of numbers. These are listed only in routing information in the nearby, more important, toll switching points and they may be duplicated in several basic numbering plan areas.

Classification of Offices

1.116 The RC, PO and TC classifications used in previous toll switching systems are retained in the nationwide toll dialing plan (see paragraph 1.39). In addition there is a National Center, (NC) and a Sectional Center, (SC). The National Center will handle overflow traffic when the trunks between two Regional Centers reach their peak traffic load. Each Sectional Center serves a group of Primary Outlets. SC's save outside plant by distributing traffic to their groups of PO's, which traffic otherwise whould have to go to an RC to be distributed.

1.117 The NC, all of the RC's and SC's and many of the existing PO's have been designated as key switching points in the nationwide dialing plan. Under 4A operation these key points are called Control Switching Points (CSP's). Although the No. 4 and A4A systems are installed in these future CSP's, the term CSP has no significance until these systems are modified to 4A operation.

1.118 With A4A operation, the most important city (usually a CSP) in each basic numbering plan area is assigned the area code. The remaining future CSP's in each area, as well as other important toll centers with the higher calling rates from other No. 4 and A4A systems, are assigned arbitrary 3-digit codes. These codes are the systems codes referred to in par. 1.115 and they will be published in operators' bulletins, (routing information), throughout the network. There are no conflicts between these codes anywhere in the nationwide network, and they identify the same destination regardless of whether they are dialed from a No. 4 or a No. A4A installation.

1.119 These arbitrary systems codes are required for toll centers in the A4A system because this system can translate only 3 digits. The 4A system can translate 6 digits and this is an important difference between the two systems. The necessity for arbitrary codes with 3-digit translation is discussed later in 1.129, Three-digit Translation.

1.120 The systems codes will be discarded when the full complement of 4A installations are in service and existing No. 4 and A4A installations are modified for 4A operation. Then the area codes will take on their full significance of designating an entire basic numbering plan area.

Switching Plan

1.121 As has been indicated, the A4A system has some of the 4A features in limited form. These features, which will be described shortly, permitted the immediate introduction of the nationwide numbering plan, (with the addition of the temporary systems codes), and make it possible to realize the important advantages of using a maximum of only 10 or 11 digits to reach any subscriber in the nationwide network.

1.122 However, the A4A system uses the manual toll switching plan with a limited amount of automatic alternate routing. The switching plan used with the 4A system makes full use of the CSP's which permits a considerable increase in the efficiency of the intertoll trunks. This plus the full use of the nationwide numbering plan requires all of the 4A system features, such as 6-digit translation, extended automatic alternate routing, etc. This switching plan is discussed under (F) No. 4A Toll Switching System.

Nationwide Toll Dialing Features - A4A System

1.123 The A4A system includes in limited form some of the 4A features which are useful during the early stages of nationwide operator dialing. The following is a description of these features, with typical calls illustrating them.

Variable Spilling and Code Conversion

1.124 To meet the requirements of nationwide dialing it is necessary on some calls to delete or to change the area or national office code digits keyed by the outward operator before the number is spilled to the next office. This is done by the use of the variable spilling and code conversion features. Either one, or both of these features may be used on a given toll call. In the A4A system they are provided in limited form and are not suitable for the full use of nationwide operator toll dialing. The limitations will become apparent later on in the description of the 4A system.

1.125 With variable spilling all the code digits can be spilled forward, or some of them can be skipped at any 4A or A4A system and the remaining code digits plus the numericals spilled forward. The A4A system can skip three code digits; the 4A can skip three or six. A common example of the use of variable spilling is in the case of a single or multiswitch call, where the last through 4A or A4A switching system receives six code digits, skips the area code (or systems code in A4A), which is no longer required, and spills forward the remaining national office code digits and numericals.

1.126 The code conversion feature makes it possible for an A4A system to convert the 3-digit national office code, which is the one keyed by the toll operator, to any single digit office code desired. The Richmond, Virginia case in Fig. 8 is an example where this type of code conversion is used. When the local telephone number has a 2-digit office code or an unsuitable 3-digit code special operating practices must be followed until the system is converted to 4A.

1.127 There is a limited amount of automatic alternate routing in the A4A system. This limitation is that on a given call not more than four subgroups or a total of 160 outgoing trunks are available. This includes the preferred route trunks and the alternate route trunks. This is not a serious limitation in the A4A system.

Typical Calls

1.128 An important difference between the A4A and the 4A systems, 3-digit versus 6-digit translation, has already been mentioned. Typical calls illustrating 3-digit translation are described below. (Similar types of calls are described in par. 1.152 and following paragraphs to illustrate 6-digit translation.) These calls and others which follow also illustrate automatic alternate routing, variable spilling and code conversion. The calls are described in nationwide numbering plan terms. However, it should be kept in mind that in completing these calls through the A4A system the area codes do not designate an entire basic numbering plan area. They perform the same limited functions as the arbitrary systems codes until the conversion to 4A is made. These typical calls assume A4A installations, although some of the places mentioned actually have No. 4 systems.

1.129 Three-Digit Translation: Figure 9 illustrates the operation of 3-digit translation on two calls from subscriber A in Oakland: one call to subscriber B in the Cleveland toll center area whose number is MAin 2-1234, and the other to subscriber C in Canton, Ohio, whose number is MAin 3-1234. Both calls are routed through Chicago.

1.130 Cleveland and Canton are in the same numbering area. The area code 216 has been assigned to the more important Cleveland toll center and an arbitray systems code, 016, has been assigned to the Canton toll center.

1.131 On the call to subscriber B, the Oakland outward operator keys 216-MA2-1234 into the Oakland A4A system, which translates the 216 to select a trunk to Chicago and then spills forward the whole number. The Chicago A4A translates the 216 to select a trunk to the Cleveland toll center. It spills forward only a portion of the digits, 622-1234, (MA2=622), skipping the Cleveland toll center code. This illustrates the variable spilling feature.

1.132 The Cleveland toll center translates the 622 to select a trunk to local office, MAin 2, and spills forward the 1234 which the local office uses to reach subscriber B.

1.133 On the call to subscriber C, the Oakland operator keys 016-MA3-1234. The Oakland A4A system translates the 016 and again selects a trunk to Chicago, spilling forward 016-623-1234. The Chicago A4A translates the 016 to select a trunk to the Canton toll center, and the call is completed to subscriber C like the Cleveland call described above.

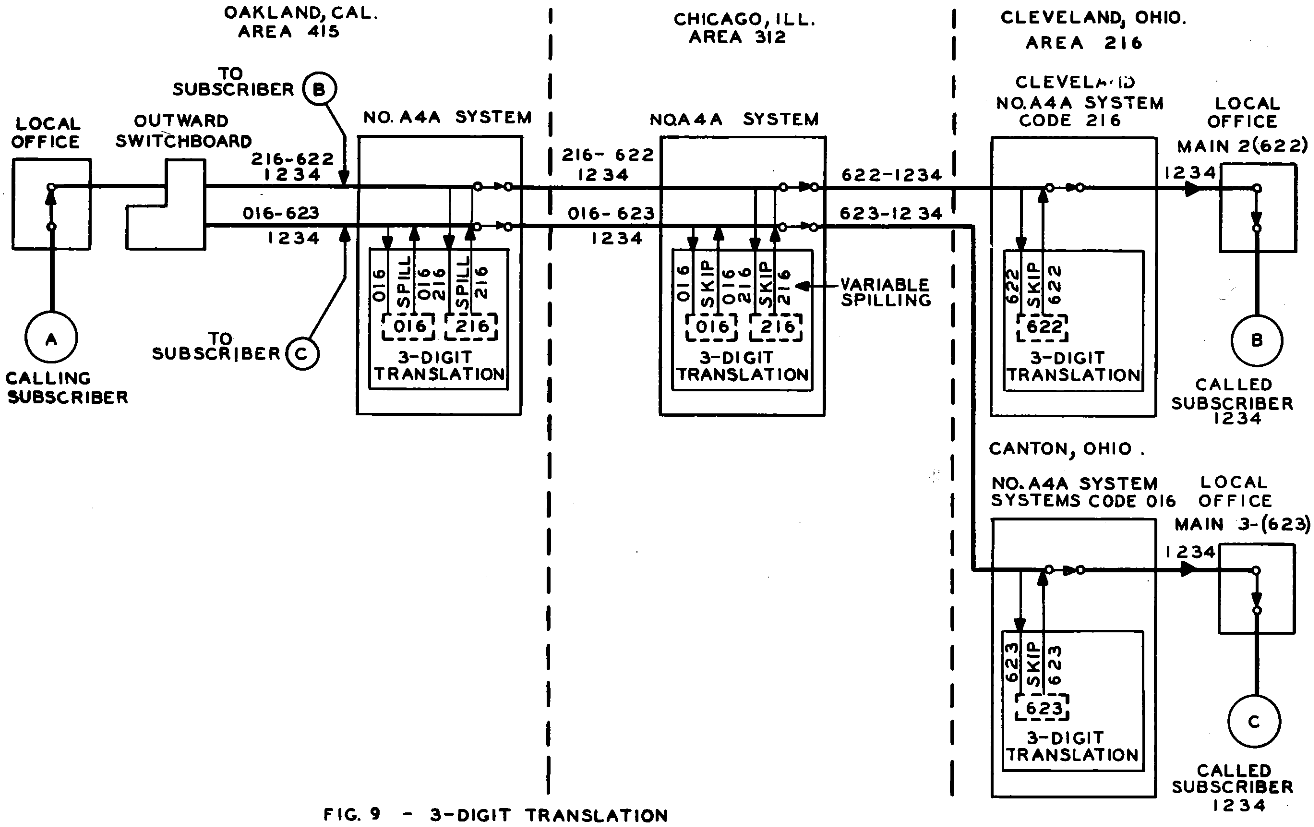


FIG. 9 - 3-DIGIT TRANSLATION
NO. A4A TOLL SWITCHING SYSTEM.

1.134 Automatic Alternate Routing: Figure 10 illustrates the use of the automatic alternate routing feature. Assume that on the typical call from Oakland, California to subscriber B in Cleveland all the trunks to Chicago are busy. In this case the Oakland A4A system may automatically select an alternate route through St. Louis. The St. Louis A4A system receives all the digits, 216-622-1234, from Oakland and translates 216 to select a trunk to Cleveland. St. Louis then uses the variable spilling feature and spills 622-1234 to Cleveland where the call is completed to subscriber B. This alternate routing does not require any action by the outward operator.

1.135 Code Conversion: Figure 11 shows how the code conversion feature works on a call from subscriber A in Chicago to subscriber B in Troy, New York. For the purposes of this illustration assume that Troy is a step-by-step area and that local calls in this area are completed by dialing five digits. Subscriber B's local telephone number is 2-1234, but for his national telephone number this is changed to TRoy 2-1234, (872-1234). The Chicago outward operator prefixes the Albany systems code 518, (which happens to be the area code too), and keys 518-872-1234. The Chicago A4A system translates 518 to select a trunk to Albany. The Albany A4A converts the 872 to a 2, selects a trunk to the Troy intertoll step-by-step switching train and spills 2-1234. The intertoll train uses the 2 to reach the local office switches which complete the call to subscriber B.

(F) No. 4A Toll Switching System

1.136 The two most important differences between the 4A and the A4A systems are the ability of the 4A system to translate six digits, and the expansion of the automatic alternate routing feature in this system.

1.137 Six-digit translation makes it possible to translate the combination of the area code and the national office code. This permits the 4A system to make a choice of more than one trunk route to a given basic numbering plan area, without requiring arbitrary systems codes for all but one of the routes. As indicated in pars. 1.128 to 1.133, with 3-digit translation, each trunk route to a given numbering plan area must have a different code.

1.138 The expanded automatic alternate routing feature makes it possible for the 4A system to automatically check the preferred route and as many as five

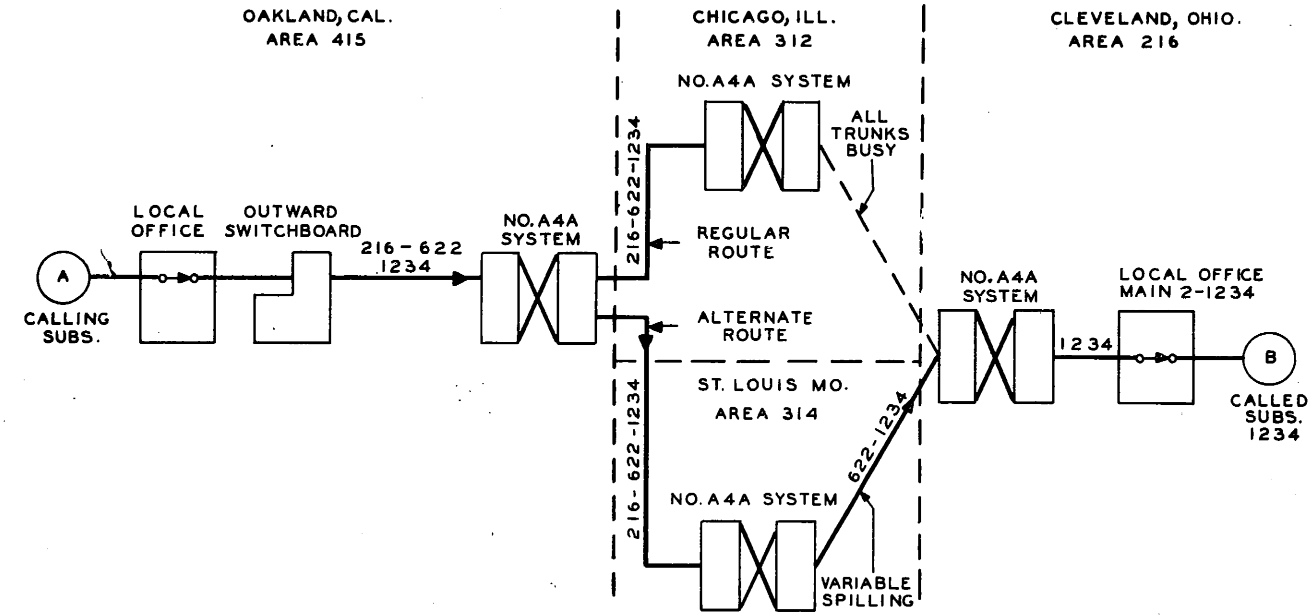


FIG. 10 - AUTOMATIC ALTERNATE ROUTING
NO. A4A TOLL SWITCHING SYSTEM.

alternate routes in rapid succession in setting up a connection.

1.139 These features are essential for the ultimate nationwide customer toll dialing plan, and without them extensive use of operator toll dialing would be impractical.

Six-Digit Translation - Card Translators

1.140 Six-digit translation is accomplished by a device called a card translator. Because the card translators used in making 6-digit translation are a very important part of the 4A system, a brief description of them is included here. They are described in more detail in Part 3.

1.141 A given No. 4A system in one basic numbering plan area may have direct trunks to two or more toll centers located in another basic numbering plan area. On a call to this numbering plan area the only routing information the No. 4A system receives is the area code, and the national office code and numericals. It does not receive any direct information as to the particular toll center in the area which serves the local office of the called customer. In order to switch the call to that particular toll center, the 4A system must be able to do its translation from a combination of the 3-digit area code and the 3-digit national office code. (This is 6-digit translation.) The area code determines the basic numbering plan area, and the combination of this code plus the

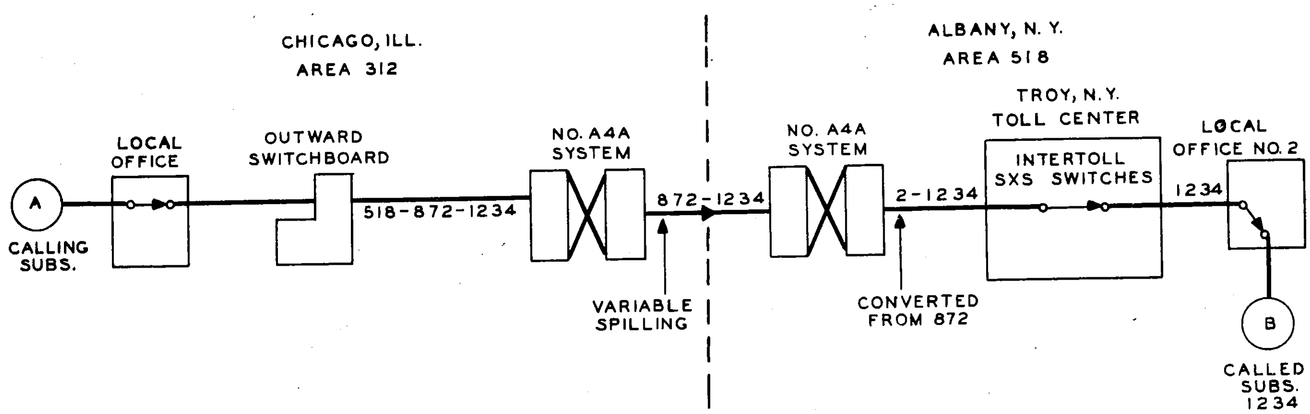


FIG. 11 - CODE CONVERSION
NO. A4A TOLL SWITCHING SYSTEM.

national office code tells which of the trunk groups to that area must be used to reach the toll center and local office which serve the called customer.

1.142 The card translator, which translates the six digits, is an electromagnetic device and uses metal cards, vacuum tubes, phototransistors and transistor amplifiers instead of relays, which are used in other types of translators.

1.143 Every 4A installation has three or more card translators. Each translator has a capacity for one thousand and twenty metal cards. (This capacity will probably be increased.) These cards contain the routing information for all the calls going through a 4A system. Each card contains the routing information which is used for switching a specific call from a 4A system to another toll switching center or to the local office where it terminates.

1.144 Each card is mechanically coded to correspond to one particular area code, to a particular national office code, or to an area code plus a national office code. This coding is done by using different combinations of small metal tabs on the bottom of the metal cards. These tabs are used to select, or "drop" a card into the position where its routing information can be read.

1.145 When a given 4A system receives a call, it determines from the area code or from a combination of the area code and the national office code, the corresponding card which has the routing information for that call. It then selects and drops this card.

1.146 All of the card blanks from which the working cards are made have 118 holes. The routing information for a working card is added to the blanks by enlarging some of these holes. That is, the routing information for switching a specific call is incorporated on a given card by enlarging certain of the holes in a definite pattern. This pattern is deciphered in the following manner:

1.147 When the translator cards are in the rack, awaiting a call, the 118 holes are all lined up to form tunnels through the cards. A light source on one side of the stack of cards shines through these tunnels and hits a group of phototransistors on the other side, lined up one in front of each tunnel. Nothing happens, however because the associated transistor amplifiers are inactive.

1.148 When a call comes in, the proper card drops about three-sixteenths of an inch. This closes all of the light tunnels except the ones corresponding to the enlarged holes in the dropped card. At the same time the transistor amplifiers are activated and those opposite the open light tunnels are energized. The resulting amplified signals are used by the 4A system to switch the call. This process is described in more detail in Part 3.

1.149 The card translator has many advantages over the conventional relay type of translator used in the No. 4 and No. A4A systems. Changes in routing information are made by simply replacing cards with the old information with cards having the changed routing information. New routings are added by inserting new cards. This eliminates the job of adding or changing numerous cross connections which is necessary with conventional relay translators.

Typical Calls

1.150 In paragraph 1.129 and following paragraphs, two typical calls are described, both to subscribers in the same numbering plan area but served by different toll centers. This is an example of 3-digit translation, which requires arbitrary systems codes for all but one toll center, in those cases where there is more than one toll center in a basic numbering plan area.

1.151 Figure 12 shows how these same calls would be completed in the 4A system with 6-digit translation which eliminates the necessity for arbitrary systems codes.

1.152 The Oakland operator keys the area code, 216, followed by the appropriate national office code and numericals, to reach <u>either</u> subscriber B or C. The arbitrary systems code 016 is not required, the area code 216 now having its full significance of meaning an entire basic numbering plan area.

1.153 On the call to subscriber B, in Cleveland, Ohio, the Oakland toll operator keys 216-MA2-1234. The Oakland toll office translates the first three digits to select a trunk to Chicago and spills forward 216-622-1234.

1.154 The Chicago 4A toll office has two trunk groups to the 216 area, (one to Cleveland and one to Canton), and must determine which one shall be used on this call.

1.155 This is done with 6-digit translation as follows: The area code, 216, indicates that one of the trunk groups to the 216 area must be selected. The national office code MA2 (622) determines that this is the trunk group to Cleveland, since the MAin 2 office is in Cleveland. In this way the Chicago toll office translates the combination of the area code and the national office code to select the trunk group to the Cleveland toll center.

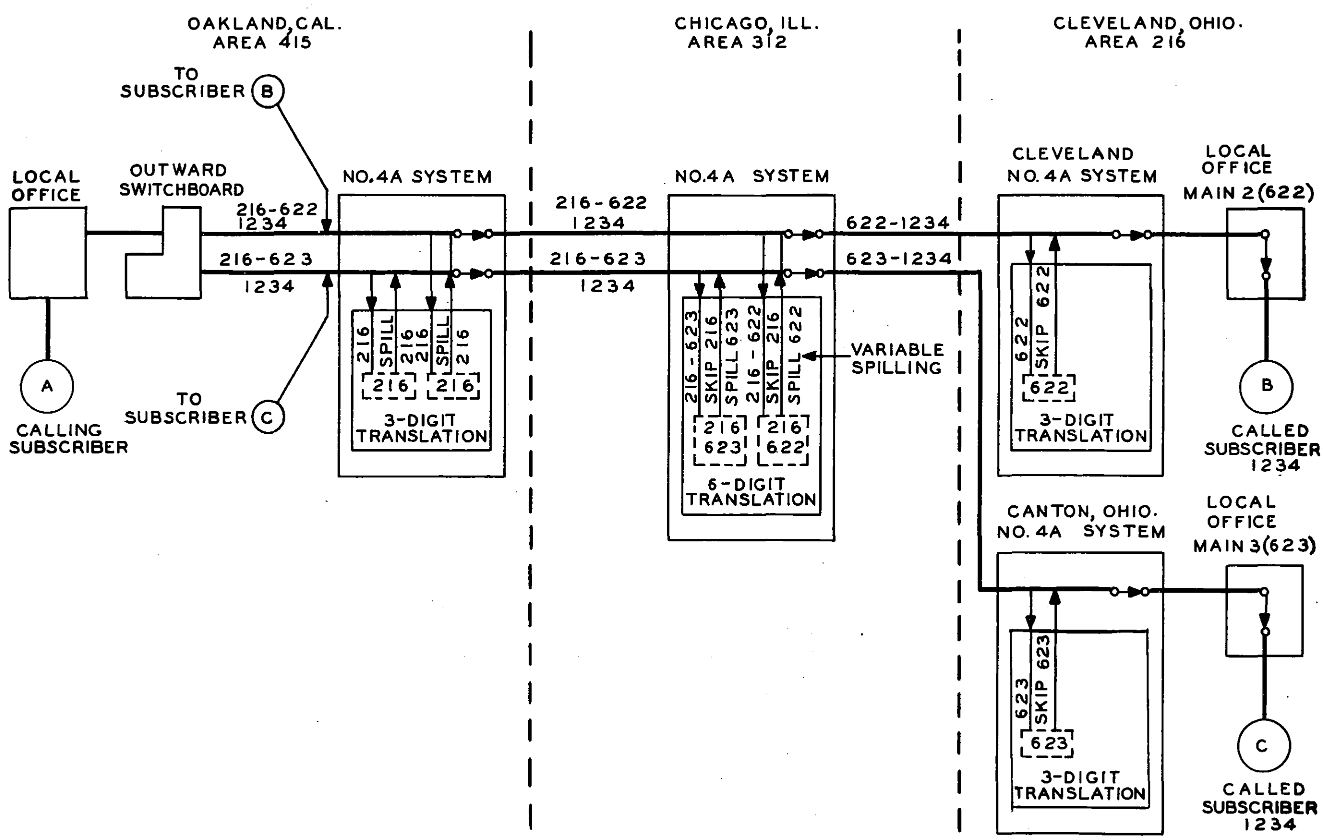


FIG. 12 - 6-DIGIT TRANSLATION
NO. 4A TOLL SWITCHING SYSTEM.

1.156 The Chicago toll center spills forward 622-1234, skipping the area code. The area code is skipped when the call is on a trunk which terminates in the called numbering area. This again illustrates the variable spilling feature. The Cleveland toll center receives 622-1234 and completes the call to subscriber B.

1.157 On the call to Subscriber C in Canton, whose number is MAin 3-1234, the Oakland toll operator keys 216-623-1234. When the call arrives in Chicago the 4A system again translates the first six digits and this time selects a trunk to Canton, because the office with national office code MAin 3, (623), is in Canton. The call is then terminated in the same manner as in the previous examples.

Variable Spilling and Code Conversion

1.158 Along with 6-digit translation and the expansion of automatic alternate routing, more comprehensive variable spilling and code conversion features are provided.

1.159 The 4A system has the ability to skip three or six digits and spill the remainder of the number forward. In addition, one, two or three code digits can be prefixed as required before spilling.

1.160 This prefixing feature can be used, for example, on a connection between subscribers in the same basic numbering plan area but where the call is routed through a neighboring area. (The call is routed through a neighboring numbering plan area because there are no trunks from the toll office in the home numbering area to the called office, but there are trunks from the neighboring area to the called office.) On such a connection the outward operator does not key an area code. However, because the call is routed through a neighboring basic numbering plan area, the equipment automatically prefixes an area code (the home area code), and this directs the call through the neighboring area. A typical call illustrating this kind of operation is described in Part 4, Method of Operation on Typical Calls.

1.161 The code conversion feature is expanded so that the national office code can be changed to any desired three, two or one digits, or can be dropped entirely. Examples of such conversions are shown in Fig. 8.

1.162 In the 4A system this feature can be used to convert the 3-digit area code to any other three digits, or to any two or one digit. This could be used, for example to route a call through a step-by-step toll center.

1.163 With these new and broader features, full use is made of the national numbering plan, and outward operators can dial the subscriber's national telephone number on the majority of calls. The result is that in many cases such calls can be completed by using information received from the subscriber without referring to a large routing bulletin or to a routing operator.

Switching Plan

1.164 The switching plan used in nationwide dialing employs a new system of routing toll calls in which intertoll trunks (the various types of intertoll trunks are discussed in Part 3) are utilized at very high efficiency and yet the chance of a call being delayed on account of finding all trunks busy is small. This is made possible by an alternate routing plan in which, on a given call, a preferred route and as many as six predetermined alternate routes can be tried in rapid succession. In this way, the call can be advanced toward its destination over any one of several routes in which an idle trunk is available.

1.165 The intertoll trunks are used at high efficiency because most of the trunk groups are engineered to carry only a part of the traffic load offered during peak, or near peak periods, the balance being overflowed successively to other groups, where it is combined with similar overloads from other sources. These are the "high usage" trunk groups and they are the preferred routes. The small percentage of calls not disposed of on these trunk routes are overflowed to a "final" group where they are almost certain to find an idle path available. These final groups of trunks are engineered on a liberal basis, that is, enough trunks are provided to make the probability small that any call will encounter an all trunks busy condition. The effect is to keep all the trunks in the network busy most of the time, while at the same time keeping the percentage of calls encountering all trunks busy at a minimum.

1.166 The traffic is distributed over these high usage and final trunk groups at the Control Switching Points. As indicated in par. 1.118, these CSP's are the most important traffic centers and they include the NC, all of the RC's and SC's, and some of the PO's. These centers require all of the features of the 4A system to do their switching jobs and therefore ultimately each will have a No. 4A installation.

1.167 All ordinary toll centers, (that is, other than CSP's), are limited to single switch calls and they may have step-by-step, or common control dial equipment.

1.168 Figure 13 is a schematic of the fundamental toll network showing the various classes of toll offices and the high usage and final trunk routes interconnecting them.

1.169 Each TC has a final group of trunks to one particular CSP. This is its "home" CSP and it may be a PO, SC, RC or the NC. In a similar manner, there is a final group from each PO to its home SC, or RC; from each SC to its home RC; and from each RC to the NC. In addition, there are final groups between RC's in the nationwide toll network where traffic justifies it. These final groups of trunks are the final routes, and they comprise the backbone network of paths from any one toll center to any other toll center.

1.170 In addition to this backbone network of final trunk routes, high usage trunk groups are provided between any two points, regardless of their categories, (that is, whether PO, SC, etc.), where the traffic justifies it. The number of high usage groups greatly exceeds the number of final groups.

1.171 The following discussion describes the possible routes which a call may take in going from a PO (A), to a TC (B). (See Fig. 13.) This figure shows seven switches, (PO-SC-RC-NC-RC-SC-PO), which is the maximum number required to switch a call between any two points in the nationwide network. Actually, a very minute percentage of calls will involve as many as seven switches, and a very small percentage as many as five.

1.172 In a great many cases not all of the high usage groups shown in the figure will be available because of insufficient traffic to justify a group.

1.173 It will be noted from the following discussion, that a call is continuously passed from one CSP to the next in the chain in its search for an idle trunk.

1.174 In the first switch, through home PO (A), there are five high usage trunk groups which can be used to get to TC (B). These are a, b, c, d, and e and they are tested in this order. (A high usage group could also be provided to NC but this is rarely used.) If no idle trunk is found in these groups, the call is switched over the final group of trunks, f, to the home SC. Here there are four high usage trunk groups available. These are tested as follows: Home SC to TC (B), and then in order to distant PO, distant SC and distant RC. If these are all busy,

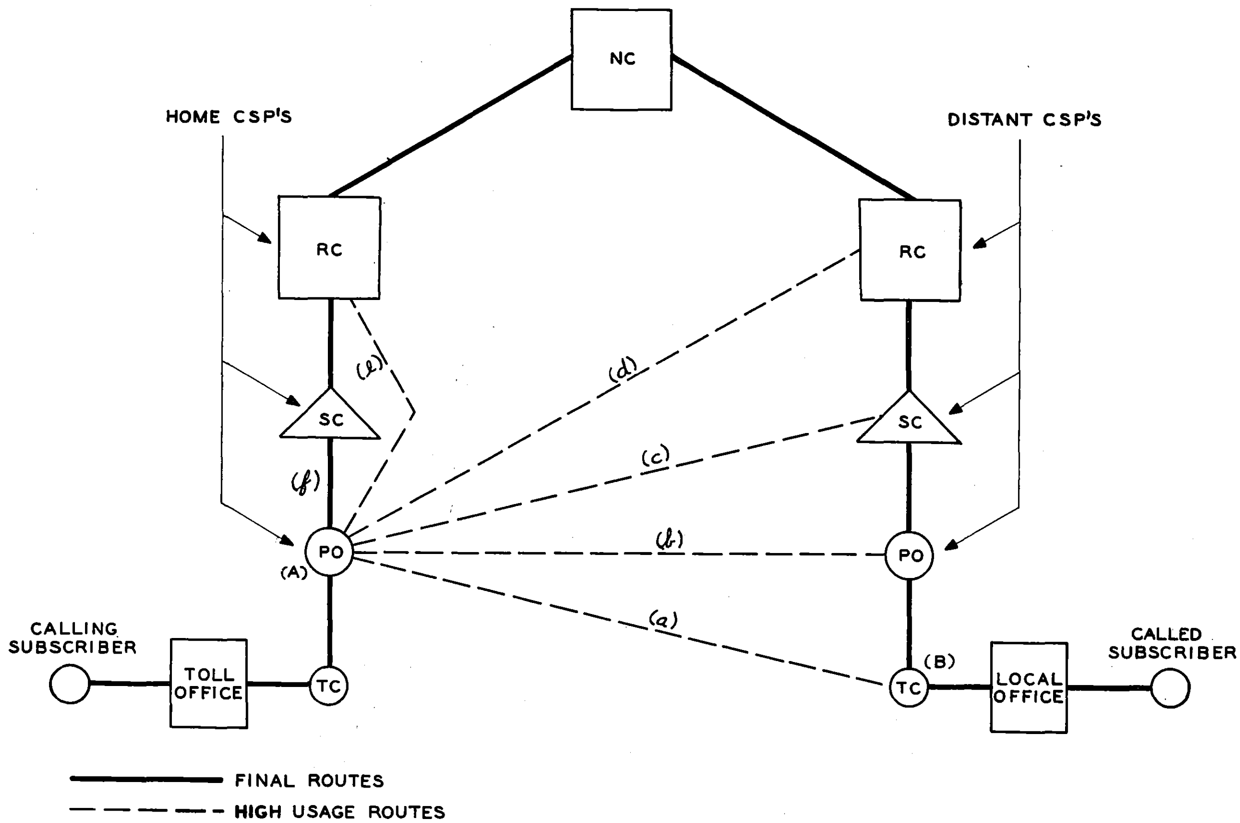


FIG. 13 - FUNDAMENTAL TOLL NETWORK

the call is switched over the final group of trunks to the home RC. Here there are three high usage trunk routes available. The call progresses in this manner until it gets to the final route between the distant PO and TC (B), which is the last one available. In this rather unlikely case, the call would be advanced to its destination, TC (B), entirely by final trunk groups. As indicated in this example, the order of rotation in testing the trunk groups is from far to near. That is, the first route tested is direct to the distant TC serving the called local office. Testing then proceeds in order to the distant PO, SC and RC, and finally to the home or near RC.

1.175 The whole operation of checking the available routes is performed in a small fraction of a second.

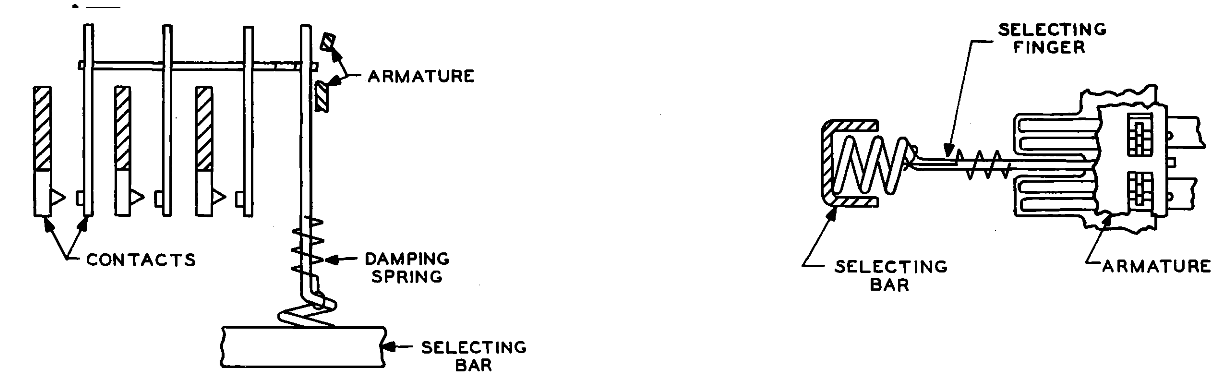
Vacant Code Routing

1.176 Since the 4A systems are scattered all over the nation, the information on changed or added national office codes will not reach all CSP's at once. Even if they did, it is not practicable to make changes in all CSP's at exactly the same time. Therefore, a CSP in one area may have a call to an office in another basic numbering plan area which looks like a vacant code because the national office code of that office was recently changed and this information was not yet recorded.

1.177 In order to handle such calls, a "principal city" CSP is assigned to each basic numbering plan area. National office code changes or additions affecting offices in any numbering plan area are recorded immediately in the principal city CSP for that area.

1.178 All calls to vacant codes are routed to the principal city CSP's. This includes calls to actual vacant codes, (unassigned), as well as those that just look like vacant codes. Codes that look like vacant codes but which are actually assigned are completed by the principal city CSP. On the others the principal city returns reorder tone.

1.179 As has been indicated, ultimately it is expected that customers will dial toll calls the same as they now dial local calls. The 4A system, being on a destination basis, anticipates this because it does not care whether the call is dialed by an operator or by the customer.



HOLD AND SELECT MAGNETS NORMAL

HOLD AND SELECT MAGNETS OPERATED
(LOWER CROSS POINT OF A PAIR OPERATED)

HOLD MAGNET OPERATED, SELECT MAGNET NORMAL
(LOWER CROSS POINT NORMAL, ARMATURE OPERATED)

FIG. 15-CROSSBAR SWITCH SELECTING MECHANISM

2. SWITCHING PRINCIPLES

(A) General

2.01 The function of the 4A system is to switch toll calls received on incoming trunks (incoming traffic) to various kinds of outgoing trunks (outgoing traffic). Incoming traffic is received from outward operators at local and toll switchboards and from other toll centers. Outgoing traffic either goes to another toll office or it is terminated in local offices served by the 4A toll office.

2.02 The switching principles used for handling this traffic are discussed here without taking into account specific trunking arrangements; these are covered in Part 3.

2.03 The 4A system is a crossbar system and therefore its basic element is a crossbar switch. A description of the switch is given in this part because an understanding of its operation is essential to an understanding of the system as a whole.

(B) The Crossbar Switch

2.04 The crossbar switch is an electrically operated relay mechanism consisting of ten horizontal paths and ten or twenty vertical paths. Any horizontal path can be connected to any vertical path by the operation of magnets. The points of connection are known as crosspoints. The switch with ten vertical paths has 100 crosspoints and is called a 100-point switch; the one with twenty vertical paths has 200 crosspoints and is called a 200-point switch. Figure 14, attached, shows a partial perspective view of a crossbar switch.

2.05 Horizontal Paths: There are five selecting bars mounted horizontally across the face of each switch. These bars can be partially rotated either up or down, under control of select magnets, thus forming two horizontal paths per bar, making a total of ten horizontal paths.

2.06 Each selecting bar has flexible selecting fingers attached to it, one finger for each vertical path.

2.07 Vertical Paths: Ten or twenty vertical units are mounted on the switch and each unit forms one vertical path. Each unit operates under control of a hold magnet and has ten groups of contacts (one for each horizontal path) associated with it.

2.08 Each group of contacts may consist of three to six pairs of contact springs. A switch is classified according to the number of crosspoints and pairs of springs - for example, a 200-point 5-wire crossbar switch.

2.09 Operation of the Crossbar Switch: The normal position of the selecting fingers is horizontal, lying between two groups of contacts. When a select magnet operates, the selecting bar is partially rotated either up or down and one of the horizontal paths available to this bar is chosen. The selecting fingers now lie in front of a group of contacts.

2.10 The hold magnet of the vertical path to be connected to this horizontal path then operates its holding bar which, using the selecting finger as a wedge, causes the group of contacts beside the selecting finger to operate, thus connecting the horizontal and vertical paths. Both the select and hold magnets must be operated in order to close a crosspoint. The other groups of contacts on this vertical unit do not operate since there is no selecting finger between them and the holding bar. Figure 15, shows the action of the selecting mechanism.

2.11 After the operation of the hold magnet the select magnet releases, returning the horizontal bar to normal. However, the finger used to establish the connection, being flexible, remains wedged against the contacts by the holding bar and in this way keeps the contacts operated. When the hold magnet releases, the connection is released and the selecting finger returns to normal.

2.12 Split Switches: A crossbar switch usually has each horizontal path strapped on the wiring side, thus making ten horizontal paths as shown on Fig. 16.

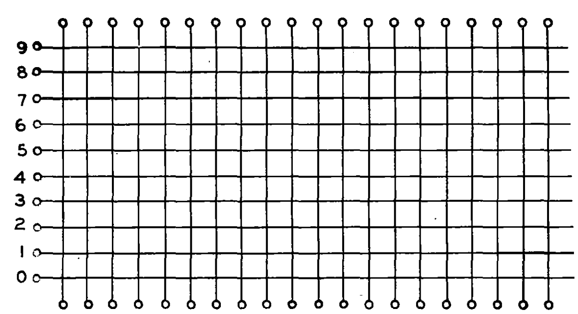


FIG. 16 - SCHEMATIC OF CROSSBAR SWITCH (10 HORIZONTAL PATHS)

2.13 In a split switch this horizontal strapping is cut in order to provide more than ten horizontal paths. For example, as shown on Fig. 17, a switch can be split between the tenth and eleventh verticals; this provides ten more horizontal paths on the switch.

2.14 Figure 18, attached, is a photograph of the apparatus sides of a 100-point and a 200-point switch.

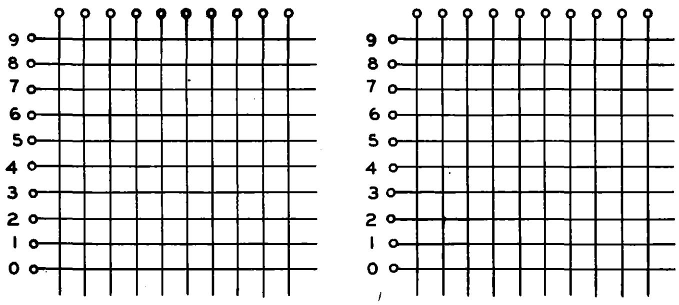


FIG. 17 – SCHEMATIC OF CROSSBAR SWITCH (20 HORIZONTAL PATHS)

(C) Switching Frames

General

2.15 As has been pointed out, the function of a 4A office is to switch toll calls coming into the office on incoming trunks, to outgoing trunks to other offices. The connections in the talking paths of these calls are established through crossbar switches located on two kinds of switching frames: incoming frames and outgoing frames. As the names indicate, the incoming trunks are located on crossbar switches on incoming frames and the outgoing trunks on crossbar switches on outgoing frames. Most offices have an equal number of incoming and outgoing frames, but in some offices certain conditions may upset this balance and result in an unequal number.

2.16 Figure 19 is a simple diagram of the talking path or "channel" between an incoming trunk and an outgoing trunk. Referring to this figure, the incoming trunks bring the toll calls to the incoming frame primary switches. The calls are extended from here to the incoming secondary switches over "incoming links" and from these to the outgoing frame primary switches over "junctors". The "outgoing links" then extend the calls to the outgoing secondary switches on which the outgoing trunks are terminated. In this manner these groups of paths, or "channels", make every outgoing trunk in an office accessible to each incoming trunk on each incoming frame in the office.

2.17 This method of connecting incoming trunks to outgoing trunks is one of the main advantages of all crossbar systems. It makes these systems desirable for use in small offices as well as in the largest, and greatly reduces the extent of changes required when an office grows.

Incoming Frames

2.18 Each incoming frame is made up of primary switches and secondary switches.

2.19 For simplicity the following discussion is confined to an installation with provision for 200 trunks per incoming frame. Later on under Method of Increasing Frame Capacity there is an explanation as to how 300 trunks per incoming frame are provided.

2.20 There are thirty 200-point crossbar switches on each frame. Twenty of these are primary switches and are mounted in pairs on two primary bays, ten switches in each bay. The other ten are secondary switches and are mounted on one secondary bay.

2.21 The corresponding verticals of each of the ten pairs of primary switches are multipled so that each pair of switches

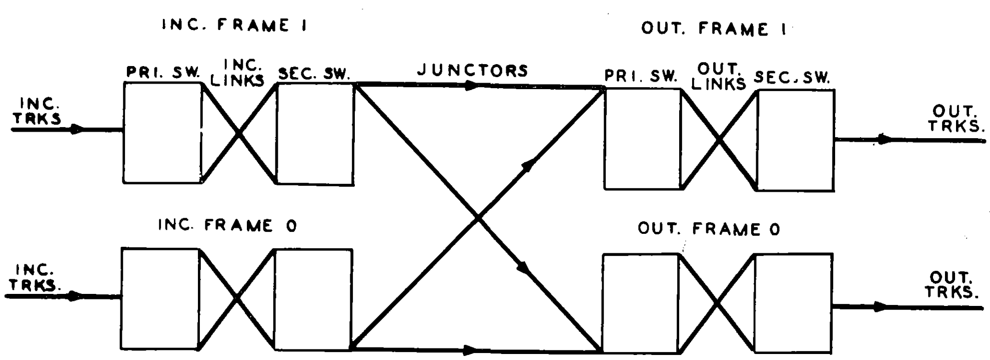


FIG. 19 - PATH OF CALL THROUGH INC. AND OUT. FRAMES

has twenty verticals and twenty horizontals. (See Fig. 20A, attached.) The incoming trunks are terminated on the horizontals of these ten pairs of switches and therefore up to 200 incoming trunks can be located on one frame. A group of trunks coming in from a given office is spread over as many incoming frames as feasible. Therefore the 200 trunks on each incoming frame consist of trunks from several offices.

2.22 The 200 pairs of verticals are connected to the horizontals of the secondary switches by means of 200 incoming links. Since in the case under discussion there are only ten secondary switches for the 200 links, the switches are split in half thus providing 20 horizontals on each switch.

2.23 These 200 incoming links from the verticals of the ten pairs of primary switches are distributed over the horizontals of the ten split secondary switches in a fixed pattern, two links to each switch. Thus the links are arranged in a vertical-horizontal spread. (See Fig. 20A.)

2.24 The verticals on the primary switches, as well as those on the secondary switches, are designated left and right, (0L to 9L and 0R to 9R). The verticals of the primary left half switches terminate on the horizontals of the secondary left half switches. Similarly, the verticals of the primary right half switches terminate on the horizontals of the secondary right half switches. The number of the primary vertical where the link originates is the same as the number of the secondary switch on which the link terminates, and the primary switch number is the same as the secondary horizontal number. For example, a link on primary switch 8, left vertical 6 terminates on secondary switch 6, left horizontal 8.

2.25 The incoming ends of 200 junctors are connected to the 200 verticals of the incoming secondary switches. (The outgoing ends connect to primary switches on outgoing frames as is described shortly.) The vertical-horizontal spread of the incoming links makes every one of these 200 junctors available to each of the 200 incoming trunks.

2.26 As a matter of interest, the primary and secondary switches with their interconnecting links on each incoming frame could be replaced by one large crossbar switch with 200 horizontals and 200 verticals. Then each incoming trunk would have access to all of the 200 junctors the same as with the link arrangement, and theoretically there could be 200 simultaneous connections. However, such a switch would be difficult to build and would be prohibitive in cost and maintenance. Furthermore, it would not be suitable for doing the many jobs in other parts of the telephone system which single small switches, or groups of the small switches can do. The links make it possible to get the same results using these small, relatively inexpensive switches.

Outgoing Frames

2.27 The outgoing frame, like the incoming frame, is made up of primary and secondary switches. The incoming toll calls from the incoming frames are carried to the outgoing frames on junctors which interconnect the incoming frame secondary switches and the outgoing frame primary switches. They are extended to the secondary switches, on which the outgoing trunks are located, over outgoing links. Outgoing links perform the same type of function as the incoming links; they give each toll call coming into a frame over a junctor access to every outgoing trunk on the frame.

2.28 The number and arrangement of the crossbar switches is the same as that on the incoming frame with one exception: there are ten primary switches and ten pairs of secondary switches which is just the reverse of the arrangement on the incoming frame. The link pattern (Fig. 20B, attached) is also the same except for the reversed position of the primary and secondary switches. The similarity is apparent in Figs. 20A and 20B.

2.29 The same kind of rule for tracing link connections applies here as it does on the incoming links: the number of the primary horizontal where the link originates is the same as the number of the secondary switch on which the link terminates, and the primary switch number is the same as the secondary vertical number. For example, a link on primary switch 8, left horizontal 6, terminates on secondary switch 6, left vertical 8.

2.30 Up to 200 outgoing trunks are terminated on the horizontals of the secondary switches. The outgoing trunks on one frame can connect to many different offices. As in the case of incoming trunks, the trunks to each office are spread over as many outgoing frames as feasible. The reason for this is brought out in the story on Control of Switching Functions.

Method of Increasing Frame Capacity

2.31 Under Incoming Frames, only the arrangement for 200 incoming trunks is described, to simplify the explanation of the switching principles. The two bays of primary switches, mentioned in paragraph 2.20, on which these 200 trunks are terminated, are called the primary bay and primary extension bay. These two bays are always provided. Where it is desired to increase the capacity to 300 incoming trunks, a third bay called a supplementary extension bay, may be furnished. The like verticals of all three bays are then multipled. The number of links and junctors remains the same.

2.32 Similarly, under Outgoing Frames, only the arrangement for 200 outgoing trunks was described, and for the same reason. Two secondary bays, the secondary and secondary extension bays, are always provided. A supplementary extension bay may be furnished where it is desired to increase the capacity to 300 outgoing trunks. As in the similar case of the incoming frame, like verticals of all three bays are multipled.

(D) Junctors

2.33 As we have seen, links provide the traffic paths between the primary and secondary switches of individual incoming and outgoing frames. Junctors, on the other hand, provide the traffic paths from the secondary switches of each incoming frame to the primary switches of every outgoing frame in an office.

2.34 Links are permanently connected in a fixed pattern which is the same for every frame on every job regardless of the size of an office. As contrasted to this, there are different junctor patterns for different sizes of offices. By pattern is meant the junctor distribution plan, that is, the incoming and outgoing frame terminations of each junctor, without regard to whether the junctor is run directly or through a distributing frame.

Junctor Patterns - General

2.35 In order to understand junctor patterns, it is necessary to have a picture of some of the traffic problems involved in connecting incoming toll calls to outgoing trunks.

2.36 Incoming trunks are assigned to the incoming frames in such a manner that each frame handles about the same amount of traffic. This traffic (from each frame) spreads equally over all the outgoing frames. Therefore the junctors from each incoming frame are divided into as many groups as there are outgoing frames. Each of these groups has the same number of junctors. (There are a few minor exceptions in which some groups may have one more than others. The reason for this is given later in this part under Intertoll or Combined Train).

2.37 A junctor joins a vertical of an incoming frame secondary switch to a vertical of an outgoing frame primary switch. There are 20 verticals on each of the ten incoming frame secondary switches and a like number on the ten outgoing frame primary switches. Therefore, there is space for connecting a maximum of 200 junctors on each of these frames.

2.38 Since each incoming frame has room for not more than 200 junctors and there is a group of junctors to each outgoing frame, it follows that the more outgoing frames there are the smaller each group will be. (However, there is a minimum number that can be provided in a group in order that the group does not become so small as to be inefficient.)

2.39 When an office grows, junctors have to be provided from each incoming frame to all of the new outgoing frames. In order to make room for the added trunks and still preserve the arrangement whereby the incoming trunks from each office are spread over several incoming frames, and the outgoing trunks to each office are spread over several outgoing frames, (see paragraphs 2.21 and 2.30), some of the existing trunks have to be reassigned. The result is that each incoming frame ends up with the same number of trunks, the same total number of junctors and the same amount of traffic. However, the traffic from any one incoming frame is now spread over more outgoing frames. Therefore the number of junctors to each outgoing frame can be reduced without impairing service.

2.40 Because the number of junctor groups from each incoming frame is always equal to the number of outgoing frames, it is obvious that there will be different junctor patterns for different sizes of offices. If an office did not grow, then junctors could all be cabled directly and would be fixed (for each size office) like links. However, offices do grow and therefore provision must be made for changing the number of junctor groups, which, of course, also changes the sizes of the groups.

2.41 Certain junctors are not affected by the growth of an office and these can be permanently connected from the incoming frames to the outgoing frames. The number that can be connected in this manner depends on the number of frames provided in an office. The larger the installation, the greater the number of junctors that can be connected directly. The remaining incoming and outgoing frame verticals are cabled to a junctor grouping frame. Here the proper number are cross-connected to provide the additional number of junctors required for the particular size of office involved.

2.42 The permanently connected junctors are in a symmetrical, easily recognized pattern. This is illustrated in Table A, which shows an intertoll or combined train office which has reached its ultimate size of 10 incoming frames and

10 outgoing frames and therefore all junctors are permanently connected.

TABLE A
Junctor Distribution
Intertoll or Combined Train Office
10 Incoming Frames and 10 Outgoing Frames (Ultimate Size Office) (All Junctors from Incoming Frame 0 to Outgoing Frames 0 to 9 are shown.)

No. of Juncts.	Inc. Fr.	Out. Vert.	Out. Fr.	Inc. Vert.	Inc. Fr. Sec. Sw.	Out. Fr. Pri. Sw.
20	0	0	0	0	(OL-9L (OR-9R	OL-9L OR-9R
20	0	0	1	1	"	"
20	0	0	2	2	"	"
20	0	0	3	3	"	"
20	0	0	4	4	"	"
20	0	0	5	5	"	"
20	0	0	6	6	"	"
20	0	0	7	7	"	"
20	0	0	8	8	"	"
20	0	0	9	9	"	"

It can be seen from Table A that the junctors are in a symmetrical pattern in which:

(a) Incoming frame number is the same as the number of the vertical on the outgoing frame primary switch. (Inc. Fr. No. = Out. Vert. No.)

(b) Outgoing frame number is the same as the number of the vertical on the incoming frame primary switch. (Out. Fr. No. = Inc. Vert. No.)

(c) Incoming frame secondary switch number is the same as the number of the outgoing frame primary switch number. (Inc. Fr. Sec. Sw. No. = Out. Fr. Pri. Sw. No.)

2.43 The cross-connected junctors do not fit into this symmetrical pattern. Their arrangement is arbitrarily set for each size of office. Because some of the cross-connections may be changed each time an office grows, these arrangements are designed for one purpose and that is to minimize the amount of work required to go from one size office to another. Table C, (shown later, under Intertoll or Combined Train), illustrates this difference between the permanently connected junctors and the cross-connected ones.

2.44 When the first addition to an office is made, some existing cross-connections are rearranged and some new ones are added. Also the cable leads from certain verticals of the existing and added incoming and outgoing frames are tied together at the grouping frame to form additional permanently connected junctors. These junctors then become part of the symmetrical pattern.

2.45 On the next addition, more cross-connections are replaced and shifted in this manner and thus more junctors join the symmetrical pattern.

2.46 When the ultimate size of an office is reached, all junctors are permanently connected in a symmetrical pattern.

Switching Trains

2.47 There are two types of traffic handled in a toll office - intertoll and toll completing. As shown in Fig. 21, intertoll traffic is traffic from one toll office to another toll office and toll completing traffic is traffic from a toll office to a local office. There are two types of "switching trains" corresponding to these two types of traffic. (A switching train is a group of incoming and outgoing frames interconnected by junctors.) In some offices intertoll traffic is carried on "intertoll trains" and toll completing traffic on "toll completing trains". An office with this arrangement is a "separate train" office. In other "combined train" offices, both types of traffic are carried on a "combined train" as shown in Fig. 22.

2.48 As stated earlier, there is a minimum size of junctor group to preserve group efficiency. Actually there are two minimum sizes, one for intertoll or combined trains and one for toll completing trains.

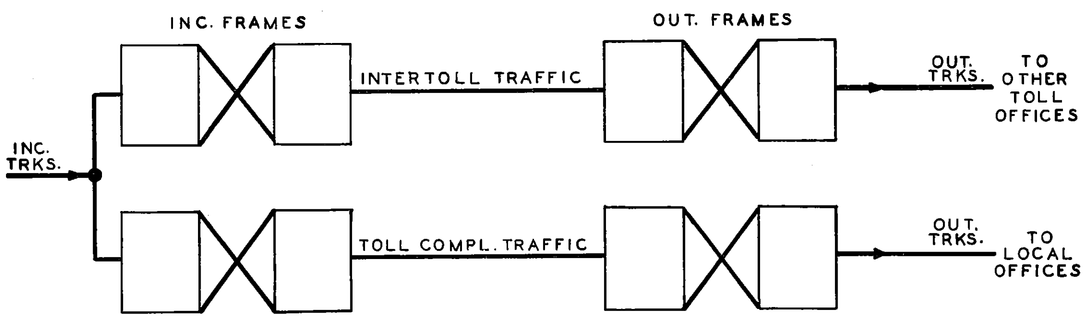


FIG. 21 - SEPARATE TRAIN OFFICE

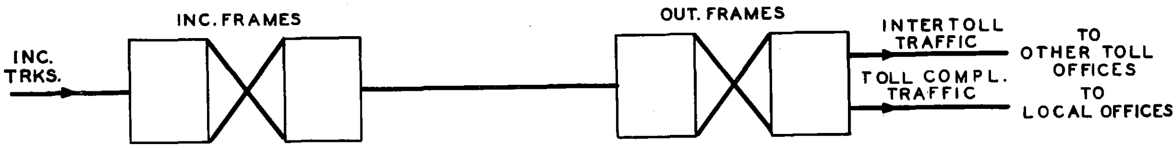


FIG. 22 - COMBINED TRAIN OFFICE

2.49 The minimum number of junctors in a group is 20 for intertoll or combined trains and 10 for toll completing trains. Because of these different minimums, there is a different set of junctor patterns for each of the two types of trains, even though they may have the same number of frames. For example, an office with 10 incoming and 10 outgoing frames in an intertoll or combined train has a different pattern from that of the same number of frames in a toll completing train.

2.50 The reasons for the different minimums for the two types of trains are explained under (E) Control of Switching Functions.

Intertoll or Combined Train

2.51 The minimum number of junctors in a group is 20 for the intertoll or combined train. Table B shows the number of junctor groups and junctors from each incoming frame for offices with different numbers of outgoing frames up to an ultimate size of 10 incoming and 10 outgoing frames. An even number of incoming frames and an even number of outgoing frames are always provided. Generally there are the same number of incoming and outgoing frames. In Table B the number of incoming frames is not shown because all the data applies independently to each incoming frame regardless of how many there are. In fact, the whole junctor story will be most easily understood if the pattern is visualized as it is seen looking from one incoming frame. This gives the whole picture because the junctors from all the other incoming frames follow the same pattern.

TABLE B
Intertoll or Combined Train
Number of Junctors per Incoming Frame
for Offices up to an Ultimate Size of
10 Incoming and 10 Outgoing Frames

	From Each Incoming Frame		
No. of Outgoing Frames	No. of Junctor Groups	No. of Junctors Per Grp.	*Total No. of Junctors
2	2	60	120
4	4	40	160
6	6	30	180
8	8	25	200
10	10	20	200

*A junctor joins a vertical of an incoming frame secondary switch to a vertical of an outgoing frame primary switch. All unused incoming secondary and outgoing primary switch verticals are cabled to the junctor grouping frame. These are not junctors - they become junctors when they are joined.

2.52 This table shows the total number of junctors provided per incoming frame as well as the number of junctors between any incoming frame and each outgoing frame. Since each incoming frame handles the same amount of traffic regardless of the size of an office, it follows that the traffic carried by each junctor group from a given incoming frame is equal to the total traffic on that incoming frame divided by the number of outgoing frames. Thus, in an office with 4 outgoing frames, each junctor group carries one fourth of the total traffic from an incoming frame, whereas in an office with ten outgoing frames each junctor group carries only one tenth of the total traffic. Therefore the size of the junctor groups must increase as the number of outgoing frames decreases. This is evident from Table B.

2.53 It will be noted that in the smaller offices the full capacity of 200 junctors for each incoming frame is not provided. For example, in an office with only 2 outgoing frames, each incoming frame has only 120 junctors, (one group of 60 to each of the 2 outgoing frames) instead of the 200 which could be provided.

2.54 There are several reasons why all the junctors are not provided on these small jobs. One is that the groups are larger, and therefore more efficient. The calculations required to determine the proper number of junctors for each size of office are complicated and are beyond the scope of this section. These calculations have been made, and from them charts have been prepared which show the number of junctors per group for each size of office.

2.55 Figure 23, attached, shows the junctor pattern for an office with an ultimate size of 10 incoming and 10 outgoing frames but equipped initially with 2 incoming and 2 outgoing frames. To simplify the diagram, only one incoming frame is shown. For the same reason only three switches 0, 4 and 9 are shown on both the incoming and outgoing frames. Directly cabled junctors and cross-connected junctors are shown as well as the spare incoming and outgoing verticals which are cabled to the junctor grouping frame. As shown in this figure the junctors are connected from the incoming left half switches to the correspondingly numbered outgoing left half switches. The incoming right half switches are connected in a similar manner to the outgoing right half switches.

2.56 Figure 23 also shows how the permanently connected junctors form a symmetrical pattern while the cross-connected ones do not. This also is clearly shown in Table C.

2.57 As discussed previously in connection with Table A, when the office has grown to its ultimate size of 10 incoming frames and 10 outgoing frames, all junctors will be permanently connected and in a symmetrical pattern for this type of office and:

(a) Inc. Fr. No. = Out. Vert. No.

(b) Out. Fr. No. = Inc. Vert. No.

(c) Inc. Fr. Sec. Sw. No. = Out. Fr. Pri. Sw. No.

2.58 While the cross-connected junctors do not have a symmetrical pattern, the numbers assigned to the incoming frame secondary vertical and outgoing frame primary vertical terminations of a junctor are the same, for example, 3 and 3, 6 and 6, etc. This simplifies the job of running the cross-connections.

2.59 It was pointed out in paragraph 2.51 that the junctor story is most easily understood by visualizing the pattern as it is seen from one incoming frame. With this in mind, Table D was made up. On this table two incoming frames are selected from an intertoll or combined train office with six incoming and six outgoing frames and the junctor pattern on each is shown separately.

2.60 The foregoing discussion of junctor patterns applies specifically to an intertoll or combined train installation with an ultimate size of ten incoming and ten outgoing frames. There are two other ultimate sizes for intertoll or combined train offices, to meet the requirements of various areas. The junctor patterns for these differ in detail but the same general philosophy applies to them, that is, there is a well defined symmetrical pattern for the permanently connected junctors. The minimum size junctor group is 20 for all three sizes of intertoll and combined train installations.

Ultimate Sizes of Offices

2.61 There are three ultimate sizes of intertoll or combined train installations as follows:

(a) 10 incoming frames - 10 outgoing frames - (plan TA).

(b) 10 incoming groups (20 frames) - 20 outgoing frames - (plan TB).

(c) 20 incoming groups (40 frames) - 20 outgoing groups (40 frames) - (plan TC).

TABLE C
Junctor Distribution
Intertoll or Combined Train
2 Incoming Frames - 2 Outgoing Frames
(Ultimate Size Office, 10 Inc. - 10 Out.)
(120 Junctors per Incoming Frame - 6 per Half Switch)

		No. of Junctors	Inc. Fr.	Out. Vert.	Out. Fr.	Inc. Vert.	Inc. Fr. Sec. Sws.	Out. Fr. Pri. Sws.
Symmetrical = Pattern	Permanently Connected	(20	0	0	0	0	(0L-9L (0R-9R	0L-9L 0R-9R
		(20	0	0	1	1	"	"
	Cross-Connected	(20	0	9	0	9	"	"
		(20	0	6	1	6	"	"
		(20	0	3	0	3	"	"
		(20	0	2	0	2	"	"
Symmetrical = Pattern	Permanently Connected	(20	1	1	0	0	"	"
		(20	1	1	1	1	"	"
	Cross-Connected	(20	1	2	0	2	"	"
		(20	1	3	1	3	"	"
		(20	1	8	0	8	"	"
		(20	1	9	1	9	"	"

	HALF SWITCH NOS.	NO. OF JUNCTORS	IV NO.	JUNCTORS CONNECTED	OUT. FRAME NO.	OV NO. JC NO.	NO. OF JUNCTORS	HALF SWITCH NOS.
INC. FRM. NO. 0	(A) 0L TO 9L OR TO 9R	20	0	PERMANENT	0	0	20	(A) 0L TO 9L OR TO 9R
	(B) SEE NOTE a	10	9	CROSS-CONNECTED		9	10	(B) SEE NOTE a
	SAME AS (A)	20	1	PERMANENT	1	0	20	SAME AS (A)
	(C) SEE NOTE b	10	9	CROSS-CONNECTED		9	10	(C) SEE NOTE b
	SAME AS (A)	20	2	PERMANENT	2	0	20	SAME AS (A)
	SAME AS (B)	10	7	CROSS-CONNECTED		7	10	SAME AS (B)
	SAME AS (A)	20	3	PERMANENT	3	0	20	SAME AS (A)
	SAME AS (C)	10	7	CROSS-CONNECTED		7	10	SAME AS (C)
	SAME AS (A)	20	4	PERMANENT	4	0	20	SAME AS (A)
	SAME AS (B)	10	8	CROSS-CONNECTED		8	10	SAME AS (B)
	SAME AS (A)	20	5	PERMANENT	5	0	20	SAME AS (A)
	SAME AS (C)	10	8	CROSS-CONNECTED		8	10	SAME AS (C)

	HALF SWITCH NOS.	NO. OF JUNCTORS	IV NO.	JUNCTORS CONNECTED:	OUT. FRAME NO.	OV NO. JC NO.	NO. OF JUNCTORS	HALF SWITCH NOS.
INC. FRM. NO. 2	(A) 0L TO 9L OR TO 9R	20	0	PERMANENT	0	2	20	(A) 0L TO 9L OR TO 9R
	(B) SEE NOTE a	10	8	CROSS-CONNECTED		8	10	(B) SEE NOTE a
	SAME AS (A)	20	1	PERMANENT	1	2	20	SAME AS (A)
	(C) SEE NOTE b	10	8	CROSS-CONNECTED		8	10	(C) SEE NOTE b
	SAME AS (A)	20	2	PERMANENT	2	2	20	SAME AS (A)
	SAME AS (B)	10	9	CROSS-CONNECTED		9	10	SAME AS (B)
	SAME AS (A)	20	3	PERMANENT	3	2	20	SAME AS (A)
	SAME AS (C)	10	9	CROSS-CONNECTED		9	10	SAME AS (C)
	SAME AS (A)	20	4	PERMANENT	4	7	20	SAME AS (A)
	SAME AS (B)	10	7	CROSS-CONNECTED		2	10	SAME AS (B)
	SAME AS (A)	20	5	PERMANENT	5	7	20	SAME AS (A)
	SAME AS (C)	10	7	CROSS-CONNECTED		2	10	SAME AS (C)

NOTE a : 0L,1R,2L,3R,4L,5R,6L,7R,8L,9R
NOTE b : 0R,1L,2R,3L,4R,5L,6R,7L,8R,9L

TABLE D - JUNCTOR PATTERN FOR 6 INCOMING - 6 OUTGOING FRAME OFFICE AS SEEN FROM INCOMING FRAMES 0 AND 2.

2.62 Early in the engineering stages of each office a decision is made as to which of these ultimate sizes will be used. This decision affects the engineering, manufacture, and installation of the job. Here we are concerned with the effect of ultimate size on frame arrangements and junctor patterns.

2.63 Junctor distribution charts have been prepared which cover the junctor distribution for every size office for each of the ultimate sizes of installation. These are included in Section AA261.432.

Grouping of Incoming Frames

2.64 The 200 junctors per incoming frame are sufficient to provide the minimum of 20 junctors per group for installations with an ultimate size of ten incoming frames and ten outgoing frames. In offices with larger ultimate sizes, this minimum group size is maintained by dividing all the incoming frames, or both the incoming and outgoing frames into "groups" of two frames each, which share their junctors.

2.65 In the 10 Incoming Group - 20 Outgoing Frame size office the incoming frames are paired to form Incoming Groups: Incoming frames 0 and 1 are group 0, frames 2 and 3 are group 1, etc. This grouping is done even on the smallest initial size office, which is 2 incoming groups and 4 outgoing frames. The 200 junctors from each frame of a group are combined into a pool of 400 which are shared by that group. The outgoing frames are not grouped and therefore have a capacity for 200 junctors each (See Fig. 24, attached.)

2.66 In order to provide space on each incoming frame of a group for the 400 junctors shared by that group, a secondary extension bay is added to each frame. The verticals of the regular secondary and secondary extension bays of one frame are multipled to like verticals on the regular secondary and secondary extension bays of the other frame of the group. Each incoming frame of the group still has its individual 200 links which are multipled to both bays. These two sets of 200 links are served in common by the 400 junctors.

2.67 It should be noted that in this ultimate size installation the incoming frame secondary switches are not split as they are in the 10 incoming - 10 outgoing frame office. From a junctor pattern viewpoint the regular secondary switch replaces the left half switch and the extension secondary switch replaces the right half switch of the incoming secondary switches of the 10 incoming - 10 outgoing frame pattern.

2.68 Table E shows the number of junctor groups and junctors per Incoming Group for different numbers of outgoing frames in offices with an ultimate size of 10 incoming groups - 20 outgoing frames.

TABLE E

Intertoll or Combined Train
Number of Junctors per Incoming Frame for Offices
Up to an Ultimate Size of 10 Incoming Groups and
20 Outgoing Frames

		From Each Incoming Group		
No. of Incoming Groups	No. of Outgoing Frames	No. of Junctor Groups	No. of Junctors Per Group	Total No. of Junctors
2	4	4	60	240
3	6	6	60 or (a)(40)	360 or (a)(240)
4	8	8	40	320
5	10	10	40 or (a)(30)	400 or (a)(300)
6	12	12	30	360
7	14	14	25	350
8	16	16	25	400
9	18	18	(b)22 or 23	400
10	20	20	20	400

Notes:
(a) These are alternative arrangements which are as follows:

2 Incoming Group - 4 Outgoing Frame, (2 IG - 4 OF), initial size always uses the next larger size - 3 IG - 6 OF pattern.

3 IG - 6 OF initial size may use this pattern or 5 IG - 10 OF pattern.

4 IG - 8 OF initial size always uses the 5 IG - 10 OF pattern.

5 IG - 10 OF initial size may use this pattern or the 6 IG - 12 OF pattern.

7 IG - 14 OF initial size always uses the 8 IG - 16 OF pattern.

Which arrangement is used in a given office depends upon the possibilities of growth in that office. For example, if initial requirements are for 3 incoming groups and 6 outgoing frames but studies indicate that the office will soon grow to 5 incoming groups and 10 outgoing frames, the pattern for the 5 - 10 office can be installed initially and there will be 40 junctors per group instead of 60. This greatly reduces the installation effort when the office does grow. Of course until this happens the number of junctors per group will be smaller than in the regular arrangement, that is, the one with 60 junctors per group. However, 40 junctors per group provide service which meets Bell Systems standards for an installation of 3 incoming groups and 6 outgoing frames.

(b) This means that certain incoming groups have 22 junctors to certain outgoing frames and 23 to others. Other incoming groups have 22 junctors to different sets of outgoing frames and 23 to the remaining frames. For example, incoming group 0 has 22 junctors to each of outgoing frame 2 to 15, and 23 junctors to frames 0, 1, 16 and 17. This makes a total of 400. Incoming group 7 has 22 junctors to each of outgoing frames 0 to 11, 16 and 17, and 23 junctors to frames 12 to 15, also making a total of 400.

2.69 The general similarity of Table E to Table B is apparent.

2.70 Figure 25, attached, is a simple diagram of an office with an ultimate size of 20 Incoming Groups and 20 Outgoing Groups. In this type of office both the incoming and outgoing frames are grouped. Each incoming frame and outgoing frame still has an individual group of 200 links, but in this size office each Incoming Group shares 400 junctors and each Outgoing Group shares 400 junctors.

2.71 Table F shows junctor arrangements for offices up to an ultimate size of 20 Incoming Groups and 20 Outgoing Groups.

TABLE F

Intertoll or Combined Train
Number of Junctors per Incoming Frame for Offices Up To an Ultimate Size of 20 Incoming Groups and 20 Outgoing Groups

No. of Incoming Groups	No. of Outgoing Groups	From Each Incoming Group: No. of Junctor Groups	No. of Junctors Per Group	Total No. of Junctors
4	4	4	60	240
5	5	5	60	300
6	6	6	60 or (a)(40)	360 or (a)(240)
7	7	7	40	280
8	8	8	40	320
9	9	9	40	360
10	10	10	40 or (a)(30)	400 or (a)(300)
11	11	11	30	330
12	12	12	30	360
13	13	13	30	390
14	14	14	25	350
15	15	15	25	375
16	16	16	25	400
17	17	17	(b)22 or 23	400
18	18	18	(b)22 or 23	400
19	19	19	20	380
20	20	20	20	400

Notes:
(a) Alternative arrangements. See note (a) Table E.
(b) See note (b) under Table E.

Toll Completing Train

2.72 The general story on frame arrangements and junctor distribution is much the same on the toll completing train as it is on the intertoll and combined trains. For example, even numbers of incoming frames and even numbers of outgoing frames are always provided, and generally there are the same number of each. There are different junctor distribution patterns for offices with different ultimate sizes, and until these ultimate sizes are reached some of the junctors are permanently connected and some are cross-connected.

2.73 The minimum number of junctors in a group is ten for this type of train. The reason for the smaller number is explained under (E) Control of Switching Operations. The differences in frame arrangements and junctor distribution patterns are mostly due to this smaller minimum size of the junctor group.

2.74 There are only two ultimate sizes of installations:

20 incoming frames - 20 outgoing frames (plan LA)

20 incoming groups - 40 outgoing frames (plan LB)

The outgoing frames are never grouped because even in the larger size installations with 40 outgoing frames the minimum group size of ten junctors can be maintained without grouping. (Because each incoming group shares 400 junctors, these are divided over the 40 outgoing frames, 10 junctors per group.)

2.75 Table G shows the junctor distribution for different sizes of offices up to an ultimate size of 20 Incoming Frames and 20 Outgoing Frames.

TABLE G
Toll Completing Train
Number of Junctors per Incoming Frame for Offices up to an Ultimate Size of 20 Incoming and 20 Outgoing Frames

No. of Outgoing Frames	From Each Incoming Frame: No. of Junctor Groups	No. of Junctors Per Group	Total No. of Junctors
4	4	30 (a)	120
6	6	30 or (a)(20)	180 or(a)(120)
8	8	20 (a)	160
10	10	20	200
12	12	(b)13 or 14(a)	160
14	14	(b)13 or 14	188
16	16	(b)12 or 13	200
18	18	10 (a)	180
20	20	10	200

Notes:
(a) Table G shows that, (as in the intertoll or combined train offices), on some initial installations a pattern for a larger size office may be used:

4 Incoming - 4 Outgoing Frame, (4 IF - 4 OF), initial size uses 6 IF - 6 OF pattern.

6 IF - 6 OF initial size may use this pattern or the 10 IF - 10 OF pattern.

8 IF - 8 OF size uses the 10 IF - 10 OF pattern.

12 IF - 12 OF size uses the 14 IF - 14 OF pattern.

18 IF - 18 OF size uses the 20 IF - 20 OF pattern.

(b) See Note (b) under Table E.

2.76 Figure 26, attached, shows the junctor pattern for a 4 IF - 4 OF office, (ultimate size 20 IF - 20 OF), using the 6 IF - 6 OF pattern. To simplify the diagram, only switches 0, 4 and 9 of one incoming frame are shown. Directly cabled junctors and cross-connected junctors are shown as well as the spare incoming and outgoing verticals which are cabled to the junctor grouping frame.

2.77 As with the intertoll or combined train, junctors are connected from incoming left half switches to correspondingly numbered outgoing left half switches. In a similar manner incoming right half switches are connected to outgoing right half switches.

2.78 Table H graphically illustrates the symmetrical pattern of the permanently connected junctors in a 4 IF - 4 OF installation (ultimate size 20 IF - 20 OF).

2.79 When the office has grown to its ultimate size of 20 incoming frames - 20 outgoing frames, all junctors are permanently connected and are in a symmetrical pattern for this type of office. In this pattern:

(a) All Out. Fr. Vert. Nos. 0 connect to Inc. Fr. Nos. 0+1
All Out. Fr. Vert. Nos. 1 connect to Inc. Fr. Nos. 2+3
All Out. Fr. Vert. Nos. 2 connect to Inc. Fr. Nos. 4+5
etc.

(b) All Inc. Fr. Vert. Nos. 0 connect to Out. Fr. Nos. 0+1
All Inc. Fr. Vert. Nos. 1 connect to Out. Fr. Nos. 2+3
All Inc. Fr. Vert. Nos. 2 connect to Out. Fr. Nos. 4+5
etc.

(c) Incoming frame secondary switch number is the same as the outgoing frame primary switch number.

TABLE H

Junctor Distribution
Toll Completing Train
4 Incoming Frames - 4 Outgoing Frames (6 IF - 6 OF Pattern)
(120 Junctors per Incoming Frame - 6 per Half Switch)
(Ultimate Size Office 20 Incoming Frames - 20 Outgoing Frames)

		No. of Juncts.	Inc. Fr.	Out. Vert.	Out. Fr.	Inc. Vert.	Inc. Fr. Sec. 1/2 Sws.	Out. Fr. Pri. 1/2 Sws.
		10	0	0	0	0	(a)	(a)
		10	0	0	1	0	(b)	(b)
		10	0	0	2	1	(a)	(a)
		10	0	0	3	1	(b)	(b)
		10	1	0	0	0	(b)	(b)
		10	1	0	1	0	(a)	(a)
		10	1	0	2	1	(b)	(b)
Symmetrical =	Permanently	10	1	0	3	1	(a)	(a)
Pattern	Connected	10	2	1	0	0	(a)	(a)
		10	2	1	1	0	(b)	(b)
		10	2	1	2	1	(a)	(a)
		10	2	1	3	1	(b)	(b)
		10	3	1	0	0	(b)	(b)
		10	3	1	1	0	(a)	(a)
		10	3	1	2	1	(b)	(b)
		10	3	1	3	1	(a)	(a)
		20	0	9	0	9	(c)	(c)
		20	0	8	1	8	(c)	(c)
		20	0	5	2	5	(c)	(c)
		20	0	4	3	4	(c)	(c)
		20	1	8	0	8	(c)	(c)
		20	1	9	1	9	(c)	(c)
		20	1	4	2	4	(c)	(c)
	Cross	20	1	5	3	5	(c)	(c)
	Connected	20	2	7	0	7	(c)	(c)
		20	2	6	1	6	(c)	(c)
		20	2	9	2	9	(c)	(c)
		20	2	8	3	8	(c)	(c)
		20	3	6	0	6	(c)	(c)
		20	3	7	1	7	(c)	(c)
		20	3	8	2	8	(c)	(c)
		20	3	9	3	9	(c)	(c)

Notes:

(a) 0L, 1R, 2L, 3R, 4L, 5R, 6L, 7R, 8L, 9R. (10 half switches)

(b) 0R, 1L, 2R, 3L, 4R, 5L, 6R, 7L, 8R, 9L. (10 half switches)

(c) 0L to 9L and 0R to 9R. (20 half switches)

2.80 It will be noted that this pattern is symmetrical but is different from the symmetrical pattern for the intertoll train 10 IF - 10 OF office on Table C.

2.81 Table I shows junctor arrangements for offices up to an ultimate size of 20 Incoming Groups and 40 Outgoing Frames.

TABLE I

Toll Completing Train
Number of Junctors per Incoming Frame for Offices
Up to an Ultimate Size of 20 Incoming Groups and
40 Outgoing Frames

		From Each Incoming Group		
No. of Incoming Groups	No. of Outgoing Frames	No. of Junctor Groups	No. of Junctors Per Group	Total No. of Junctors
4	8	8	40 (a)	320
5	10	10	40	400
6	12	12	20 (a)	240
7	14	14	20 (a)	280
8	16	16	20 (a)	320
9	18	18	20 (a)	360
10	20	20	20 or (a) (13 or 14)	400 or (a) 268
11	22	22	(b)13 or 14 (a)	294
12	24	24	(b)13 or 14 (a)	320
13	26	26	(b)13 or 14 (a)	348
14	28	28	(b)13 or 14 (a)	374
15	30	30	(b)13 or 14	400
16	32	32	(b)12 or 13	400
17	34	34	10 (a)	340
18	36	36	10 (a)	360
19	38	38	10 (a)	380
20	40	40	10	400

Notes:

(a) On some initial installations a pattern for a larger size office may be used.

4 IG - 8 OF uses the 5 IG - 10 OF pattern.

6 IG - 12 OF, to 9 IG - 18 OF offices use the 10 IG - 10 OF office size pattern.

10 IG - 20 OF size office may use its own pattern or the 15 IG - 30 OF size pattern.

11 IG - 22 OF, to 15 IG - 30 OF offices use the 15 IG - 30 OF size pattern.

17 IG - 34 OF, to 20 IG - 40 OF offices use the ultimate size pattern 20 IG - 40 OF.

(b) See note (b) under Table E.

(E) Control of Switching Operations

2.82 The 4A System is a Common Control system. This means that a relatively small number of circuits common to an office, (common control equipment), store the digits as they are received and then set up the talking connection on the switching train. The common control equipment then releases and is ready to serve another call. This type of system is distinguished from the Direct Dial Control systems in which the switching train is set up directly from the digits as they are received.

2.83 Further, the 4A system is a Marker type of common control system. This means that when an incoming call has been recorded, the equipment called a marker first makes sure there is an idle outgoing trunk to the called office. It then sets up a talking connection between the incoming trunk and the outgoing trunk on the switching train. This is distinguished from other, non-marker common control systems, which, after the call is recorded, set up the switching train between the incoming and outgoing trunks progressively, without first determining whether there is an idle outgoing trunk to the called office.

2.84 Some of the common control circuits are: markers, senders, decoders, card translators, link controllers, and trunk block connectors. These are described in Part 3, Functions of Principal Equipment Elements.

2.85 There are several possible connections between each incoming and every outgoing trunk in an office. These are called channels. A channel is a combination of an incoming link, a junctor, and an outgoing link, that can be formed, (by crosspoint closures), into a chain that interconnects an incoming trunk and an outgoing trunk. (See Fig. 27, attached.)

2.86 On each call, the part of the common control equipment called a marker receives the location of the incoming trunk which handles the call, and the location of the called office. It then locates an idle outgoing trunk to the called office and proceeds to set up a channel between the incoming and outgoing frames. Figure 28 shows this channel and the relationship between the common control equipment and the switching frames.

2.87 The location of the incoming trunk is obtained by the marker in terms of the incoming link frame number. This number is given to the marker over the winding of the primary select magnet associated with the incoming trunk. The marker then operates this select magnet and identifies the particular twenty links available to the incoming trunk - two to each of the incoming frame secondary switches on which one end of the junctors are terminated. (See Fig. 20A.) Similarly, the outgoing link frame number is obtained by the marker over the winding of the secondary select magnet associated with the outgoing trunk. The marker then operates this magnet and identifies the twenty links available to the outgoing trunk - 2 links to each of the outgoing frame primary switches on which the other ends of the junctors are terminated. (See Fig. 20B.)

2.88 (To simplify the story, the following discussion applies to the intertoll or combined train. The story is the same for the toll completing train except for the number of junctors in the groups.)

2.89 While each incoming trunk and each outgoing trunk has twenty links which it can use, the total number of junctors which can interconnect these links to form channels varies from a minimum of 20 for the ultimate size office to 60 for the smallest office. (See Tables B, E, and F under Junctors.)

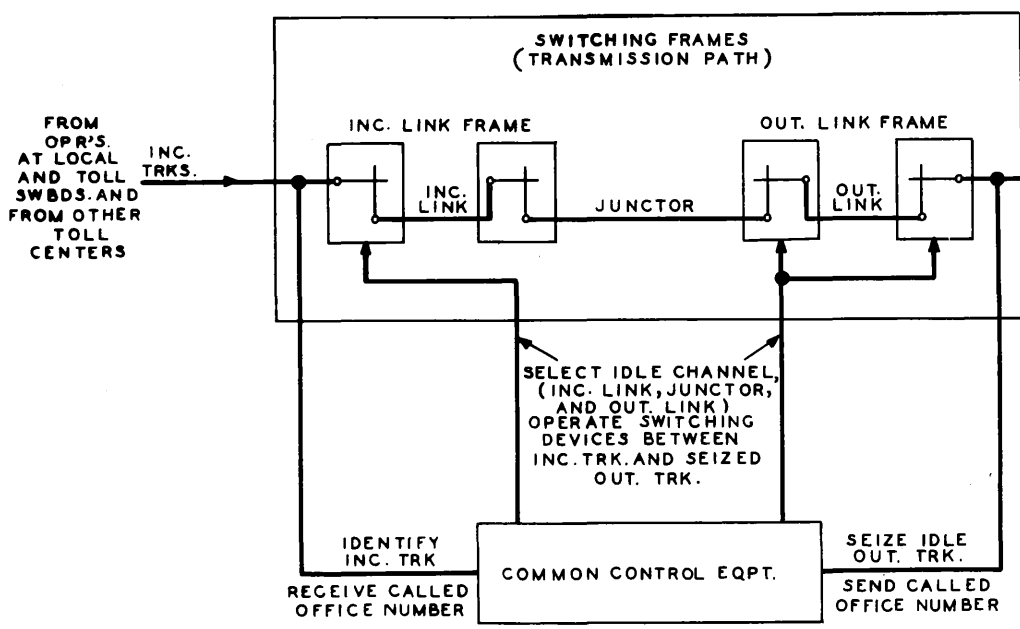


FIG. 28 - RELATIONSHIP BETWEEN COMMON CONTROL EQUIPMENT AND SWITCHING FRAMES.

2.90 It is the function of the marker to pick an idle channel between the incoming trunk handling the call and an outgoing trunk to the desired office. Twenty incoming trunks share a given twenty incoming links. Similarly, twenty outgoing trunks share a given twenty outgoing links. On the other hand, the group of junctors which interconnect these sets of twenty incoming links and twenty outgoing links are shared at the incoming frame end by the nine other sets of twenty incoming links. In other words, all ten sets of incoming links use the same group of junctors to reach a given outgoing frame.

2.91 Because of this sharing of links and junctors the marker has to select, or "match" an idle incoming link, junctor and outgoing link to form a transmission channel between the incoming trunk and the outgoing trunk.

2.92 When there are more than twenty junctors in a group, they are divided into subgroups of twenty. When the group is not an even multiple of twenty, there is one group of less than twenty. For example, in an office with two outgoing frames the 60 junctors from the incoming frame to each outgoing frame are divided into three subgroups of twenty. In an office with six outgoing frames the 30 junctors are divided into one subgroup of twenty and one of ten.

2.93 The marker tests twenty channels at a time. In cases such as the above, where there are more than twenty junctors in a group, the marker can make several tests using a different subgroup of junctors each time. However, the same twenty incoming and twenty outgoing links are used on each test because there are only twenty available to each incoming and outgoing trunk.

2.94 As has been stated, for safety and traffic reasons, the outgoing trunks to a given office are spread over as many outgoing frames as feasible. If an idle channel to the first idle outgoing trunk seized by the common control equipment cannot be found, this trunk is released and the marker tries to find another. The marker tests in such a manner that the second outgoing trunk chosen is generally on a different outgoing frame. If a second idle trunk can be found, a new group of junctors and outgoing links will be used. Of course the incoming links are the same since the same incoming trunk still has the call. The marker can now test all the new junctors in the same way until an idle channel is found. If these tests fail, a busy or reorder is returned to the incoming trunk.

Minimum Size Junctor Groups

2.95 Now that the general method of picking an idle channel has been discussed, the reason for the different minimum sizes of junctor groups for Intertoll or Combined Trains and Toll Completing Trains can be explained.

2.96 Toll completing trunks are less expensive than intertoll trunks and therefore are engineered more liberally. For this reason on a failure to match on a toll completing train, there is a good chance on second trial of finding an idle trunk on a different outgoing frame, and therefore a new group of junctors.

2.97 As contrasted with this, on the intertoll or combined train, there is a good chance of finding the same idle trunk on second trial because it is likely to be the only idle trunk available. For this reason, enough junctors must be provided to match on the first trial. This is the reason behind the difference in the minimum groups of junctors provided for these two types of trains - ten for toll completing and twenty for intertoll or combined trains.

3. FUNCTIONS OF PRINCIPAL EQUIPMENT ELEMENTS

(A) General

3.01 The basic circuit functions of the equipment elements (common control and switching equipment) are described here. In order to understand the functions of these individual equipment elements, it will help to see how they work together. For this reason, an over-all picture is presented first by taking a call through an office. This illustrates the part each equipment element plays in switching the call. The function of each element is briefly discussed but the primary purpose is to name the elements and point out the relationship between them.

3.02 Two calls are discussed: one through a combined train office and the other through a separate train office. In this discussion, it is assumed that these calls do not encounter any irregularities or competition from other calls.

3.03 After tracing these calls, the functions of each equipment element are discussed more fully, emphasizing the how and why of these functions.

(B) Calls

Call Through a Combined Train Office

3.04 A combined train office uses one switching train to handle both intertoll and toll completing traffic.

3.05 The transmission path and the elements used in setting up the path for a call through a combined train No. 4A toll office are shown on Fig. 29, attached. In this example, it is assumed that the call requires 3-digit translation and is switched to a system which receives multifrequency pulsing.

3.06 This call arrives at the 4A office over an incoming trunk and leaves over an outgoing trunk. The incoming trunk may be selected by an outward operator or it may be seized at a distant automatic toll office. (The procedure in this 4A office is the same in either case.)

3.07 As shown on Fig. 29, each incoming trunk has two major appearances in a 4A office: one on the incoming frame (used for the talking connection) and one on the sender link frame (used for passing information to the common control equipment). The sender link frame appearance is used first.

3.08 The sender link frame consists of two sets of crossbar switches. The incoming trunks appear on one set of crossbar switches and the incoming senders on another.

3.09 As soon as the incoming trunk is seized, it signals a sender link (connection 1) to connect an incoming sender for registering the incoming pulses. Then the sender link connector signals a controller connector to seize an idle link controller (conn. 2). The link controller then tests for and seizes an idle incoming sender and closes the crosspoints between this sender and the incoming trunk at the sender link frame (conn. 3). This completes the function of the link controller and controller connector so they release from the connection and serve other calls.

3.10 As soon as the incoming sender is attached, it signals either for the outward operator to begin pulsing or, if the call is from a distant automatic toll office using senders, for the sender in that office to begin pulsing. When the incoming sender in this office has received and registered three digits, it signals the decoder connector to seize an idle decoder (conn. 4). This decoder immediately connects to its home translator (conn. 5), which contains all the 3-digit code cards. (The foreign area translator is used on calls requiring 6-digit translation.) Now the three code digits in the sender are transmitted through the decoder to the home translator. Here a card coded to correspond to these digits drops. This card contains information for switching the call with 3-digit translation. (Pretranslation and 6-digit translation are described later in this part under Decoder.)

3.11 The decoder reads the card and signals a marker connector to seize an idle marker (conn. 6). When a marker is seized, the marker connector signals the decoder connector to connect the incoming sender to this marker (conn. 7 and 7a). (This connection is necessary because the marker has to give certain information to the sender later after the decoder may have been released.)

3.12 The marker obtains the locations of the outgoing trunks suitable for this call from the decoder and the dropped card. Guided by this information the marker selects an appropriate outgoing trunk through a trunk block connector (conn. 8). This trunk then registers its outgoing frame appearance in the marker.

3.13 The decoder and the card also tell the marker that the incoming sender should outpulse on a multifrequency basis for this call, and whether the digits should be outpulsed as received, or skipped, or converted. When the marker has received all this information, it signals the decoder to release.

3.14 Now the marker proceeds to set up the talking path from the incoming trunk to the selected outgoing trunk. Through the outgoing frame connector, the marker gains access to the outgoing links and to the junctors (conn. 9). At the same time, the marker gains access to the incoming links through the incoming frame connector (conn. 9). (The incoming trunk has already registered its incoming frame appearance to the marker over conn. 1, 3, 4 and 7a.) The marker then tests the incoming and outgoing links and the junctors to find an idle channel between the incoming trunk and the outgoing trunk. It then closes the crosspoints to establish this channel (conn. 10).

3.15 Now the marker passes the outpulsing information to the sender and releases from the connection. The sender outpulses the digits through the sender link over the transmission path to the outgoing trunk and through to the called office; then the incoming sender and sender link release.

3.16 The connections in the transmission path remain until a disconnect signal is received. Then all the connections are released.

Call Through a Separate Train Office

3.17 A separate train office has one switching train that handles intertoll traffic, and another train that handles toll completing traffic. Each train has a separate set of incoming and outgoing frames, markers and trunk block connectors. Both trains share the same incoming senders (and outgoing senders, where required) sender links, link controllers and decoders.

3.18 An incoming trunk in this office also has two major appearances: one on the incoming frame, and one on the sender link frame. Incoming intertoll trunks that handle intertoll traffic as well as mpleting traffic have appearances on the incoming frames of both the intertoll and toll completing trains.

3.19 In the example in Fig. 30, attached, a call comes into a separate train office on an intertoll trunk from an outward operator or a distant automatic toll office. It is assumed that this call is to be switched through the intertoll train to another toll office that receives MF pulsing. This call is also completed using 3-digit translation, and proceeds in the same way as the call just described in a combined train office, up to the point where the decoder selects a marker (connections 1 through 5).

3.20 The decoder reads the card which was dropped on this call and is directed to an outgoing intertoll trunk on the intertoll train. Therefore the decoder signals a marker connector to seize an idle intertoll marker (conn. 6). When a marker is seized, the marker connector signals the decoder connector to connect the incoming sender to this marker (conn. 7 and 7a).

3.21 The marker obtains the locations of the outgoing trunks suitable for this call from the decoder and the card. Guided by this information, the marker selects an appropriate outgoing intertoll trunk through an intertoll trunk block connector (conn.8). This trunk then registers its outgoing frame appearance in the marker.

3.22 The decoder and the card also tell the marker that the incoming sender should outpulse MF for this call, and whether the digits should be outpulsed as received or skipped or converted. When the marker has received all this information, it signals the decoder to release. Again from this point on, the call proceeds just as in the combined train office.

3.23 As a further illustration of the operation of a separate train office, if the call discussed above were a toll completing call, then the toll completing train appearance of the incoming trunk would be used. This call would proceed in the same manner as above up to the selection of a marker (see Fig. 30). Then a toll completing marker would be used. The call is completed on the toll completing train.

Calls Requiring Outgoing Senders

3.24 Outgoing senders are necessary for calls which are switched through a 4A office to offices which receive revertive or call indicator pulsing. This is because incoming senders can outpulse only MF and DP to distant offices.

3.25 The outgoing trunks that connect to such offices have an appearance on outgoing sender link frames. These frames are similar to incoming sender link frames.

3.26 A call going to an office that requires PCI or revertive pulsing needs two senders: an incoming sender to register the called number and an outgoing sender to outpulse the called number.

3.27 When an outgoing trunk to an office requiring revertive or PCI pulsing is seized at the 4A office, it signals the outgoing sender link that an outgoing sender is needed. The sender link seizes a link controller through a controller connector. The link controller tests for an idle sender and attaches it to the outgoing trunk; the link controller and connector then release and are free to serve other calls.

3.28 As soon as the outgoing sender is attached, a signal is sent to the incoming sender telling it to pulse the called digits into the outgoing sender. (Incoming senders pulse d-c K-P into outgoing senders.) These digits are pulsed from the incoming sender through the incoming and outgoing frames, the outgoing trunk, the outgoing sender link and into the outgoing sender. The incoming sender and sender link then release from the connection. Now the connection consists of the transmission channel, the outgoing trunk, and the outgoing sender. The outgoing sender then outpulses the called digits over the outgoing trunk and releases from the connection. (See Fig. 30.)

(C) Equipment Elements

General

3.29 The major equipment elements are discussed in the order of their use during a call with the exception of the marker. The marker is discussed first because it controls most of the operations of the other elements.

The Marker

3.30 The marker is one of the major equipment elements in the No. 4A toll switching system. It locates an idle outgoing trunk and identifies the incoming trunk handling a call. It then marks an idle path between them and establishes the transmission path. This path or channel between the incoming and outgoing trunk consists of an incoming link, a junctor, and an outgoing link.

3.31 One of the features of the marker is that if it encounters trouble during a call, it can make another attempt (second trial) to complete the call. The procedure for this is discussed under Second Trial Feature.

3.32 The marker uses directive information supplied by the card translator and the decoder (see Fig. 31) to establish the transmission path of a call through the office. Some of this information is used by the marker to seize a suitable outgoing trunk. The marker stores other information supplied by the decoder and card translator and later transmits it to the sender. This information instructs the incoming sender how to outpulse the registered digits.

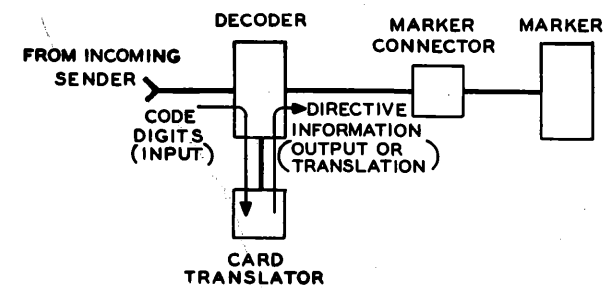


FIG. 31 - INFORMATION TO MARKER.

3.33 There are three types of markers: intertoll, toll completing, and combined. Intertoll and toll completing markers are provided in separate train offices, combined markers in combined train offices. The operation of these markers is so similar that no distinction is made among them in this discussion.

Establishing the Transmission Path

3.34 Seizing an Outgoing Trunk: In a 4A toll office, all the outgoing trunks, (a trunk group), going to a certain distant office are spread over as many outgoing frames as is practical. In order for the marker to select one of these trunks without having to go to each frame, the test leads for a trunk group are gathered at the trunk block connector. This arrangement enables the marker to go to just one place to test for an idle trunk to a certain office.

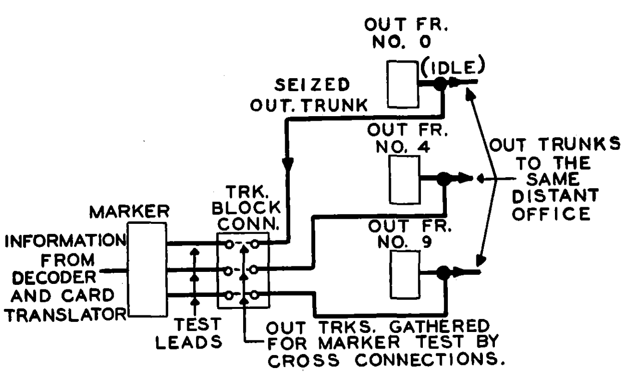


FIG. 32 - SEIZING AN OUTGOING TRUNK.

3.35 As shown on Fig. 32, information from the card translator and the decoder directs the marker to the proper trunk block connector which contains the leads of the desired group of trunks. Here the marker tests for an idle trunk and seizes the first one available. As soon as a trunk is seized, a signal is sent to the distant office telling it to expect a call on this trunk.

3.36 Identifying the Outgoing Frame: So far the marker knows it has an idle outgoing trunk but it does not know the number of the outgoing frame on which this trunk appears. It must know this in order to establish the transmission path. The outgoing trunk supplies the outgoing frame number to the marker by sending the distinctive MF signal assigned to this frame over the select magnet lead associated with the trunk. This signal is extended to the marker through the trunk block connector (Fig. 33, conn. 2a).

3.37 Identifying the Incoming Frame: The marker also has to know the incoming frame number in order to establish the transmission path. Therefore the incoming trunk sends its distinctive MF signal identifying this number to the marker over the select magnet lead associated with this trunk. This lead is extended to the marker through the sender link, the incoming sender and the decoder connector (Fig. 33, conn. 2b).

3.38 Testing Incoming and Outgoing Links: When the incoming and outgoing trunks have identified their respective frames, the marker reaches out to these incoming and outgoing frames by seizing their associated connectors: an incoming connector for the incoming frame and an outgoing connector for the outgoing frame (Fig. 33, conn. 1). Through these connector circuits, the marker gains access to the incoming links, outgoing links and junctors.

3.39 The marker operates the primary select magnet associated with the incoming trunk being served (conn. 2b). This operation signals, to the incoming connector, the number of the primary switch on which the incoming trunk appears (conn. 3). The connector then presents the test leads of the twenty incoming links which are between this primary switch and the ten secondary switches on the incoming frame to the marker (conn. 4).

3.40 Similarly, the marker operates the secondary select magnet associated with the seized outgoing trunk (conn. 2a) and the secondary switch number is signaled to the outgoing connector (conn. 5). The connector then presents the test leads of the twenty outgoing links between the secondary switch and the ten primary switches to the marker (conn. 6).

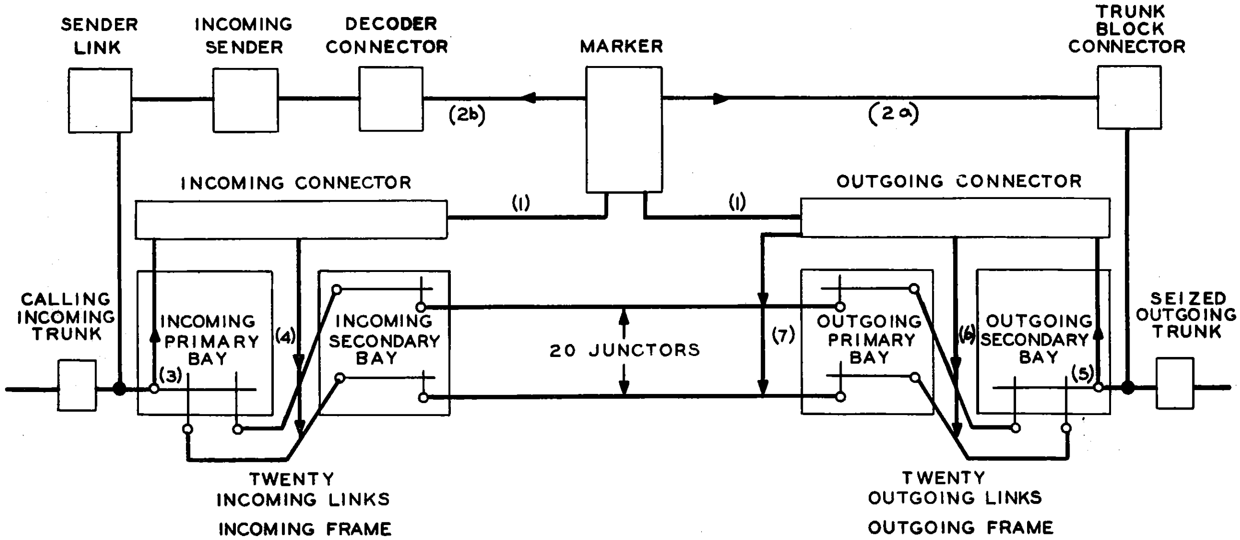


FIG. 33 - ESTABLISHING A CHANNEL.

3.41 Access to Junctor Group: Before the marker can select the particular links to be used in the channel, it must gain access to the junctors. Since the marker knows which incoming and outgoing frames are being used on this call, it also knows which junctor group is between these frames. The outgoing frame connector extends the test leads for twenty junctors in this group to the marker (conn. 7).

3.42 Seizing an Idle Channel: The marker now has access to the test leads for the twenty incoming links, twenty junctors and twenty outgoing links that can be used to switch this call.

3.43 The marker tests these links and junctors simultaneously and seizes the first channel that matches. Matching means that, starting with the primary switch which has the incoming trunk handling the call, the marker must seize:

(a) An idle incoming link going to an incoming secondary switch which has:

(b) An idle junctor to an outgoing primary switch which has, in turn:

(c) An idle outgoing link to the outgoing secondary switch with the seized outgoing trunk.

(See Fig. 33, conns. 4, 6 and 7.)

3.44 When the marker has seized the idle channel, the incoming secondary and outgoing primary select magnets and all of the hold magnets associated with this channel are operated. (It will be remembered that the incoming primary and outgoing secondary select magnets were previously operated by the marker.) This establishes the transmission path between the incoming trunk with the call and the seized outgoing trunk.

Junctor Subgroups

3.45 The marker is arranged to test the minimum size junctor group in each type of train at one time: that is, twenty junctors in an intertoll or combined train and ten junctors in a toll completing train. When the junctor group has more than the minimum number of junctors, then the group is divided into subgroups.

3.46 For example, a combined or intertoll train with four incoming groups (eight incoming frames and eight outgoing frames) has forty junctors in each junctor group. Therefore each group is divided into two subgroups of twenty. When the marker is establishing the channel, it first tests one subgroup for an idle junctor that matches the incoming and outgoing links and if none is found, the marker "walks" to the other subgroup and repeats the test. Another example of subgrouping is in an office where there are seven incoming groups and fourteen outgoing frames (combined or intertoll train). In this case 25 junctors are available in each group. These are divided into two subgroups, one subgroup with twenty junctors, the other subgroup with five. The marker first tests the subgroup of twenty junctors and if an idle junctor which matches the incoming and outgoing links cannot be found, it tests the second subgroup of five.

Junctor Pattern Feature

3.47 On both toll completing and intertoll and combined trains, the marker, when matching, always extends twenty junctor test leads to the outgoing connector. The outgoing connector, in turn, always connects the test leads from twenty junctors to these twenty test leads from the marker, even though these twenty junctors may overlap more than one junctor group. In this case there is a junctor pattern feature in the marker which automatically makes busy the junctors which cannot be used in switching the call being served. This junctor pattern feature can be included in the marker because the junctor pattern for all junctor groups in one particular office is the same. The junctor pattern feature for intertoll or combined trains can be illustrated using the example above for an office with seven incoming groups and fourteen outgoing frames (25 junctors in a group). The marker tests the first subgroup of twenty junctors, then if they are all busy, it again extends the twenty test leads to the connector, which connects the test leads of the second subgroup of five junctors plus the test leads of fifteen junctors from some other group. Now only these five wanted junctors are made available for test, the other fifteen appear busy.

3.48 Another example is found in a toll completing train office with twenty incoming and twenty outgoing frames. In such an office there are ten junctors in each group. When establishing a channel, the marker's twenty test leads are again connected to twenty junctors. The junctor pattern feature makes the ten junctors not wanted appear busy and leave the ten wanted junctors for matching with the incoming and outgoing links on the desired frames.

Information to the Incoming Sender

3.49 When the decoder and card translator send information to the marker, some of this information is used immediately and some is stored in the marker. This stored information is sent to the incoming sender when required.

3.50 The stored information directs the incoming sender to outpulse the digits in such a way that the needs of the next office are met. For example, if the call is switched to a step-by-step office then the sender spills forward dial pulses to direct the step-by-step switches toward completion of the call. In another case, such as to another No. 4A toll office, the sender is directed to spill forward multifrequency pulses. If the call is switched to a manual office, the sender is told not to spill forward any digits.

3.51 Other directives include the number of code digits to be outpulsed. For example, the next office may not require the area code therefore the incoming sender is instructed to skip these code digits when spilling forward. In other cases, the incoming sender is instructed to convert the code digits to fit the needs of the next office. This is done when the national office code keyed or dialed by the outward operator is not the same as the local office code used by local subscribers. In this case, the incoming sender is instructed to convert the registered national office code to the local office code required by the switches in the local office. Another important use of code conversion is to switch calls through step-by-step intertoll systems which use arbitrary route codes.

Second Trial Feature

3.52 The marker has a second trial feature for making a second attempt to complete a call. Second trial is made under various conditions: (a) if the marker encounters trouble, (b) if the marker cannot match a channel, and (c) if the marker is given a second trial routing instruction.

(a) Second trial because of trouble conditions is performed in two slightly different ways depending on what phase of marker operation the trouble occurs. If the marker encounters trouble while the decoder is still connected, the decoder causes a trouble record to be taken by a piece of maintenance equipment called a trouble recorder. The decoder also signals the decoder connector that a second trial is to be made. Then the decoder releases itself, the marker connector, and the marker from the connection. Now the call cycle starts again: the decoder connector selects a decoder which in turn selects a marker. This marker is given a second trial indication which causes it to change the direction of its trunk hunting and channel testing. In this way, if the trouble encountered on first trial was connected with the selection of a trunk or channel, testing the second time from the other end might avoid it.

If this marker also encounters trouble in completing the call, the above process is repeated. However, this time the marker does not test the outgoing trunks but routes the call directly to reorder.

If the marker encounters trouble after the decoder has been released in the normal course of its functions, the marker causes a trouble record to be taken. Then the marker sends a second trial indication to the decoder connector and releases itself and the marker connector. The call now proceeds in the same way as described above: A decoder and marker are again selected and another attempt is made to complete the call.

(b) Failure to match: Second trial is made when the marker has seized an outgoing trunk but cannot establish a channel between the outgoing and incoming trunks. This condition is called failure to match and is usually caused by not finding junctors that match with the available links. The procedure for second trial in this case is exactly the same as those discussed above except in one detail: no trouble record is made.

(c) On some calls, the marker is given a follow with second trial routing instruction by the dropped card. The marker uses this instruction if it finds all desired outgoing trunks busy on first trial. Then second trial is made the same way as described before except that no trouble record is made.

3.53 A sketch of the marker frame is shown on Fig. 34.

Switching Frames and Their Connectors

Incoming and Outgoing Frames

3.54 The incoming trunk appearances used in the talking connection are on the incoming frames. Similarly, the outgoing trunk appearances used in the talking connection are on the outgoing frames. The trunk capacities of these frames and other features are described in Part 2.

3.55 As discussed in Part 2, the primary and secondary switches of both the incoming frames and the outgoing frames are connected by links, and the incoming and outgoing frames are connected by junctors.

3.56 The marker gains access to the incoming links for test purposes through an incoming connector mounted on the incoming frame. It gains access to the outgoing links and the junctors through an outgoing connector mounted on the outgoing frame. (See Fig. 33, conns. 1, 4, 6 and 7.)

Home and Mate Operation of Frames

3.57 The marker has dual access to each incoming and outgoing frame for testing links and junctors. For this purpose the incoming, and also the outgoing, frames are paired into home and mate frames. This pairing is as follows: 0 and 1, 2 and 3, etc. (While it happens that a pair of frames is also a group of frames, where grouping is done, there is no relationship between pairing and grouping. Frames are grouped into pairs to maintain the minimum number of junctors per group in large offices, as discussed in par. 2.64 in Part 2. On the other hand, frames are paired with home and mate frames to prevent a frame being put out of service by failure of its connector.)

3.58 Dual access is provided by enabling the connectors on home and mate frames to reach both frames of the pair. Therefore the marker has two ways to reach each frame. Figure 35 shows how this home and mate arrangement works.

3.59 The solid lines show how the marker uses the home connector. When a call comes in on an incoming trunk which appears on frame 0, the marker gains access to the incoming links through incoming frame connector 0. Similarly, the marker, after

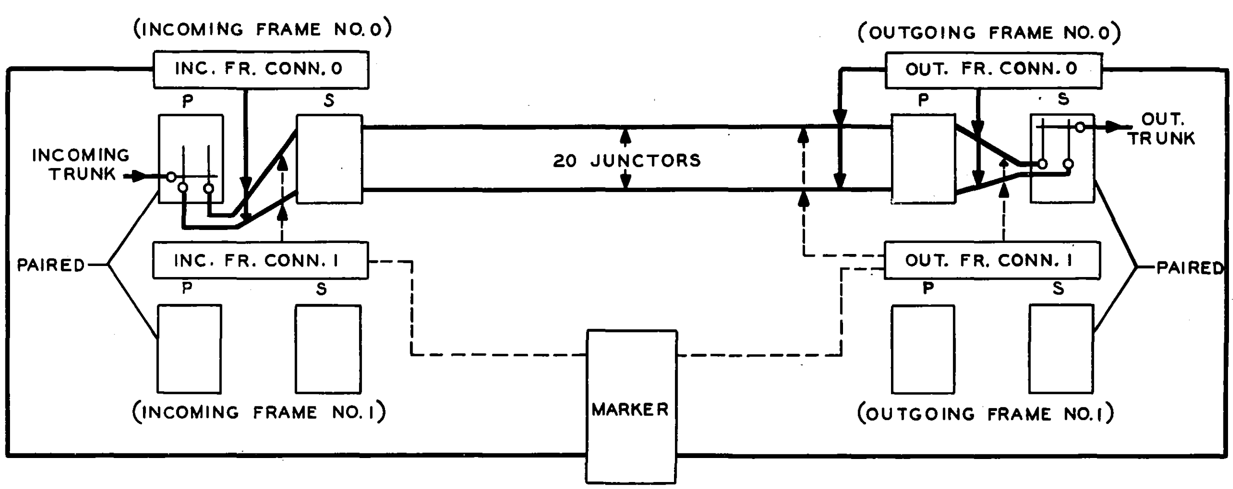


FIG. 35 — PAIRING SWITCHING FRAMES. (HOME AND MATE OPERATION)

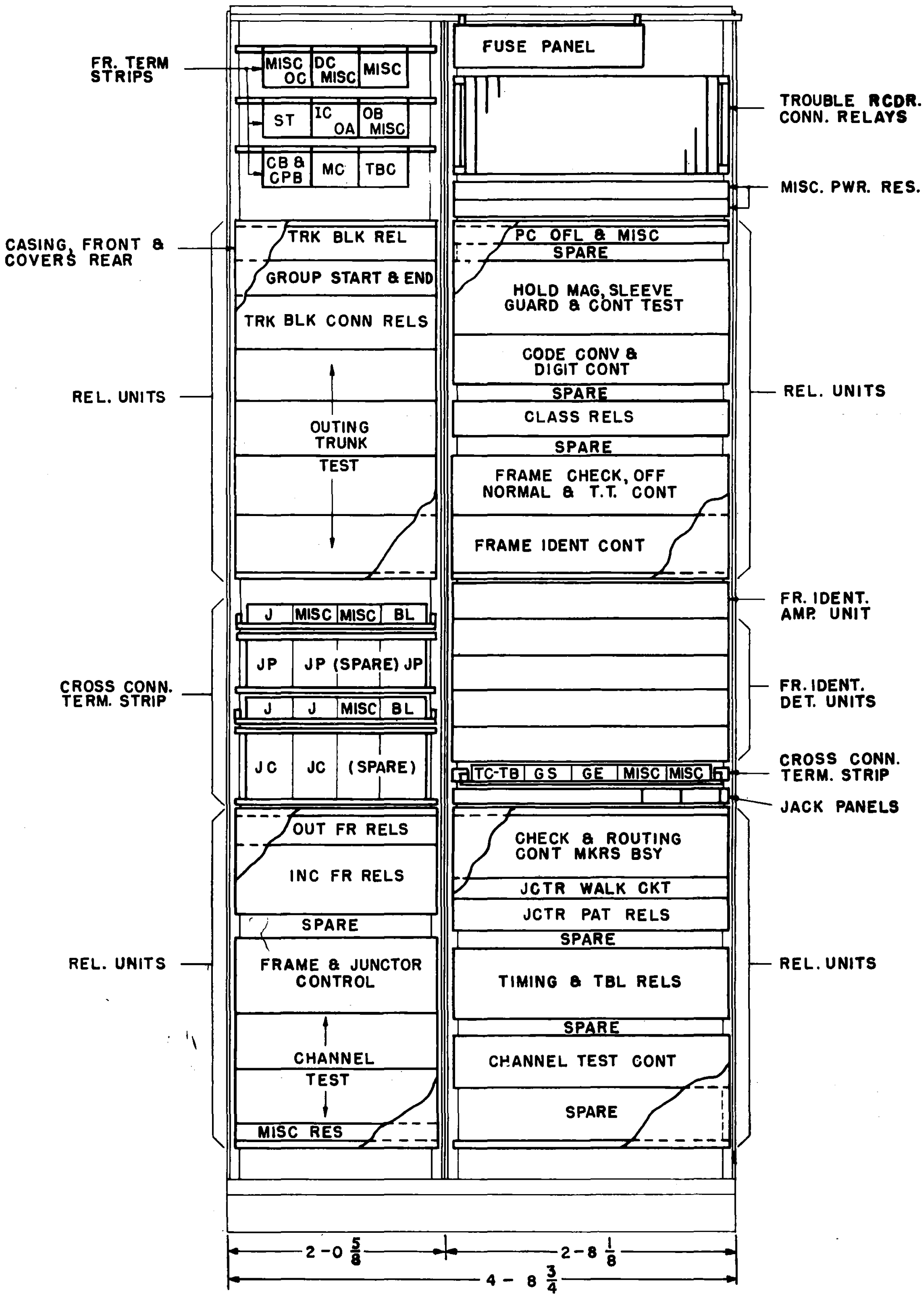


FIG. 34 MARKER FRAME

seizing an outgoing trunk on frame 0, gains access to the outgoing links and the junctors through outgoing frame connector 0.

3.60 The dotted lines show how the marker can use the mate connectors to reach the same links and junctors. For example, if the incoming frame connector 0 is not available for some reason, the marker uses incoming frame connector 1 on mate frame 1 to reach the links on incoming frame 0.

3.61 In the same manner, if outgoing connector 0 is not available the marker gains access to the links and junctors on outgoing frame 0 through outgoing connector 1.

3.62 Sketches of the incoming and outgoing frames are shown in Figs. 36 and 37.

Incoming Sender

3.63 The major functions of the incoming sender are to register the incoming digits and to outpulse them (according to directions from the marker) to a connecting office or an outgoing sender. The incoming senders are arranged to register and outpulse a minimum of three and a maximum of fourteen digits.

3.64 The incoming senders in a 4A toll office are divided into two types according to the kind of pulses they

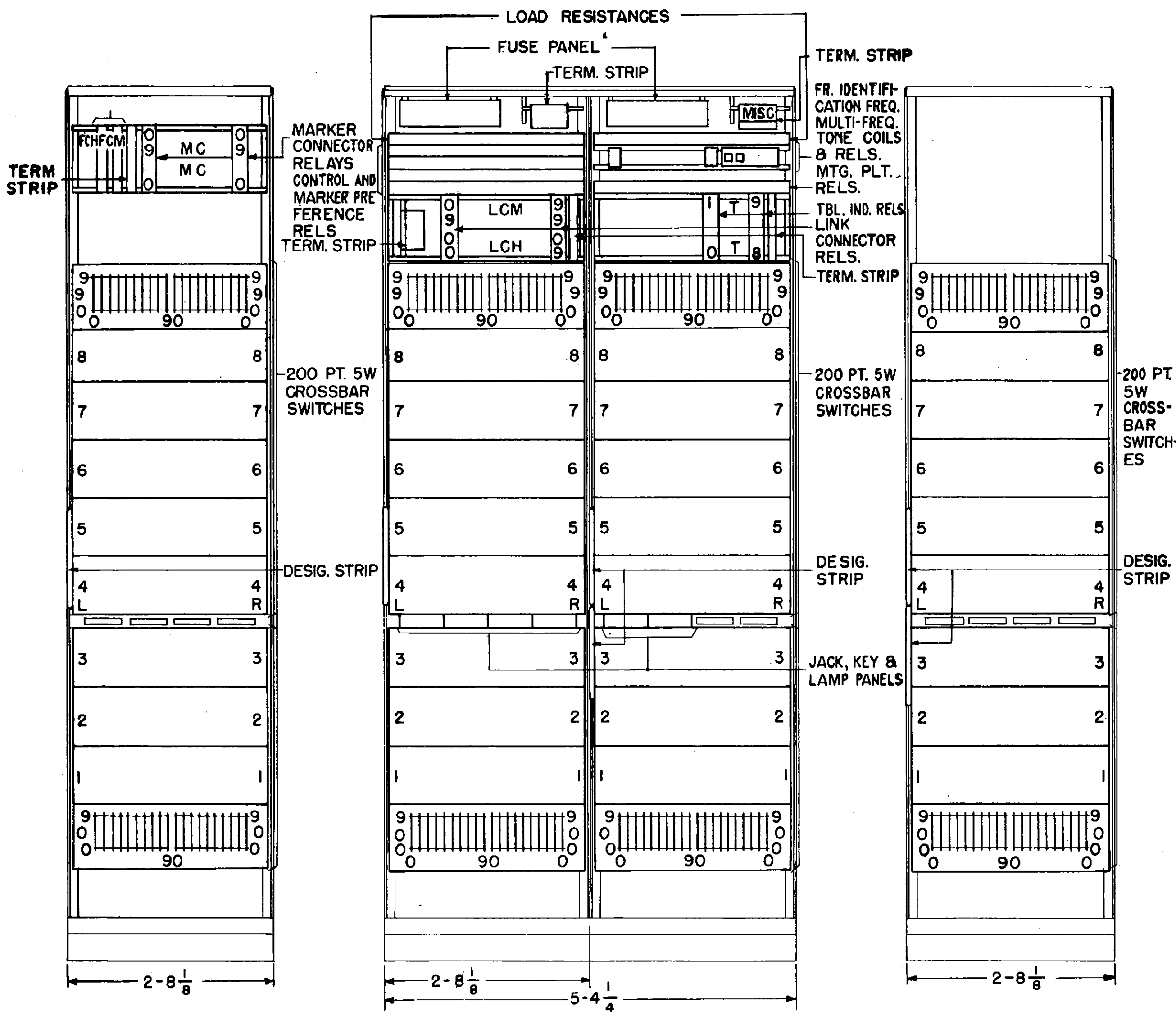


FIG. 36 - INCOMING FRAME

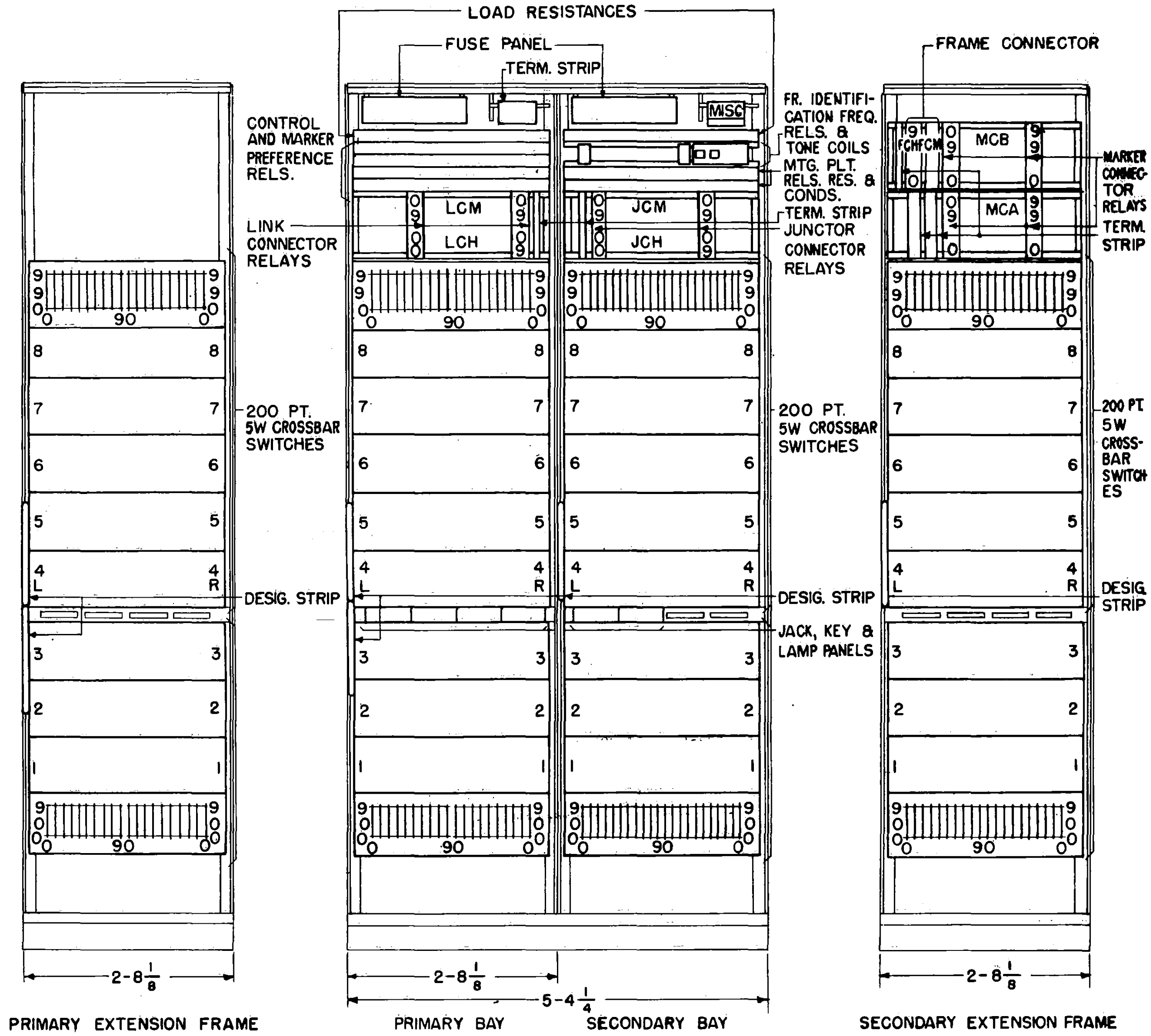


FIG. 37 - OUTGOING FRAME

receive. Multifrequency senders register MF pulses from switchboards equipped with MF key sets or from senders in other automatic offices which can transmit MF pulses. Dial pulse senders register digits from switchboards equipped with dials or from senders which transmit dial pulses.

3.65 Although they register different kinds of pulses, these senders can outpulse both MF and DP in accordance with the needs of the next office. For example, a call switched to a step-by-step office requires the incoming sender to spill forward dial pulses. This same sender can be used on another call to spill forward MF pulses.

3.66 Both types of incoming senders are also arranged to outpulse d-c key pulses when serving calls that require outgoing senders. Outgoing senders are used when the No. 4A toll systems switch calls directly to panel offices or No. 1 Crossbar systems which require revertive pulses, or to manual offices equipped with call indicator positions which require PCI pulses. In such cases the incoming sender spills forward d-c key pulses to the outgoing sender. Then the outgoing sender converts these d-c pulses to revertive or panel call indicator (PCI) pulses and spills them forward to the local office over the outgoing trunk.

Seizure of the Incoming Sender

3.67 Upon receiving a signal from a sender in a distant office, or from an operator, the incoming trunk in the 4A office signals the sender link to connect an incoming sender. (Incoming trunks that carry MF pulses have access to MF incoming senders only, while trunks that carry dial pulses have access to DP incoming senders only.)

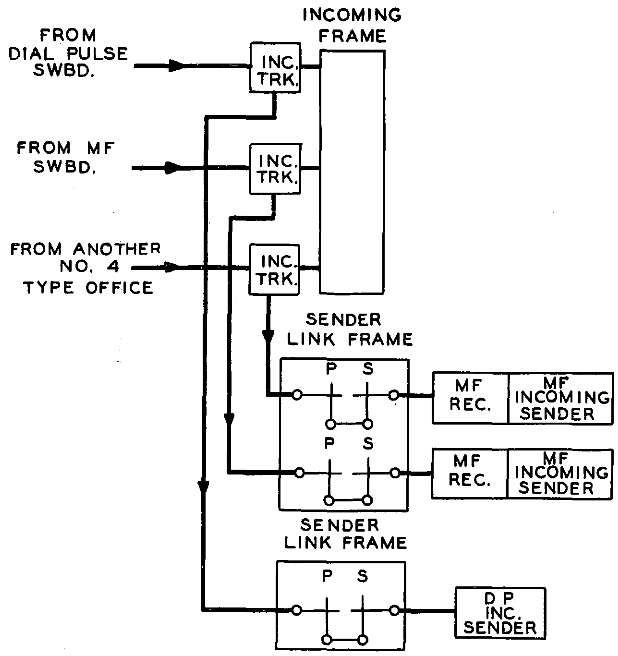


FIG 38 - ACCESS TO INCOMING SENDERS.

3.68 When the incoming sender is attached to the incoming trunk and is ready to receive pulses, it signals the operator or sender in the distant office to begin outpulsing.

Registering the Pulses

3.69 DP Incoming Sender: When an operator receives a signal from the sender, she dials the called number. For example, 212-MU2-1234 is dialed by the operator and registered in a DP incoming sender in the 4A office. On some calls, the decoder and card translator tell the sender how many digits to expect. On other calls, the sender just waits a short time to make sure all the digits are received.

3.70 MF Incoming Sender: When an operator at a switchboard equipped with MF keysets receives a signal, she keys KP 212-MU2-1234 ST. (The same digits are pulsed when this call is outpulsed by an MF sender in a distant office instead of by an operator.)

3.71 The KP pulse is a distinctive combination of frequencies which prepares the MF receiver associated with the incoming sender to receive and register the code digits 216-682, the numericals 1234 and the ST pulse which follow.

3.72 The ST pulse (start pulse) indicates to the sender that all the digits necessary for the control of switching the call have been sent.

Outpulsing Instructions

3.73 After the code digits and numericals are registered, the incoming sender must receive instructions on how to outpulse this called number.

3.74 After the code digits are registered the incoming sender seizes a decoder and marker which instruct the sender how to outpulse the called number. These instructions tell the sender:

(1) The kind of pulses to be spilled forward (MF or DP).

(2) How many of the registered code digits are to be spilled forward.

(3) Whether any of the code digits should be converted before spilling forward.

(4) Whether any code digits should be prefixed before spilling forward.

(5) Not to outpulse anything (for example, on a call to a manual office).

Outpulsing the Digits

3.75 The incoming sender prepares to outpulse the registered digits in accordance with these instructions. In the meantime the marker has established a channel between the incoming trunk and the outgoing trunk. The incoming sender waits for a signal from the distant office, or from an outgoing sender in the same office, that it is ready to receive pulses. Upon receipt of this signal, the incoming sender spills forward the digits, as instructed, via the sender link, incoming trunk circuit, incoming frame, outgoing frame and outgoing trunk circuit to the distant office or outgoing sender.

3.76 At the end of outpulsing the incoming sender and sender link release, leaving the transmission path through the incoming and outgoing frames.

3.77 In case the call is to a manual office and no outpulsing is required, the sender simply checks that an outgoing trunk is attached and releases.

3.78 A sketch of the incoming sender frame is on Fig. 39.

Sender Link Frame

3.79 At the sender link frame, incoming senders are attached to incoming trunks. One frame has appearances for 100 trunks and 40 senders. Each sender link frame contains sixteen 100-point, 6-wire crossbar switches. Eight of these are primary switches and eight are secondary switches. (See Fig. 40, attached.) (From a circuit standpoint, eight 200-point switches could have been used. 100-point switches are used for equipment reasons.) Incoming trunks appear on the horizontals of the primary switches and incoming senders on the horizontals of the secondary switches. The primary and secondary switches are connected by links which are spread in a vertical-to-vertical pattern. This arrangement permits any incoming trunk to reach any available sender on the same sender link frame.

Trunk Appearances on Primary Switches

3.80 As shown on Fig. 40, the eight primary switches are divided into two groups: four A switches and four B switches. The same trunks (a maximum of 100) appear on both the A and the B switches in order to give each trunk duplicate access to the senders. These trunks are connected to like numbered horizontals. Therefore, the A and B groups of primary switches on one sender link frame are symmetrical.

3.81 The four switches in each group are arranged to accommodate 100 trunks. These 100 trunks require 200 horizontal terminations because each trunk has twelve leads and these are only six-wire switches. In order to get two horizontals for each trunk each switch is split after every second vertical (Fig. 40). This split divides the four A switches into twenty pairs of verticals with 200 horizontals. One group of ten trunks terminates on the twenty horizontals of two pairs of verticals.

3.82 Each trunk group has four sender links. The A switches provide two of these links, for example, links 0 and 1 for trunk group 0. The two additional links are provided by the B switches. As shown on Fig. 40, the trunk groups are multipled to the corresponding B switches, therefore trunk group 0 has links 0' and 1' from the B switches.

Sender Appearances on Secondary Switches

3.83 A maximum of forty incoming senders have appearances on the horizontals of the secondary switches. These senders are arranged in four groups of ten or fewer senders. Two of these groups appear on the A switches and two on the B switches. As shown on Fig. 40, each group of ten senders is terminated on two switches (twenty horizontals). Two horizontals (one on each of the two switches) are required for each sender because the twelve leads from each trunk must, of course, be carried all the way from the trunk to the sender.

Sender Links

3.84 Each trunk group has four sender links: two from the A switches and two from the B switches. The sender links from trunk groups 0 and 9 are shown in Fig. 40. For example, trunk group 0 has links 0 and 1 from the A switches to the senders on the secondary switches. Link 0 consists of twelve leads: six from vertical 0 and the other six from vertical 0'. These leads go to the verticals of secondary switches 0A and 0'A (sender group A0 to A9 appears on these switches). Similarly link 1 goes to secondary switches 1A and 1'A and gets access to sender group A10 to A19.

3.85 In the same way, the B switches provide the other two links to sender groups B0 to B9 and B10 to B19 for trunk group 0.

3.86 The four links provide duplicate access for each incoming trunk in case sender link equipment is removed from service for any reason. Also, if either the A or B group cannot be used, two links are still available.

Attaching the Sender

3.87 When an incoming trunk signals for an incoming sender, the sender link connector signals a controller connector to seize an idle link controller. The link controller closes the crosspoints between the incoming trunk on a primary switch and the incoming sender on a secondary switch as described under Link Controller and Connector.

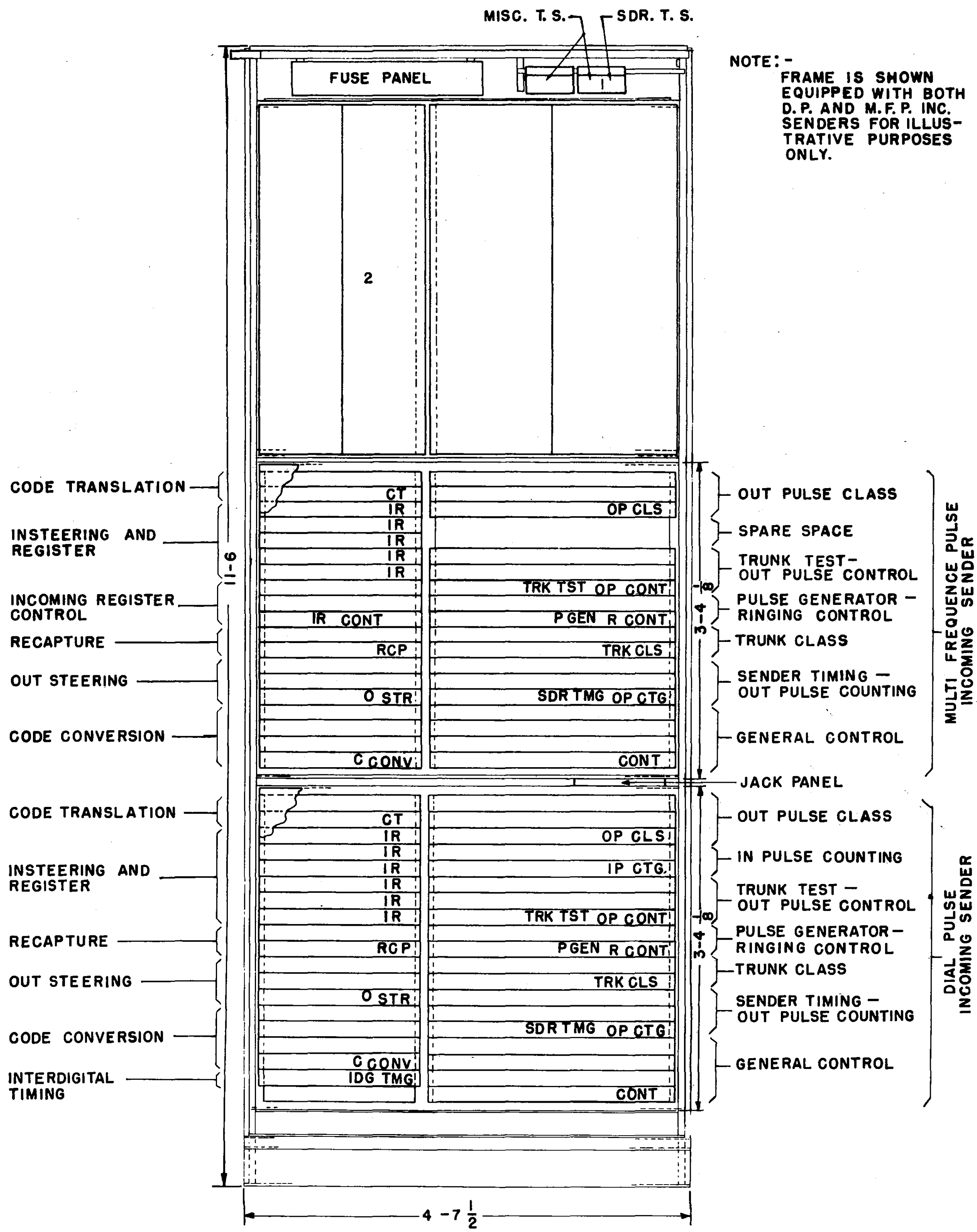
3.88 When the connection is established between the incoming trunk and incoming sender, the sender link connector releases and is ready to serve other calls on its sender link frame.

3.89 MF incoming senders and trunks appear on some sender link frames and DP incoming senders and trunks appear on other sender link frames as shown on Fig. 38. MF and DP senders and trunks do not appear on the same frames.

3.90 A diagram of a sender link frame is shown on Fig. 41.

Link Controller and Connector

3.91 The link controller operates like a simple marker (see Fig. 42). It



FRONT VIEW

FIG. 39 — INCOMING SENDER FRAME

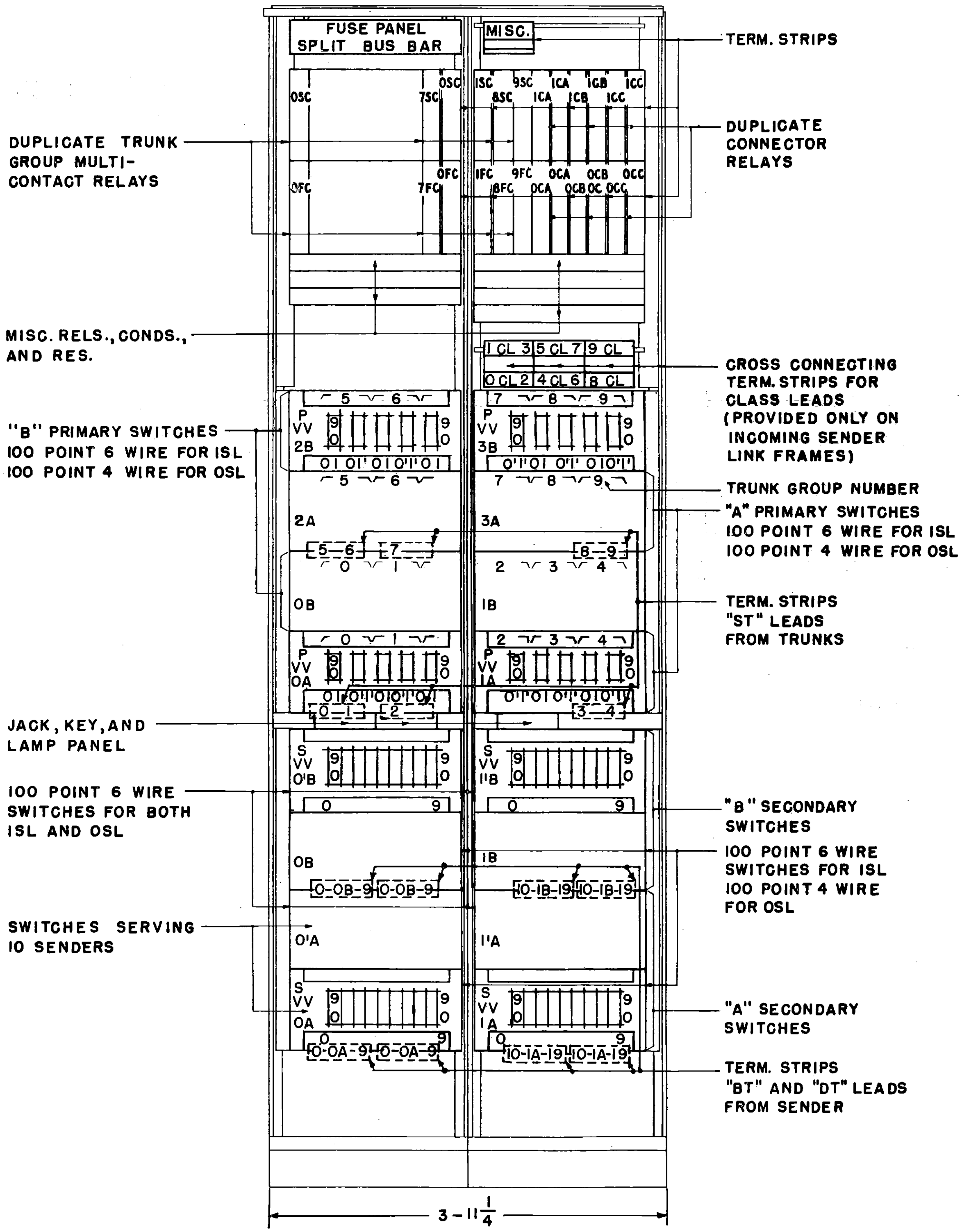


FIG. 41 — INCOMING OR OUTGOING SENDER LINK FRAME

closes the crosspoints between an incoming trunk and an idle incoming sender on a sender link frame.

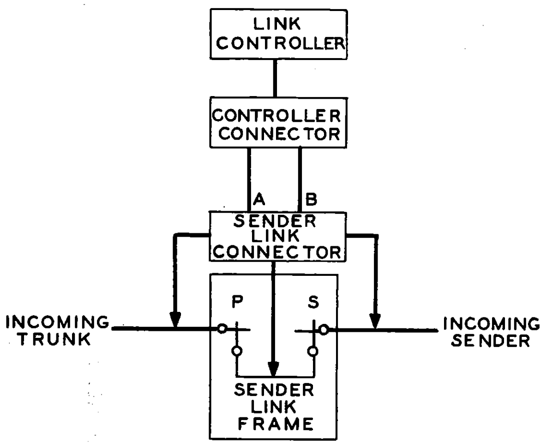


FIG.42 – LINK CONTROLLER OPERATION

3.92 Each sender link connector has access to two controller connectors (see A and B on Fig. 42). When an incoming trunk signals for an incoming sender, the sender link connector signals one of the controller connectors (depending on which is available or, if both are available, which one is preferred at that time) to connect to a link controller.

3.93 Test leads associated with the incoming trunks, the sender, links, and the incoming senders are closed through the sender link and controller connectors to the link controller. The link controller then tests for and selects an idle sender and sender link and connects the incoming trunk to the sender. The controller then releases from the connection and is ready to serve other calls.

3.94 The link controller and connector frame has space for two link controllers and two controller connectors. Link controllers and controller connectors are usually furnished in groups of six which are mounted on three frames. This group of controllers and connectors serves approximately twenty sender link frames. The number of sender link frames served by one group of six controllers is not fixed because traffic requirements vary in different offices. When the capacity of six controllers is reached, another group of six controllers and connectors is provided.

3.95 Figure 43 shows the sender link access to controller connectors and link controllers when a group of six controllers is used.

3.96 Another arrangement is available where it can be definitely determined that four link controllers can meet ultimate requirements.

3.97 A diagram of the link controller and connector frame is shown on Fig. 44.

Decoder

General

3.98 The decoder, together with the card translator, decodes the code digits registered in the incoming sender into information for switching the call. This information is obtained from a card which

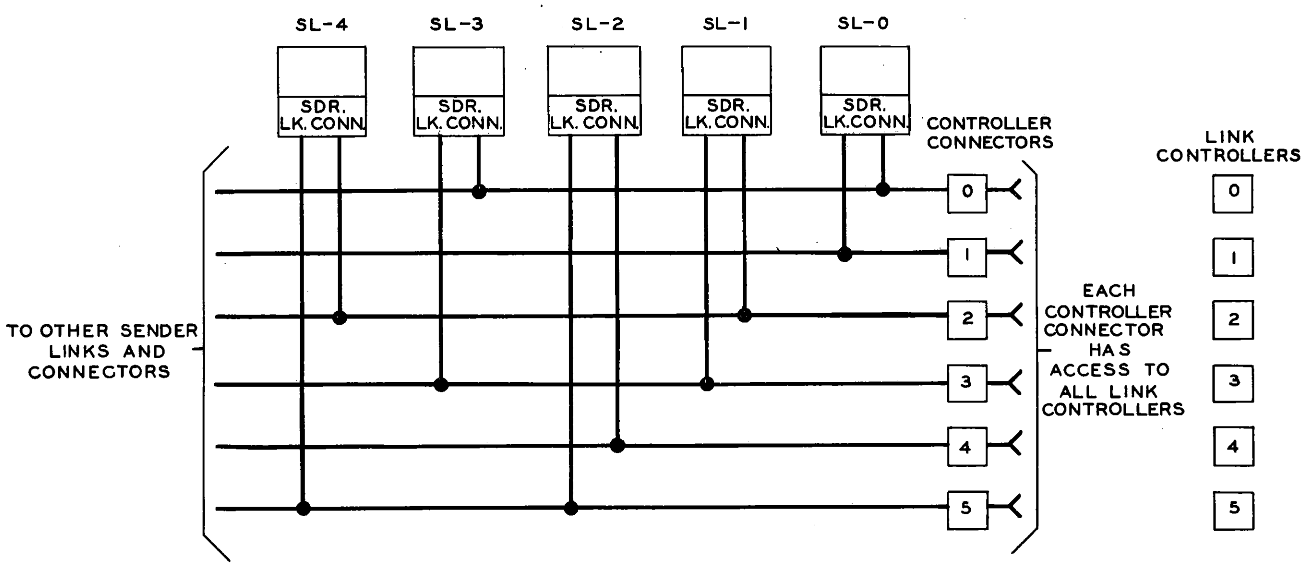


FIG.43 – SENDER LINK ACCESS TO LINK CONTROLLERS.

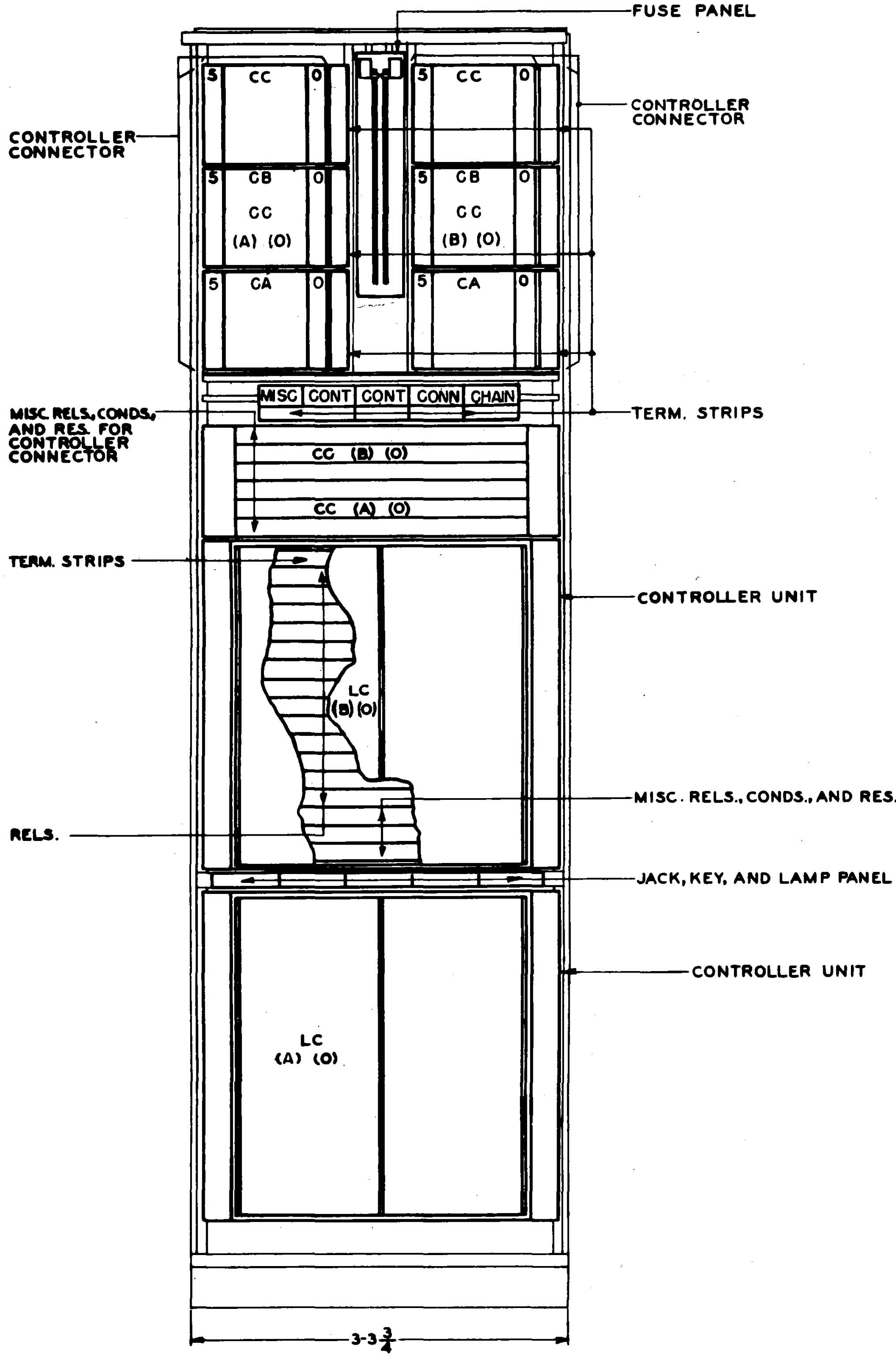


FIG. 44 - LINK CONTROLLER AND CONNECTOR FRAME

the decoder causes to be dropped in the card translator. The decoder, like the marker, has second trial features. Because these are associated with a card failing to drop, they are discussed later in connection with the card translator.

Seizure of the Decoder

3.99 When a decoder is seized by an incoming sender for the first time, it always sends the first three digits registered in that sender to the home translator. Here a card corresponding to these three digits is dropped. This procedure can be considered a starting point for obtaining a translation on every call. Any further action that the decoder takes is determined by the information contained on this first card as follows.

3.100 Three-digit Translation: If the first card indicates that it has enough information to switch the call, then the decoder signals a marker connector to seize an idle marker. The decoder then passes the information it obtains from the card to the marker. The call is then completed in the usual manner.

3.101 Pretranslation: When more than three digits are required to obtain a translation, the first card dropped indicates specifically how many digits are required. For example, one card indicates that four digits are necessary for a certain call; another card indicates that five digits are required for another call; another card indicates that six digits are required for a particular call. In all these cases, the decoder action is the same. The decoder restores the card, signals the incoming sender that more digits are required, releases from the sender, and is available for serving other calls.

3.102 Six-Digit Translation - Six Code Digits Available After Pretranslation: (In this discussion, 6-digit translation is used as an example; the procedure is the same for 4- and 5-digit translation.) After pretranslation has taken place and the sender has the six digits available, it seizes an idle decoder through a decoder connector. Again the decoder drops an identical 3-digit card in its home translator. At this point the sender signals the decoder that six digits are available. This card then directs the decoder to a card translator which has the card corresponding to the six code digits. The decoder restores the first card and reaches out to the proper card translator and drops the 6-digit card. The decoder reads and decodes the information on the card and signals for a marker. The marker then completes the call.

3.103 Six-Digit Translation - Six Digits Available When the First Card Drops: If an incoming sender signals that it has six digits when the decoder drops the first 3-digit card, there is no pretranslation. The decoder learns from the first card (3-digit card) the number of the card translator which contains the 6-digit card. The decoder then restores the 3-digit card and reaches out to this translator and proceeds with the call. Unlike the procedure discussed in paragraph 3.101, in this case the decoder does not release after restoring the 3-digit card.

3.104 As the traffic in an office builds up and incoming senders are waiting for decoders, there will be more instances when six digits are registered in the incoming sender when it first seizes a decoder. Therefore the number of separate attempts for pretranslation will be considerably reduced. However, this is only true for calls requiring 6-digit translation; on calls requiring 4- or 5-digit translation, there is always pretranslation.

Decoder Operation

3.105 One important item of information that the decoder gets from the card and passes to the marker is the location of the outgoing trunks that can be used for a particular routing. The locations of a maximum of forty trunks can be obtained from one card; if there are more than forty trunks for a particular routing, then two or more cards are necessary. (One card is limited to forty trunks because the marker can test a maximum of forty trunks at one time.)

3.106 When there are two or more cards available, a decoder can operate in one of three different ways: card-to-card, relay-to-relay, or card-to-relay operation. In card-to-card operation, the decoder presents a series of cards to a marker and leaves it up to the marker to test for an idle trunk. In relay-to-relay operation, the decoder first checks for idle trunks and then presents the card corresponding to the subgroup containing one or more idle trunks to the marker. Card-to-relay operation contains certain features of both card-to-card and relay-to-relay operation.

(1) Card-to-Card Operation: In this type of operation, the decoder advances from one subgroup of forty trunks to another subgroup of trunks by presenting a series of cards (maximum four) to a marker which then tests for idle trunks in these subgroups.

From a routing instruction on the 3D card (or 6D card) that it drops, the decoder learns that this is card-to-card operation. It passes this information on to the marker by sending a hold signal (meaning more cards available) along with the location of the forty trunks on the first card.

If the marker finds an idle trunk on this 3D (or 6D) card, it signals the decoder to release and proceeds with the call. If the marker finds the first forty trunks busy, it signals this to the decoder. Then the decoder restores the 3D (or 6D) card and, from information supplied by this card, advances to another card (RA1 card) which represents additional trunks. In this way a maximum of four cards, a 3D (or 6D) card and three route advance cards (RA1, RA2 and RA3) representing 160 trunks, can be presented to the marker.

In order to dispose of the call, if there are no idle trunks available, the last card carries a routing instruction which directs the marker to connect the call to a reorder or overflow trunk.

This type of operation is generally used on outgoing trunks to local offices.

(2) Relay-to-Relay Operation: In this type of operation, unlike card-to-card, the decoder does not present a series of cards to the marker for finding an idle trunk. In relay-to-relay operation, the decoder first checks for the availability of trunks in both direct and alternate route trunk groups before it presents a card to the marker. However, the decoder does not actually drop each card but it learns from the 3D or 6D card which trunks to check. It checks these trunks by means of a group of route relays known as a relay tree. Each route relay represents a group of (maximum) 160 trunks. These relays are interconnected to provide a definite order of progression (a direct route progressing to successive alternate routes) according to the basic switching plan.

Each route relay is associated with a maximum of four group busy chain lead circuits; one chain lead circuit for each subgroup of 40 trunks. The operation of a route relay permits the decoder to check the group busy chain leads and determine whether there are idle trunks in any of the subgroups. If there are no idle trunks the decoder operates the next route relay and so on.

In order to dispose of the call if there are no trunks available, it always appears to the decoder that there are idle trunks in the last subgroup. Therefore the decoder drops the card representing this subgroup and presents it to the marker. The marker then tests these trunks, finds them busy, and uses the routing instruction on the card to dispose of the call.

A maximum of 960 trunks can be checked by the decoder in relay-to-relay operation. These 960 trunks are represented by 24 cards called alternate route (AR) cards. The decoder can drop any one of these cards which contains idle trunks.

(3) Card-to-Relay Operation: This is a combination of the above two types of operation. The first part of this operation is like card-to-card operation: the decoder presents up to a maximum of four cards to the marker. The second part is like relay-to-relay operation: the decoder goes to the relay tree and checks the alternate route trunks that can be used to switch the call.

During the card-to-card part of this operation, the decoder presents a 3D (or 6D) card and, if necessary, a series of route advance (RA) cards to the marker. If the marker finds an idle trunk on one of these cards, it uses this trunk to complete the call.

However, if it is necessary to advance as far as the last RA card, the decoder starts the relay-to-relay part of card-to-relay operation. This last RA card carries the card-to-relay routing instruction which tells the decoder to go to the relay tree.

A maximum of 1120 trunks (160 in the card-to-card part and 960 in the relay-to-relay part) can be tested in this way.

3.107 One of these three methods of operation is used by the decoder on every call for which there are more than forty trunks available. The decoder is told which method to use on a particular call by the routing instructions on the first 3D or 6D card dropped.

3.108 A diagram of the decoder frame is shown on Fig. 45.

Card Translator

General

3.109 The card translator translates the code digits registered in the incoming sender into information which is used by the common control equipment to switch a call. The card translator gets

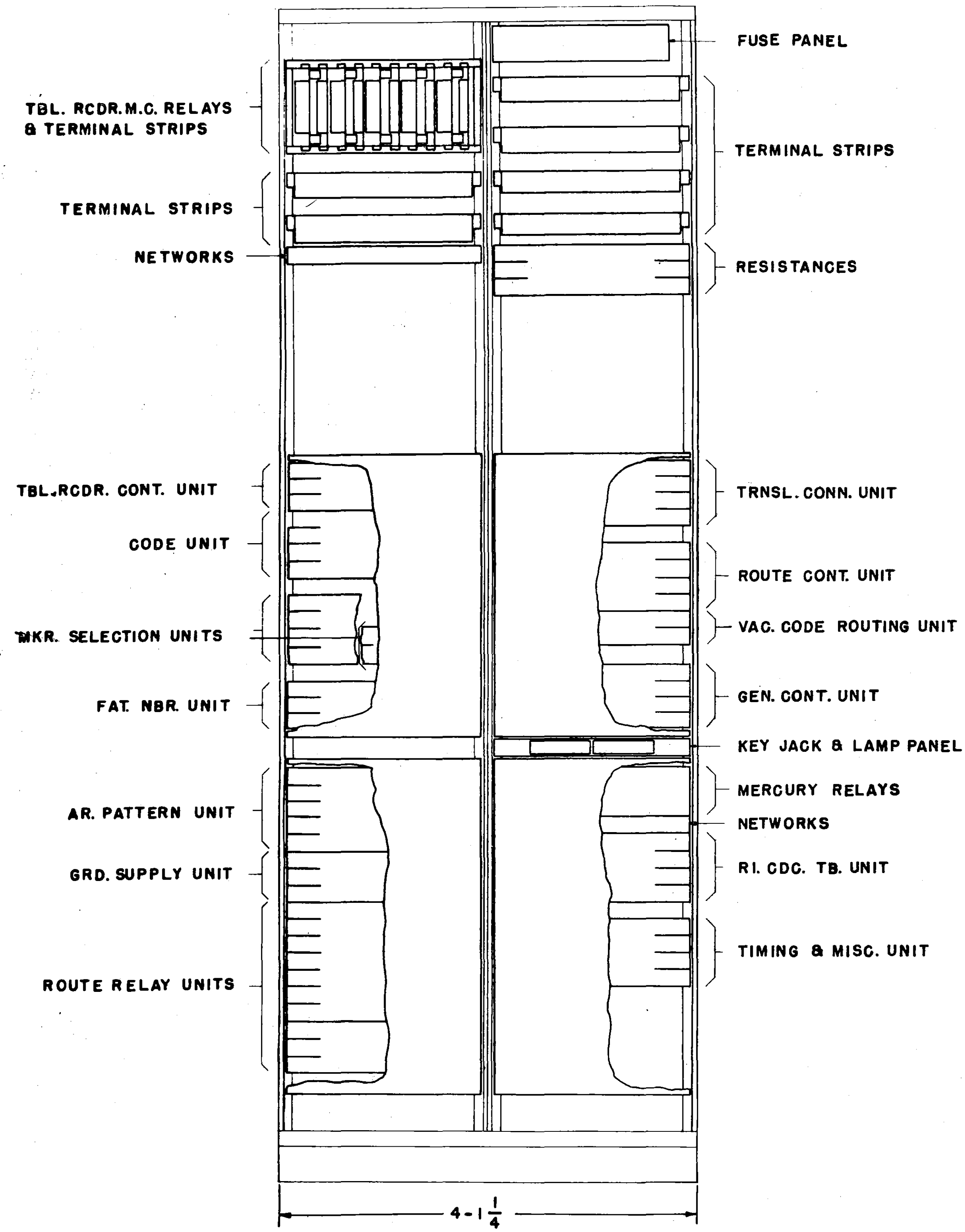


FIG. 45 — DECODER FRAME

its name from the fact that metal cards are used in the translation process. This type of translator is new with the 4A system and is quite different from the conventional relay-type translators used in other systems.

3.110 Each card translator contains metal cards which provide the switching information. As shown on Fig. 46, attached, each uncoded card has 40 tabs and 118 holes. The tabs are used to mechanically code the card so that the proper card can be selected in the card translator. This is done by removing some of the tabs so that the remaining tabs are arranged in a definite pattern. The holes in the card are also coded; these correspond to the switching information needed for a particular called code. Each of these holes has a meaning and the switching information is put on the card by enlarging certain of the holes.

Types of Translators

3.111 There are four types of card translators:

(1) Home Translators

(2) Foreign Area Translators

(3) Decoder Foreign Translators

(4) Emergency Translator

These translators are basically the same both from physical and electrical characteristics. Their main difference is in the type of cards they contain, for example, cards for 3-digit translation in home translators and cards for 6-digit translation in foreign area translators.

3.112 The maximum number of card translators in one 4A office is 40: 10 home translators (one for each decoder), 19 foreign area translators, 10 decoder foreign translators (one for each decoder) and one emergency translator.

3.113 One home translator is directly associated with each decoder in the office (Fig. 47). On every call, once a decoder is seized, it drops a 3-digit card in its own home translator. It will be remembered from the discussion of the two calls in the beginning of this part, that any decoder can handle any call. Therefore all the home translators in the office contain identical sets of cards.

3.114 If a 3-digit card fails to drop, the decoder releases and gives a second trial indication to the decoder connector. The connector selects another decoder and a second attempt is made to drop an identical card. If a card drops, the call goes to completion and the decoder calls in the trouble recorder which records the failure to drop a card on the first attempt. However, if a card fails to drop on second trial, the decoder assumes this is a blank code and routes the call to a reorder trunk.

3.115 The home translator does two things:

(1) Provides switching information for calls requiring 3-digit translation.

(2) Directs decoders to foreign area translators for calls requiring 4-, 5-, or 6-digit translation.

3.116 Each foreign area translator contains all the 6-digit cards required for completion of calls to several particular foreign areas. For example, one translator may contain all the cards for three foreign areas and another for five foreign areas. Therefore, unlike home translators, a certain foreign translator must be used on each call. On a particular call the foreign area translators are available to all decoders through connectors. The card dropped in the home translator directs the decoder to a specific foreign area translator.

3.117 These foreign area translators can be arranged in two ways: (1) they can be paired and nonpaired, or (2) they can all be nonpaired.

3.118 Nonpaired translators contain 6-digit cards for calls which, if routing is not obtained (no card drops, out of service, etc.) at the foreign area translator, can be routed by principal city routing from the home translator without second trial. (See Part 1, par. 1.176 to 1.178.)

3.119 If there is no principal city routing for certain calls, then some of the foreign area translators in an office are paired. Both members of a pair of translators have identical sets of cards.

3.120 If a 6-digit card fails to drop for any reason in one paired translator, the decoder releases and gives the decoder connector a second trial indication. This connector selects another decoder which goes to the other translator in the pair and attempts to drop a duplicate 6D card. If the card drops, the call goes to completion and the decoder calls in the trouble recorder which records the failure of the paired translator to drop a card on the first attempt. However, if a card fails to drop on second trial, the decoder assumes this is a blank code and routes the call to a reorder trunk.

3.121 The number of paired and nonpaired foreign area translators depends on

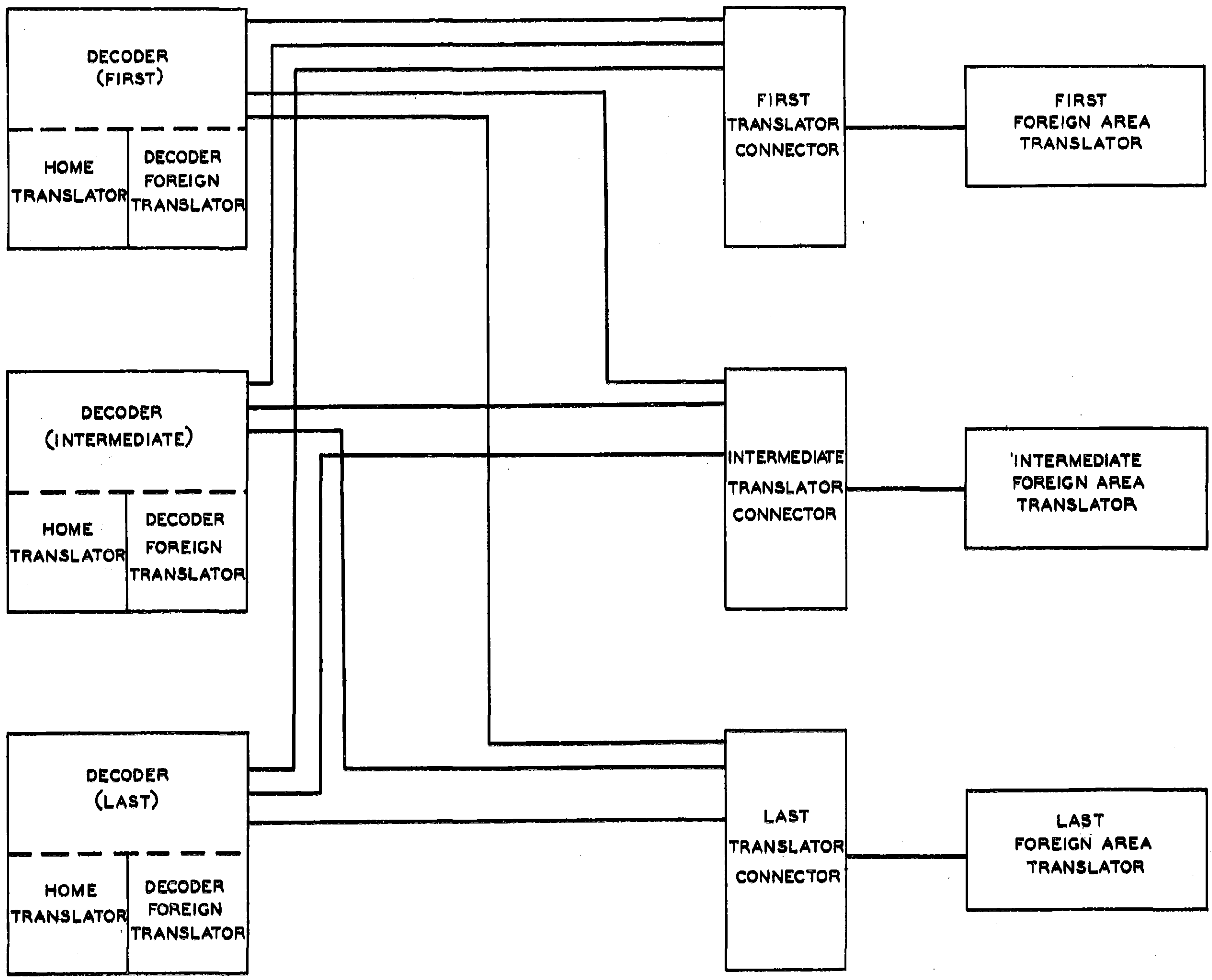


FIG. 47-DECODER ACCESS TO CARD TRANSLATORS

the needs of an individual office. Each translator is numbered, starting with 01 and going up to 19.

3.122 In some cases, the demand for 6-digit translations to certain foreign areas is so heavy that decoder foreign translators are needed. Like home translators, these decoder foreign translators are directly associated with the decoders (Fig. 47). This avoids decoder delays in obtaining translations which might occur if the cards for these frequently called foreign areas were in the common group of foreign translators. For example, New York may require decoder foreign translators containing cards for Washington and Philadelphia because of the heavy traffic to those areas.

3.123 If a 6-digit card fails to drop in the decoder foreign translator, the action taken depends on whether a principal city route is available for that particular call. If there is no principal city route, second trial is made. If there is a principal city route, the decoder goes back to the home translator and completes the call from the principal city routing instruction on the 3D card.

3.124 Like the foreign area translators, these translators must contain all the cards for certain areas; however, because they are associated with decoders, the decoder foreign translators contain identical sets of cards. All decoder foreign translators are designated 00.

3.125 One emergency translator is furnished in each office. This translator can, when necessary, replace any translator in the office.

3.126 Whenever a translator has to be taken out of service, its cards are transferred to the emergency translator. Usually the emergency translator is furnished with a set of home translator cards so that a home translator can be replaced very quickly.

3.127 In this discussion of the basic functions of the card translator, it is not necessary to distinguish between these four types.

Operating Features

3.128 One card translator contains a maximum of 1020 cards and each card has a different combination of tabs left on it so that one card provides a translation for one called code. One of the advantages of the card translator is that a translation change can be made quickly by replacing one of these cards.

3.129 In the translator the cards are stacked between a light source and a bank of phototransistors. There is one phototransistor for each hole in the card. Each phototransistor has an amplifier and detector circuits associated with it. The principle of the card translator is based on the activating of these light-sensitive phototransistors by beams of light. The phototransistors respond to these light beams by passing a signal on to the amplifier and detector circuits. These circuits operate relays that correspond to the enlarged holes in the card and thus transmit information to the decoder.

3.130 When the card translator is unoperated the light has no effect on the amplifier and detector circuits. However, when the translator is operated, that is, a card is dropped, these circuits are activated and then the light is effective.

3.131 Dropping a Card: In the translator, the stack of cards rests on forty code bars which correspond to the forty code tabs. Figure 48A shows a card resting on these code bars when the card translator is unoperated. When the decoder connects to its card translator, it operates certain code bars in the card translator to drop the desired card. One card drops, all the rest remain in their original position. Figure 48B shows operated code bars and how the card with the corresponding tabs drops. It can be seen by comparing Figs. 48A and 48B that the card with the corresponding tabs drops down to the operated code bars. Since each card in one card translator has a different combination of code tabs, only one card drops at a time.

3.132 There are two holes in each card (see Fig. 46) called index holes (IND1 and IND2) which are used to indicate whether the cards are in the proper position during both the operated and unoperated periods. When the card translator is normal (unoperated), the light goes through all the holes on the card, including these IND1 and 2 holes. If a card is dislocated and the light through either or both of the

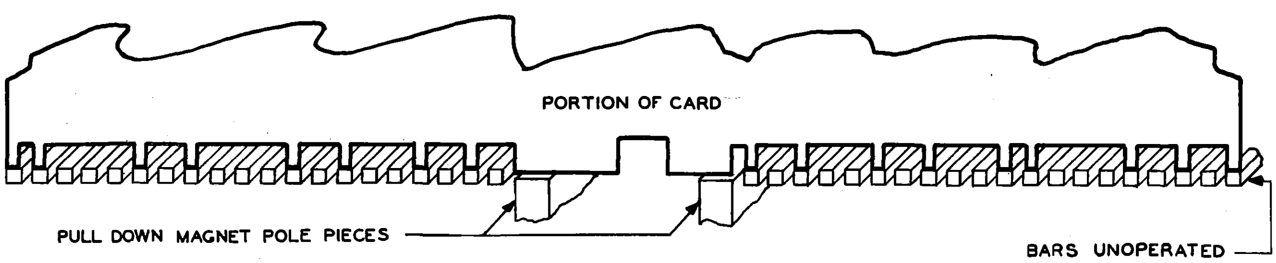


FIG. 48A-CARD SUPPORT AND CODE BARS NORMAL

IND1 and 2 holes is cut off, the card translator sounds an alarm.

3.133 The IND1 and 2 holes are never enlarged, therefore when a card drops, the light channels through these holes are always cut off. The cutting off of these light channels signals the decoder that a card is in position to be read. However, if a card does not drop properly, and the light channels through either or both the IND1 and 2 holes are open, the card translator sounds an alarm.

3.134 Reading the Dropped Card: When a card drops, there is a shutter effect on all the light channels except the ones in line with the enlarged holes on the dropped card. Figure 49 shows a dropped card with light channels going through the enlarged holes and cut off from the other holes. When the card is in a position to be read, the amplifier and detector circuits associated with the phototransistors are energized and read the coded light channels. The translation information is then obtained by the decoder and the marker. (The "gate" shown on Fig. 49 is the mounting for the phototransistors.)

3.135 It is important to note that when a card translator is unoperated, the light shines through all the holes in the card. When a translator is operated and a card is dropped, light passes only through the enlarged holes on the dropped card.

Mechanical Sequence of Operation

3.136 Figure 50 is a simple schematic showing the mechanical and optical elements of the card translator. When a decoder connects to a card translator, the pull-up magnets are energized to lift the card stack about 3/16 of an inch from the code bars. This magnetic action also tends to separate and straighten the cards in the stack. (To assist in lifting the stack of cards, the code bars under the card support tabs (CS1 and 2, Fig. 46) also raise slightly. These tabs are always left on the card.) The latch supporting the code bars then operates, freeing the code bars for downward motion.

3.137 As shown in the figure, there is a solenoid attached to both ends of each code bar. The solenoids on the code bars which correspond to the called code are activated by the decoder and pull down the desired bars and the CS1 and 2 bars. Then the latch releases and holds the code bars down. The pull-up magnets are released and the pull-down magnets operate. All the cards now are back in their original position on the unoperated code bars while the selected card drops to the operated code bars.

3.138 When the card has dropped, the cutting off of the light channels through the IND1 and 2 holes in the face of the card signals the decoder that a card is in position to be read. The amplifier circuits associated with the

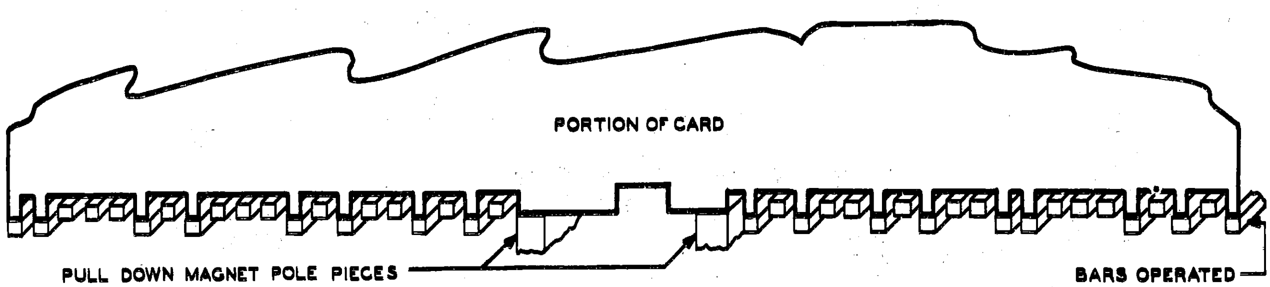


FIG. 48B-CARD SUPPORT AND CODE BARS OPERATED (CORRESPONDING CARD DROPS)

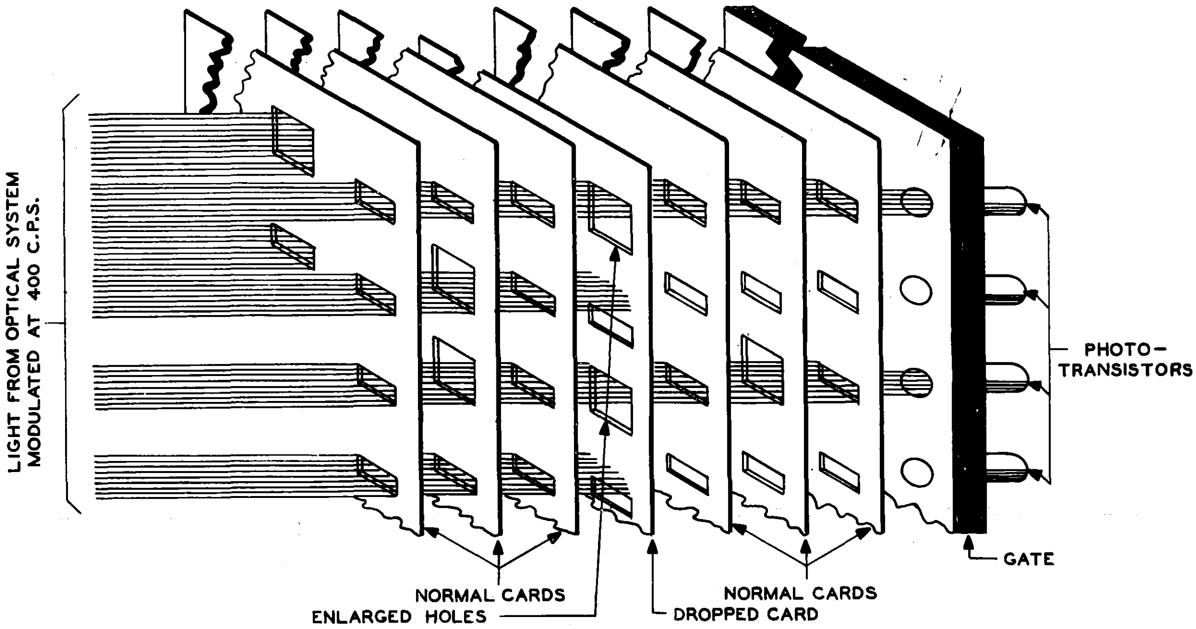


FIG.49 – EFFECT OF DROPPED CARD ON LIGHT CHANNELS

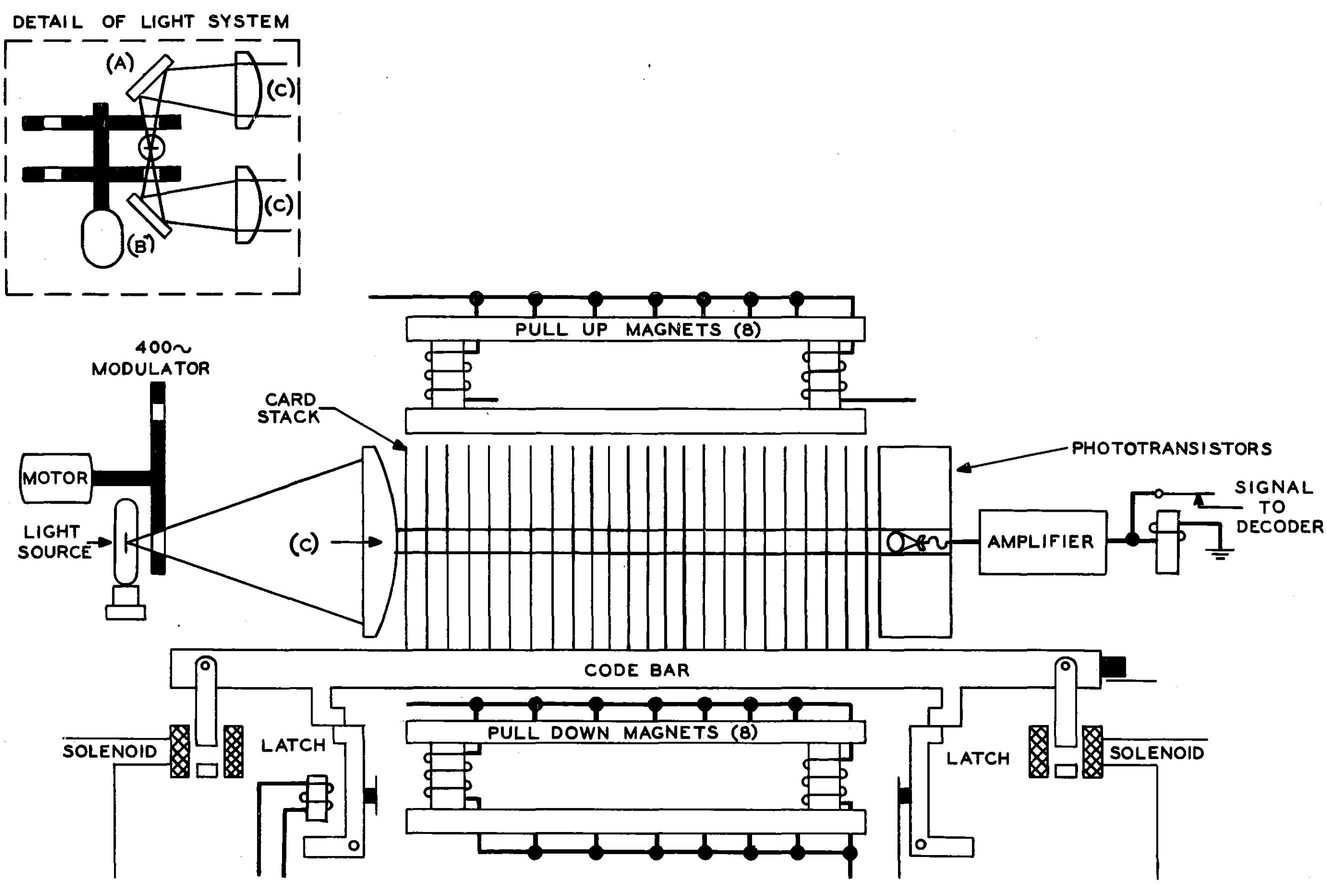


FIG. 50 – ELEMENTS OF THE CARD TRANSLATOR.

phototransistors are then energized and the decoder and marker read the open channels to obtain the translation information.

3.139 When the card translator is restored to normal, the latches are again operated. The pull-up magnets and the CS1 and 2 code bars again lift the cards off the code bars which restore to their normal position. The latches also go back to their normal position, the pull-up magnets and the CS1 and 2 code bars release and the card translator is normal.

3.140 During periods of heavy traffic the card translator may be immediately reseized. To save time, the pull-up magnets remain operated a short time in order to permit releasing the latches immediately upon reseizure.

The Light System

3.141 The light or optical system is arranged in the following way (see Fig. 50). A lamp is mounted between two slotted wheels (attached to a motor) that are constantly chopping the light at 400 cycles a second. Mirrors A and B reflect the light to two lenses (C) which are mounted in front of the card stack. (Each lens covers half the card.)

Equipment and Maintenance Features

3.142 The card translator equipment is mounted in a shop-wired metal floor cabinet. This cabinet contains the detectors, tubes, amplifiers and relay equipment needed in the operation of the card translator. The card translator machine is mounted on top of this cabinet. (See Fig. 51.) The 1020 cards in the card translator are placed in 12 bins, each with a capacity of 85 cards. (The minimum number of cards in one bin is 60.) However, these cards are not in any particular order and any card may be placed in any bin.

3.143 Provision is also made for removing or inserting cards in the translator. A card can be selected and removed by a mechanism in the translator which is activated by some controlling keys on the test frames. Cards are added by manually inserting them in the bins (see Fig. 52).

3.144 The code bars, latches and solenoids, which are the critical apparatus, are built into a unit which can be removed for maintenance purposes. The lenses are also easily removable for cleaning. The phototransistors can be reached by swinging out the gate on which they are mounted.

3.145 Figure 53 is a photograph of the punching machine used for enlarging the holes and coding the tabs on each card.

The Translator Card

3.146 A short discussion of the sort of information supplied by the translator card (see Fig. 46) is given here. The complete story on how various coded cards are used is in the detailed Section A828.121, No.4A Toll Switching Office.

3.147 The information on a card is divided into two major categories: input information and output information.

3.148 Input information is put into the translator by the decoder in order to drop a card. This information is put on the tabs at the bottom of the card. As mentioned before, the card is coded by using various combinations of these tabs. The arrangement of these tabs determines:

(a) What kind of card this is - 3-digit, 6-digit, alternate route, route advance.

(b) Called code - area code, national office code, TX code, service code.

(c) The grade of trunk to be used in the connection.

3.149 Looking at Fig. 46, the CG position identifies the kind of card. A combination of two tabs is used for each kind. For example, a 3-digit card retains tabs 1 and 4, the other two tabs are removed.

3.150 The A through F positions are used for the various called codes. Using a 2-out-of-5 coding system, two tabs are left in each position to identify one digit. For example, a card for area 201 would retain tabs 0 and 2 in the A position, 4 and 7 in the B position, and 0 and 1 in the C position. The tabs in the D through F positions would be removed.

3.151 The VO and NVO tabs identify the grade of trunk to be used in switching the call. The VO tab means Via Only trunk (high grade transmission); the NVO tab means Non Via Only (low-grade transmission).

3.152 Output information, which is used for switching a call, is provided by the holes on the card. On Fig. 46, groups of holes are labeled according to the types of information they furnish. The enlarging of certain holes within each group gives the specific information. Not all groups of holes are used on every call. Various calls require different amounts and kinds of information.

3.153 One of the most important pieces of information provided by the card is the location of the outgoing trunk to be used in the call. This is given by the OGT

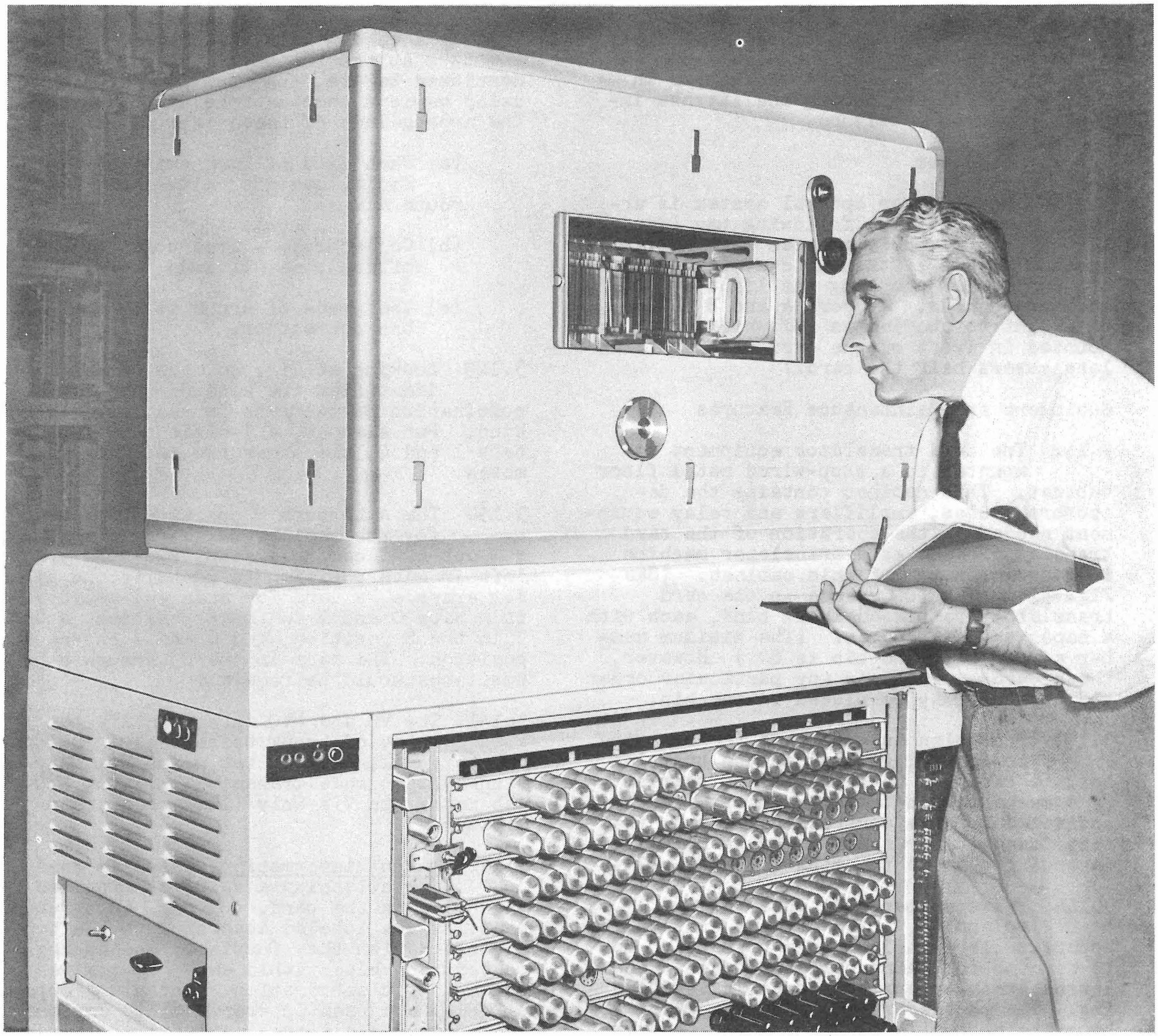


FIG. 51
CARD TRANSLATOR
(COVER REMOVED)

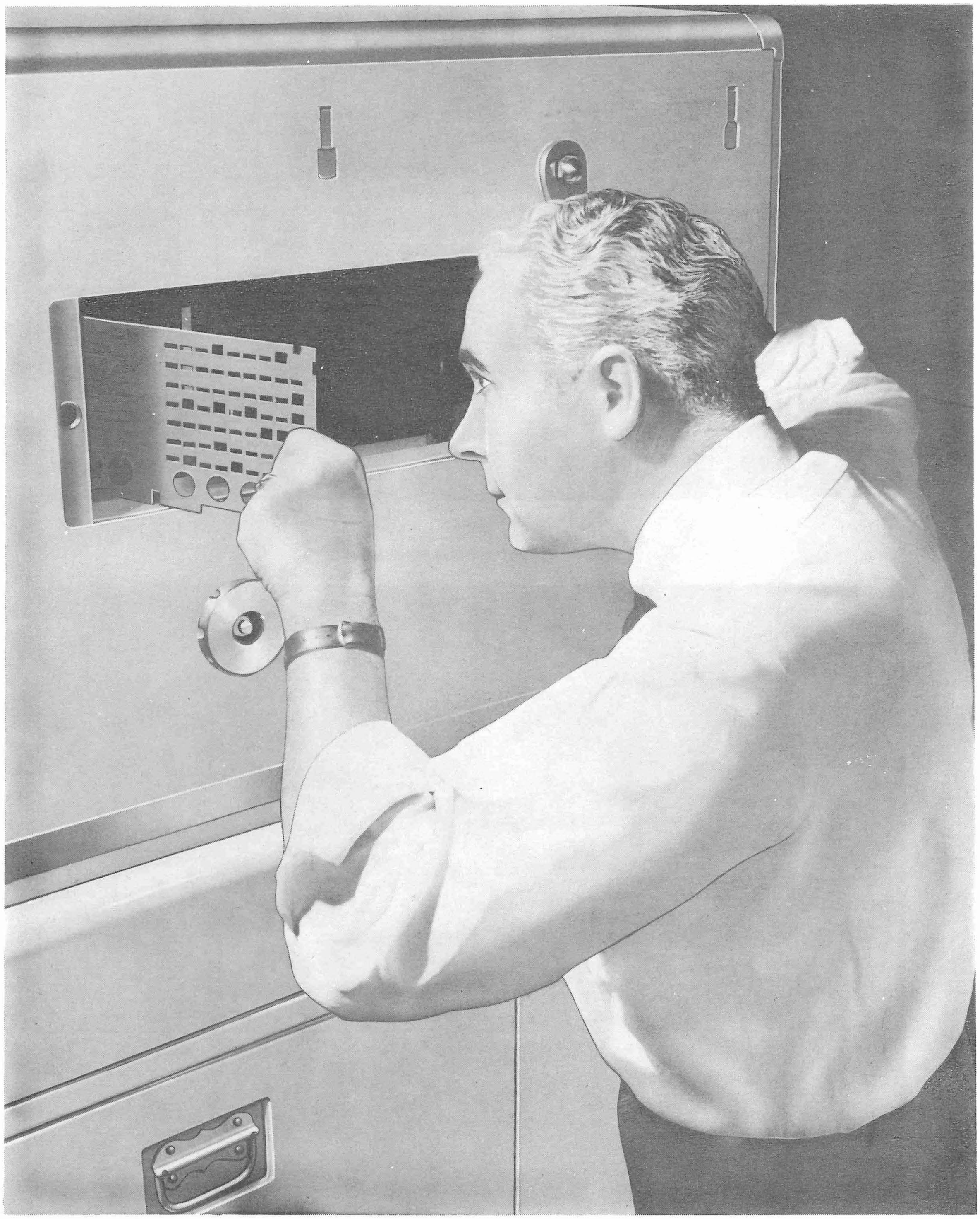
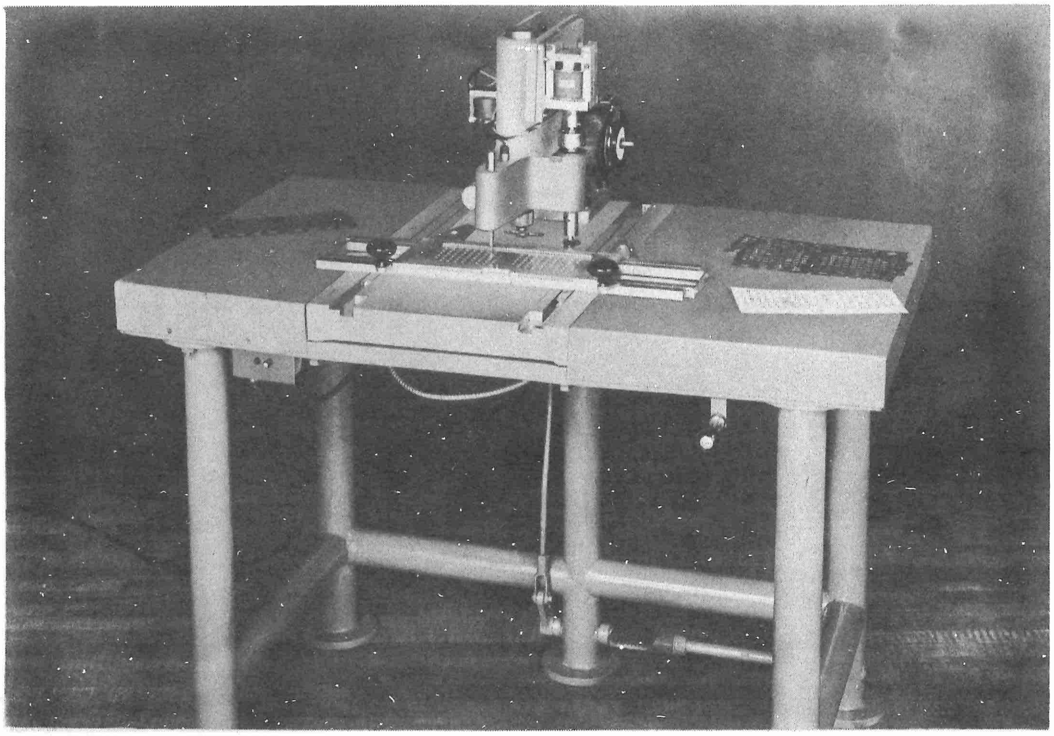
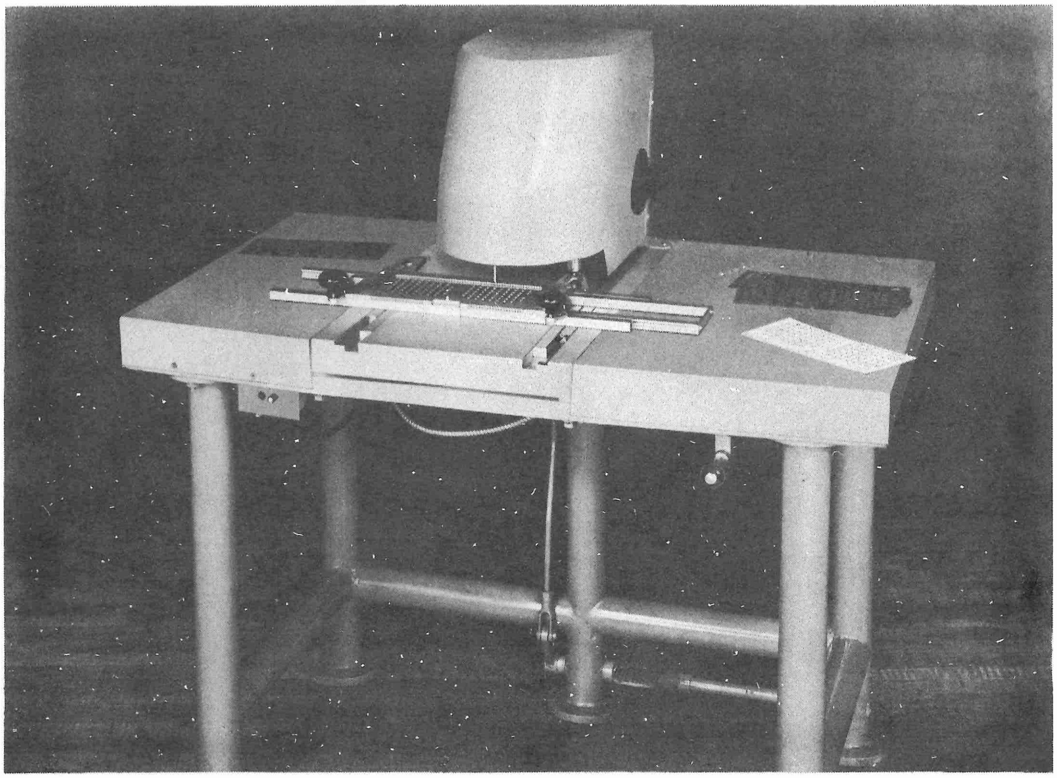


FIG. 52
INSERTING CARD IN
CARD TRANSLATOR



FRONT ELEVATION GUARD REMOVED



FRONT ELEVATION GUARD IN PLACE

FIG. 53
PUNCHING MACHINE FOR ENLARGING
HOLES IN THE CARD

appearance and the Trunk Block Connector groups of holes. The following are other examples of the sort of information that the card provides:

(a) PRETRANSLATION - This tells whether pretranslation is needed and how many digits are required. For example, when the CA6 hole is punched in the pretranslation group, it means that 6-digit translation is necessary and that the decoder should "come again" when it has received six digits.

(b) ROUTING INSTRUCTIONS - These instruct the decoder how to proceed: card-to-card, relay-to-relay, card-to-relay; follow with second trial, master busy, or overflow; and whether there is principal city routing. For example, a card-to-card routing instruction is shown by punching the RI4 and RI7 holes.

(c) VARIABLE SPILL CONTROL - This tells how many digits are to be spilled forward to the next office. For example, when a called code is to be spilled forward without any change, the NSK (no skip) hole is punched.

3.154 A list of the abbreviations for the various holes and their meanings is given below.

Group	Designation	Significance
PRETRANSLATION	NCA	No come again
	CA4-5-6	Come again with 4, 5 or 6 digits
OGT APPEARANCE	IT	Outgoing trunk appears on the intertoll train
	TC	Outgoing trunk appears on the toll completing train
	ITC	Outgoing trunk appears on both trains. The decoder must determine the proper train from the location of the incoming trunk.
TRAFFIC SEPARATION PEG COUNT	TSO-2	Outgoing traffic separation class (arbitrary numbers) peg count 0 through 6
THROUGH TRAFFIC PEG COUNT	TPC	Through traffic peg count
TRUNK GROUP PEG COUNT AND OVERFLOW	TPO-2	Trunk group peg count and overflow (arbitrary numbers) 0 through 7
INDEX	IND1-2	Index channels used for checking that card dropped properly
TRANSLATOR BOX NUMBER	HB	Home box
	BTO-1	Foreign translator box tens digit 0 or 1
	BUO-7	Foreign translator box units digit 0 through 9
CLASS	CLTO-1	Class number tens digit 0 or 1
	CLUO-7	Class number units digit 0 through 9
	CDLC	Cancel delayed loop closure
AREA CODE CONTROL	NAC	No area code registered) used on regular card
	AC	Area code registered)
	AHA	Alternate route terminates in home area) used on alternate route card
	AFA	Alternate route terminates in foreign area)
ALTERNATE ROUTE PATTERN NUMBER	ARTO-7	Alternate route pattern number tens digit 0 through 9
	ARUO-7	Alternate route pattern number units digit 0 through 9
ROUTING INSTRUCTIONS	RIO-7	Routing instruction number 0 through 9
CONTINUITY AND DIGIT CONTROL	CDCO-7	Continuity and digit control category 0 through 9
CODE CONVERSION	CCHN	Code conversion hundreds digit none
	CCTN	Code conversion tens digit none
	CCUN	Code conversion units digit none
	CCHO-7	Code conversion hundreds digit 0 through 9
	CCTO-7	Code conversion tens digit 0 through 9
	CCUO-7	Code conversion units digit 0 through 9

Group	Designation	Significance
VARIABLE SPILLING CONTROL	NSK	No skip (send as received)
	SK3	Skip the first 3 code digits
		Skip the first 6 code digits
TRUNK BLOCK CONNECTOR	TCTO-2	Trunk block connector number tens digit 0 through 2
	TCUO-7	Trunk block connector number units digit 0 through 9
TRUNK BLOCK	TBO-7	Trunk block number 0 through 9
GROUP START (Arbitrary Numbers)	GSTO-1	Group start number tens digits 0 or 1
	GSUO-7	Group start number units digits 0 through 9
GROUP END (Arbitrary Numbers)	GETO-1	Group end tens number digits 0 or 1
	GEUO-7	Group end number units digits 0 through 9

Trunk Block Connector

3.155 As previously mentioned (par. 3.34), an outgoing trunk group is spread over at least two outgoing frames. In order to facilitate the checking of these trunks, leads from each of the outgoing trunks are brought to trunk block connectors and grouped according to destination. In this way, a marker goes to only one place to test trunks that may be spread over many outgoing frames. A marker seizes the proper trunk block connector in accordance with the information obtained from a decoder and card translator. There a marker tests for an seizes an idle outgoing trunk.

3.156 A trunk block connector contains the appearances of up to 400 outgoing trunks. These trunks are arranged in groups of forty which is the maximum number a marker can test at one time.

3.157 A connector is made up of multi-contact relays and is mounted on a 2-bay frame called a block relay frame (Fig. 54). It is divided into two parts which are referred to as the even half-connector (in the left bay) and the odd half-connector (in the right bay). These two half-connectors are exactly alike: the 400 trunks which are terminated on the even half-connector are multipled to corresponding contacts in the odd half-connector. This is done in order to provide duplicate access for the markers to these trunks.

3.158 The 400 trunks appearing on each half trunk block connector are divided into two groups (0 and 1) of 200 trunks each. When a marker seizes group 0 in the even half-connector, all other markers are locked out of this connector and group 0 on the odd half-connector (since these are the same trunks). But another marker can seize group 1 in the odd half-connector.

3.159 The preference for a particular trunk block connector depends on the number of the sender used in the call. A marker connected to an even-numbered sender prefers an even half-connector while a marker connected to an odd-numbered sender prefers an odd half-connector. However, if one of the connectors is busy, a marker will use the other one, regardless of preference.

3.160 When a marker has selected an outgoing trunk, the trunk block connector releases and is ready to serve another call.

3.161 There are two trunk block connectors mounted on each block relay frame. As shown in Fig. 54, marker cut-in relays are also mounted on this frame. In separate train offices, each train has its own block relay frames. One such frame can serve ten markers.

Connectors

General

3.162 The decoder, marker, and translator connectors are discussed here; the incoming frame, outgoing frame, sender link, and link controller connectors have already been discussed together with their respective frames.

3.163 The function of the various connector circuits is to temporarily join major circuits to each other during the process of serving a call. This is done by a group of multi-contact relays in a connector which cut through a number of leads between circuits.

3.164 Connectors are equipped with a chain or preference circuit which checks for and selects an idle equipment element. For example, if a decoder signals a marker connector to seize an idle marker, the chain or preference circuit in the marker connector selects an idle marker and

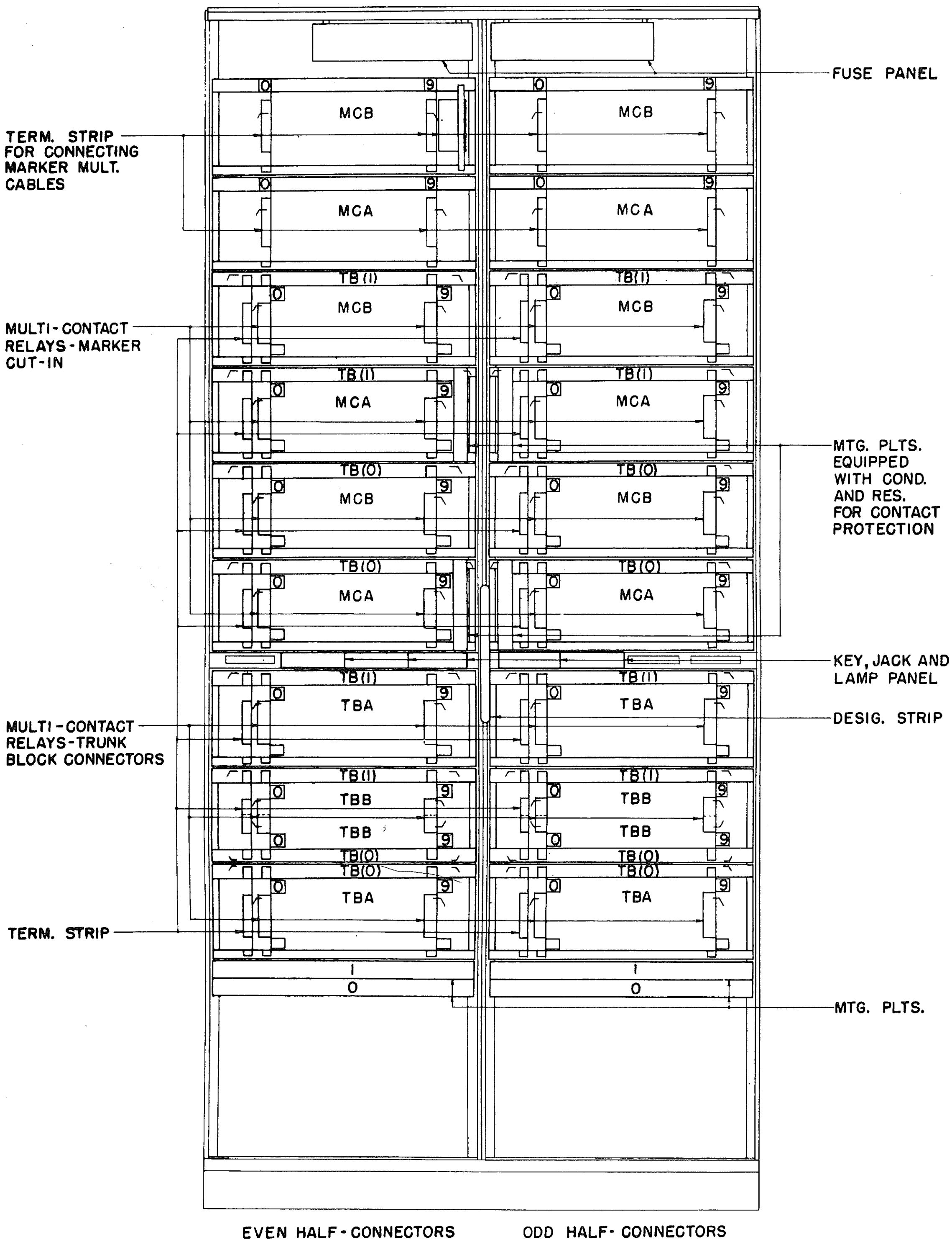


FIG. 54— BLOCK RELAY FRAME

then operates the multicontact relays to close certain leads between the decoder and the selected marker.

3.165 An exception to using a preference chain for selecting is the translator connector because a decoder is instructed to connect to a specific card translator, in order to obtain the proper routing. In case the desired card translator is busy, the decoder must wait to gain access to it.

Decoder Connector

3.166 This connector is used to connect an incoming sender to a decoder and later in the call (when the decoder seizes a marker) to connect the incoming sender directly to that marker.

3.167 A decoder connector can serve five incoming senders. These senders have access to all the decoders in the office. Each decoder connector can reach all the markers in the office.

3.168 When an incoming sender signals for a decoder, a chain circuit in the selected decoder connector selects an idle decoder and cuts through the necessary leads by operating its multicontact relays. When this decoder signals a marker connector to seize an idle marker, (for example marker 0), the marker connector then signals the decoder connector to operate the multicontact relay associated with marker 0. This ties the incoming sender to the marker used on this call. When the decoder is released, the incoming sender remains connected to the marker until the marker completes its functions. Then the marker and the decoder connector are released.

3.169 Decoder connectors with different capacities are provided in combined and in separate train offices. A decoder connector in a <u>combined train office</u> (Fig. 55) can serve a maximum of ten decoders and ten markers in addition to five incoming senders. A decoder connector in a <u>separate train office</u> (Fig. 56) can serve a maximum of eighteen decoders, twenty markers (ten intertoll and ten toll completing), in addition to five incoming senders.

Marker Connector

3.170 This connector cuts through a large number of leads between a decoder and a marker. In addition, the marker connector also signals the decoder connector to cut through some leads between the incoming sender used on the call and the selected marker.

3.171 Marker connectors used in a <u>combined train office</u> can serve a maximum of ten combined markers. When a decoder signals a marker connector to seize an idle marker, the chain, or preference circuit, selects any idle marker (since they are all combined markers), and the marker connector operates the multicontact relays which cut through the leads from the decoder to the marker. Then the marker connector signals the decoder connector to cut through the incoming sender used on the call to the selected marker. The marker connector releases when the decoder is released from the call.

3.172 Fig. 57 shows a marker connector frame for a combined train office.

3.173 Marker connectors used in a <u>separate train office</u> can serve a maximum of twenty markers: ten intertoll and ten toll completing markers.

3.174 In order to select the proper kind of marker (intertoll or toll completing), this connector is equipped with two chain or preference circuits. One chain for the intertoll markers and another for the toll completing markers. When a decoder signals a marker connector for a marker, the decoder also tells the marker connector which kind of marker is required. If an intertoll marker is desired, the intertoll chain relays are used. If a toll completing marker is desired, then the toll completing chain is used. In this way the proper kind of marker is selected and seized.

3.175 The other functions of the connector are the same as those described for the combined train office marker connector.

3.176 Fig. 57 also shows a marker connector frame for a separate train office.

Foreign Translator Connector

3.177 A foreign translator connector connects a decoder and a foreign area translator. Each foreign area translator has an associated connector to which all decoders have access.

3.178 Since a decoder must reach a specific foreign area translator to drop a card, if a particular foreign area translator is busy the decoder must wait its turn.

3.179 A foreign translator connector in a <u>combined train office</u> (Fig. 58) can serve a maximum of ten decoders.

3.180 A foreign translator connector in a <u>separate train office</u> (Fig. 58) can serve a maximum of eighteen decoders.

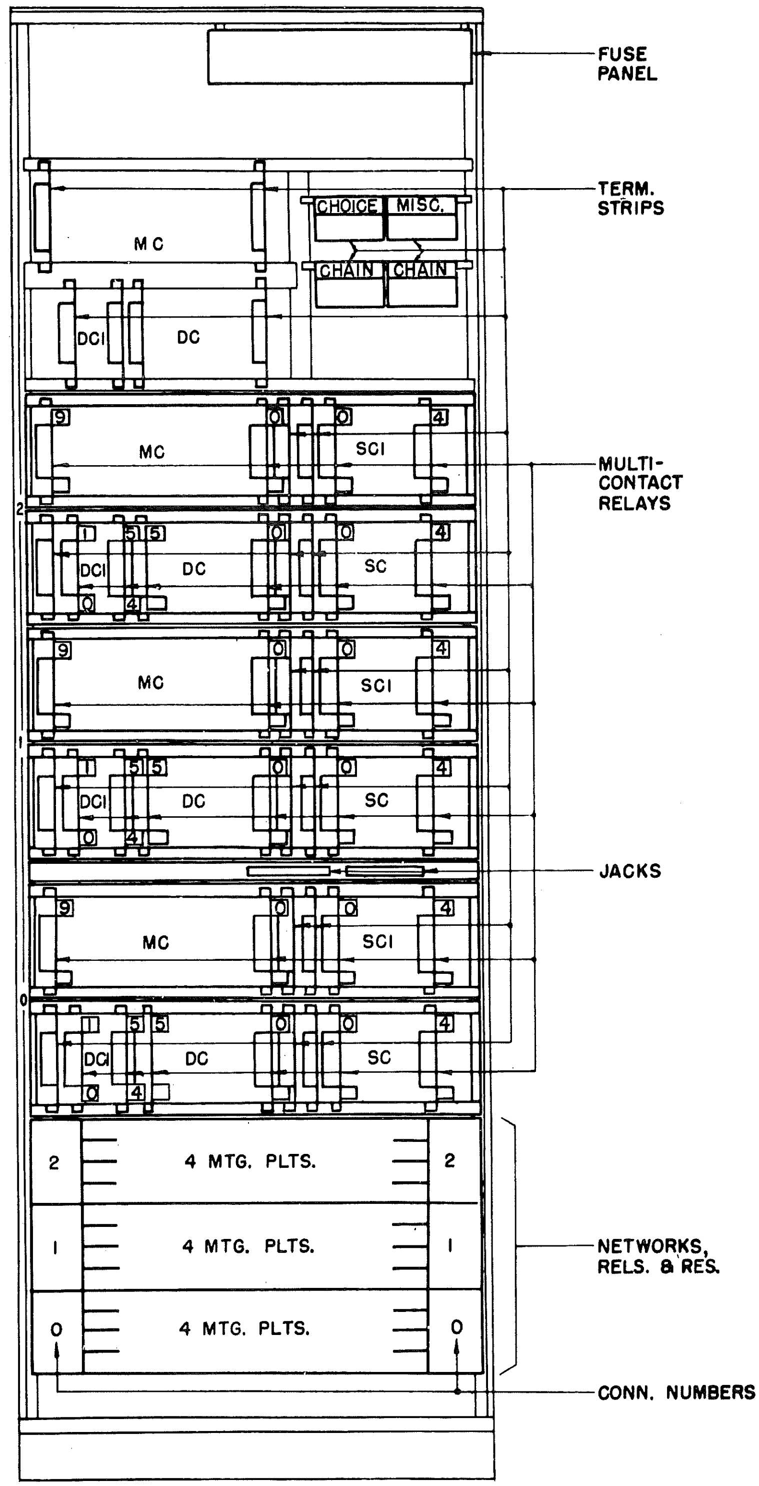


FIG. 55 - DECODER CONNECTOR FRAME FOR COMBINED TRAINS

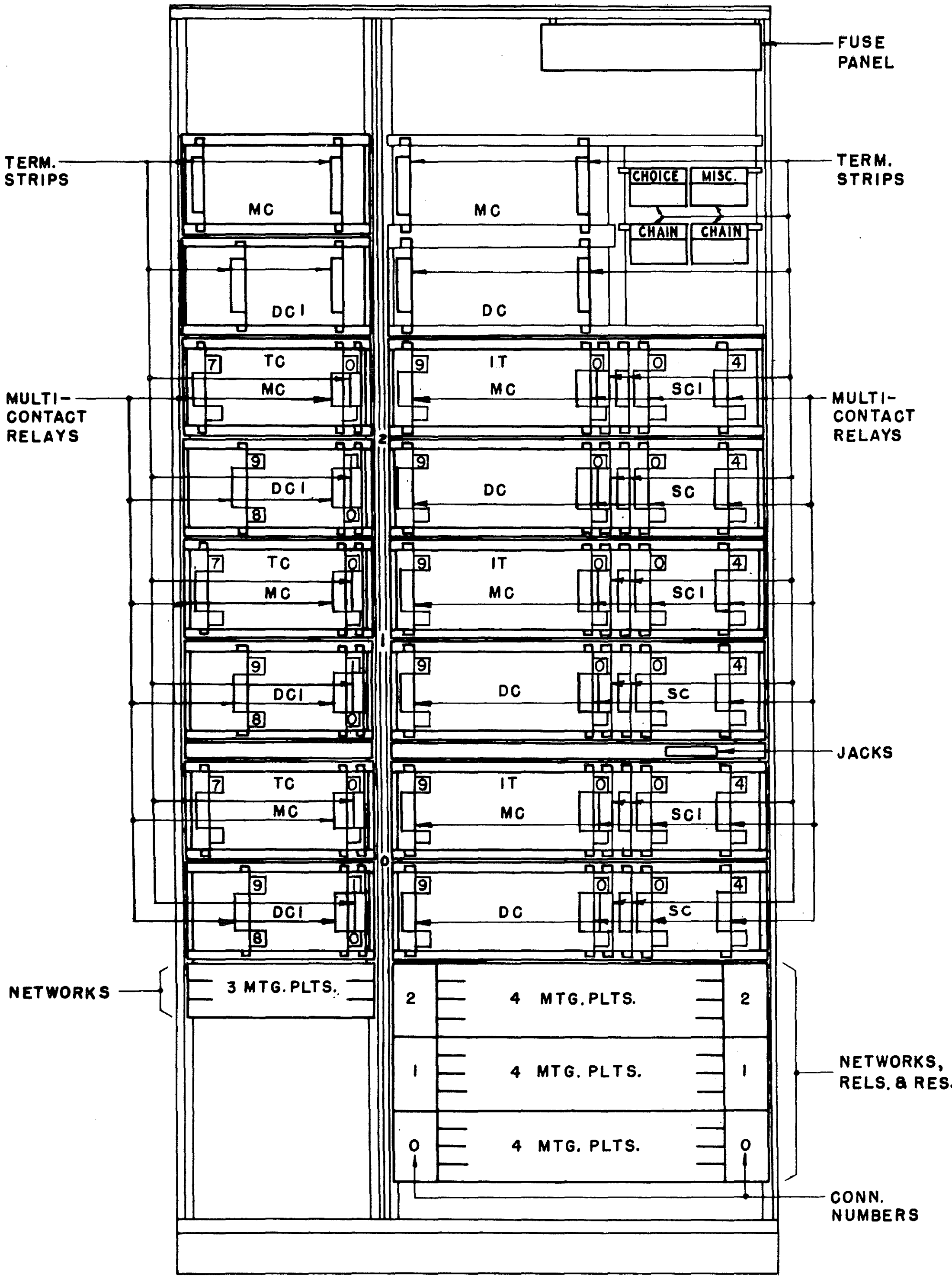


FIG. 56 — DECODER CONNECTOR FRAME FOR SEPARATE TRAINS

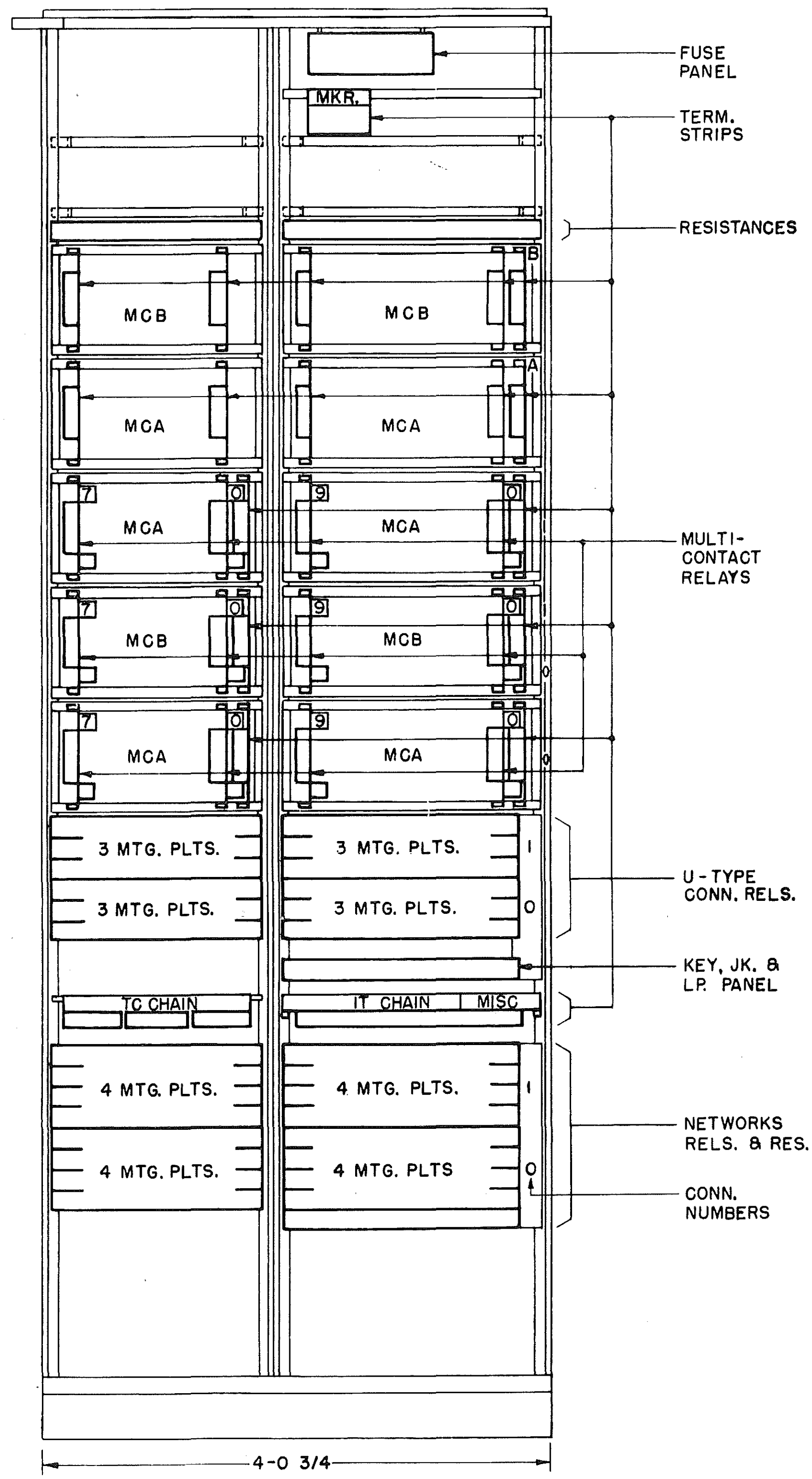


FIG. 57– MARKER CONNECTOR FRAME FOR SEPARATE TRAINS (COMBINED TRAIN FRAME SAME AS RIGHT-HAND BAY ABOVE)

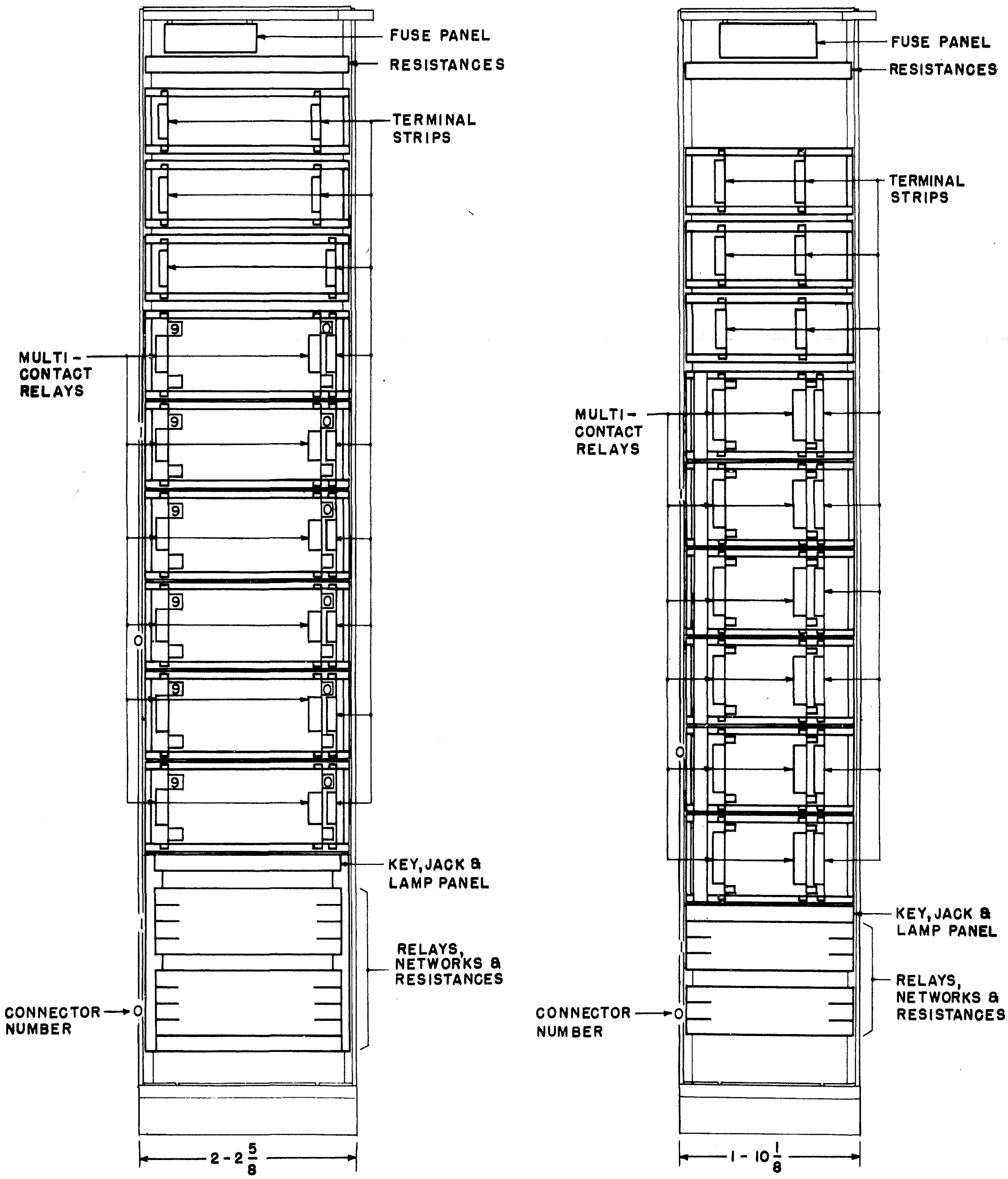


FIG. 58 — FOREIGN TRANSLATOR CONNECTOR FRAMES

Emergency Translator Connector

3.181 The emergency translator connector (see Fig. 59) is associated with the emergency card translator. In a combined train office, this connector can serve the office maximum of ten decoders. In a separate train office, this connector can serve the office maximum of eighteen decoders.

Outgoing Senders

3.182 Outgoing senders are used to outpulse either revertive or PCI pulses or both. This depends on the kind of local offices in the area served by the No. 4A toll office. Figure 60 shows an outgoing sender frame.

3.183 Outgoing trunks to local offices that require revertive or PCI pulses are connected to outgoing senders by an outgoing sender link and connector, controller connector and link controller. These connect the outgoing trunk to an outgoing sender in exactly the same way as an incoming sender link and connector, controller connector and link controller connect an incoming trunk to an incoming sender. (See paragraphs 3.24 to 3.28.)

Multifrequency Pulsing Receiving Frame

3.184 The receiving units on this frame receive and amplify MF pulsing signals. These signals are then repeated as d-c pulses and transmitted to the sender.

3.185 One MF receiving frame mounts twelve receiving units. Each unit serves one MF sender, therefore one receiving frame is required for four MF incoming sender frames (one sender frame mounts three senders).

Multifrequency Current Supply Frame

3.186 This frame mounts the oscillator units which generate the multifrequency current for MF outpulsing. Two supply frames are furnished in each office. (See Fig. 61.)

Frame Identification Frequency Supply Frame

3.187 This frame mounts the oscillators which supply the frequencies for frame identification during marker operation. Figure 62 shows this single bay frame and the oscillators, amplifiers, and mixing resistances which are mounted on it.

Alternate Route Traffic Control Frame

3.188 Provision is made to deny alternate route traffic to CSP's that become congested. For example, office B is used as an alternate route by office A in order to reach offices C and D. When office B becomes congested, office A is notified. Then, at office A, the key regulating alternate route traffic via B is operated. Now all alternate route traffic from office A, regardless of whether it goes to office C or D, is temporarily cut off from office B. As soon as office B is able to handle alternate route traffic again, office A is notified and the traffic control key is restored.

3.189 This type of operation applies only to alternate route traffic, direct traffic between office A and office B is not affected by the alternate route traffic control keys.

3.190 The traffic which is denied access to the trunk group to B as an alternate route is automatically transferred to master busy.

3.191 The route transfer relays that are controlled by the operation of a traffic control key are located on the alternate route traffic control frame (see Fig. 63). These relays are associated with the decoders in an office. In a particular CSP, there is one relay for each trunk group between this CSP and all the other CSP's it can reach. A CSP will not have trunk groups to more than 100 other CSP's, therefore a maximum of 100 route transfer relays is provided. There is one traffic control key and lamp for each route transfer relay. These keys and lamps are in the operating room of the traffic supervisory rack.

Overflow Trunks and Trunk Group Busy Relays

3.192 The outgoing intertoll trunk group busy relays and the overflow trunks and their control circuits are on the overflow trunk frame (see Fig. 64). These items are all concerned with the overflow traffic in the office.

3.193 Overflow trunks are associated with certain trunk groups (usually outgoing intertoll trunks) in the 4A office. When these trunk groups are busy, calls are connected to overflow trunks. Then an overflow signal (30 IPM) is sent from that trunk to the outward operator. As soon as a trunk in the desired group becomes idle, a reorder signal (120 IPM) is substituted for the overflow signal by a control circuit. Then the originating operator again tries to complete her call.

3.194 However, if a reorder signal is not sent back within a short time, the outward operator releases the connection. Then she usually turns the call over to a delay through operator at a No. 5 switchboard

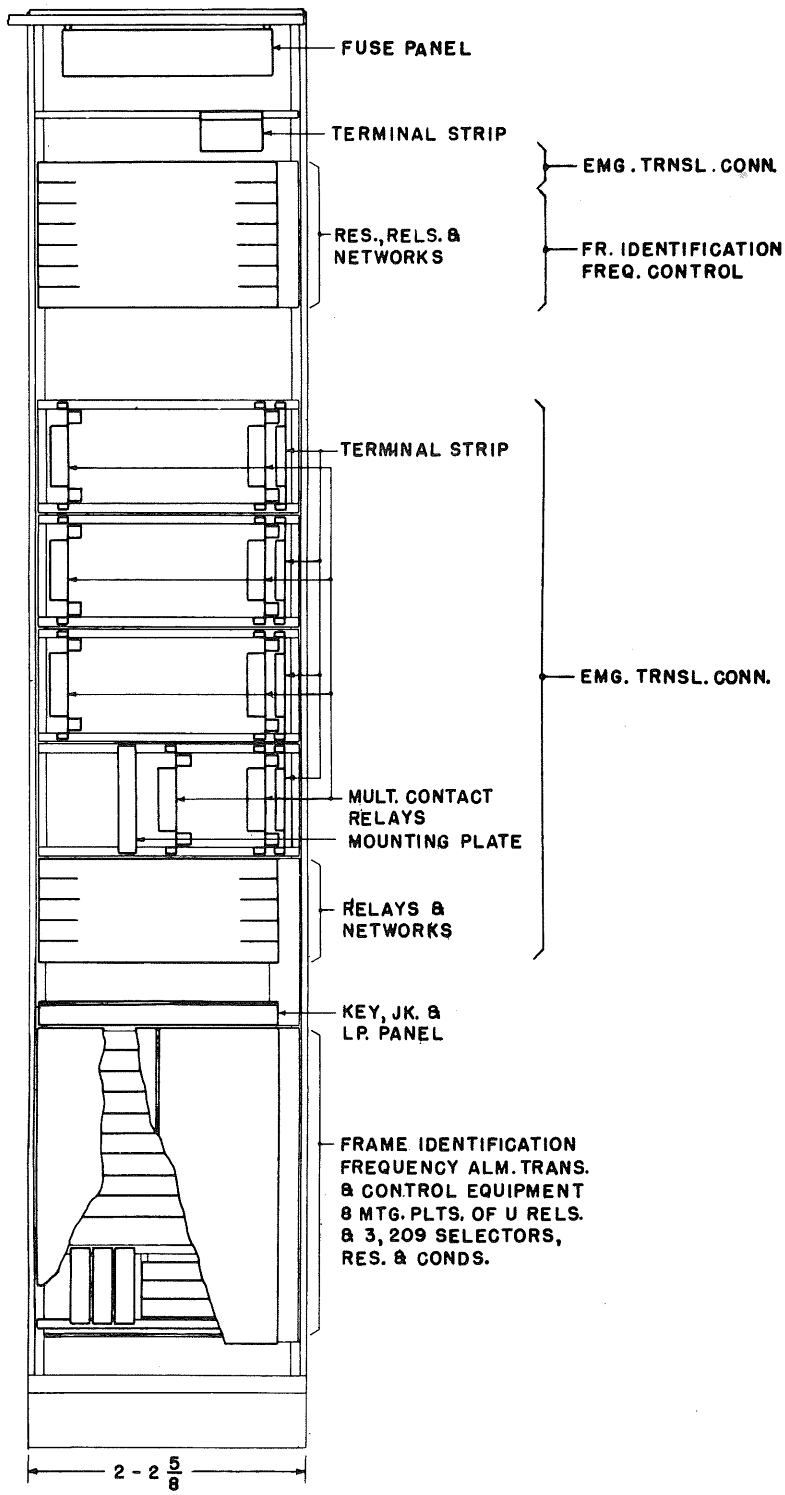


FIG. 59—EMERGENCY TRANSLATOR CONNECTOR AND FRAME IDENTIFICATION FREQUENCY CONTROL FRAME

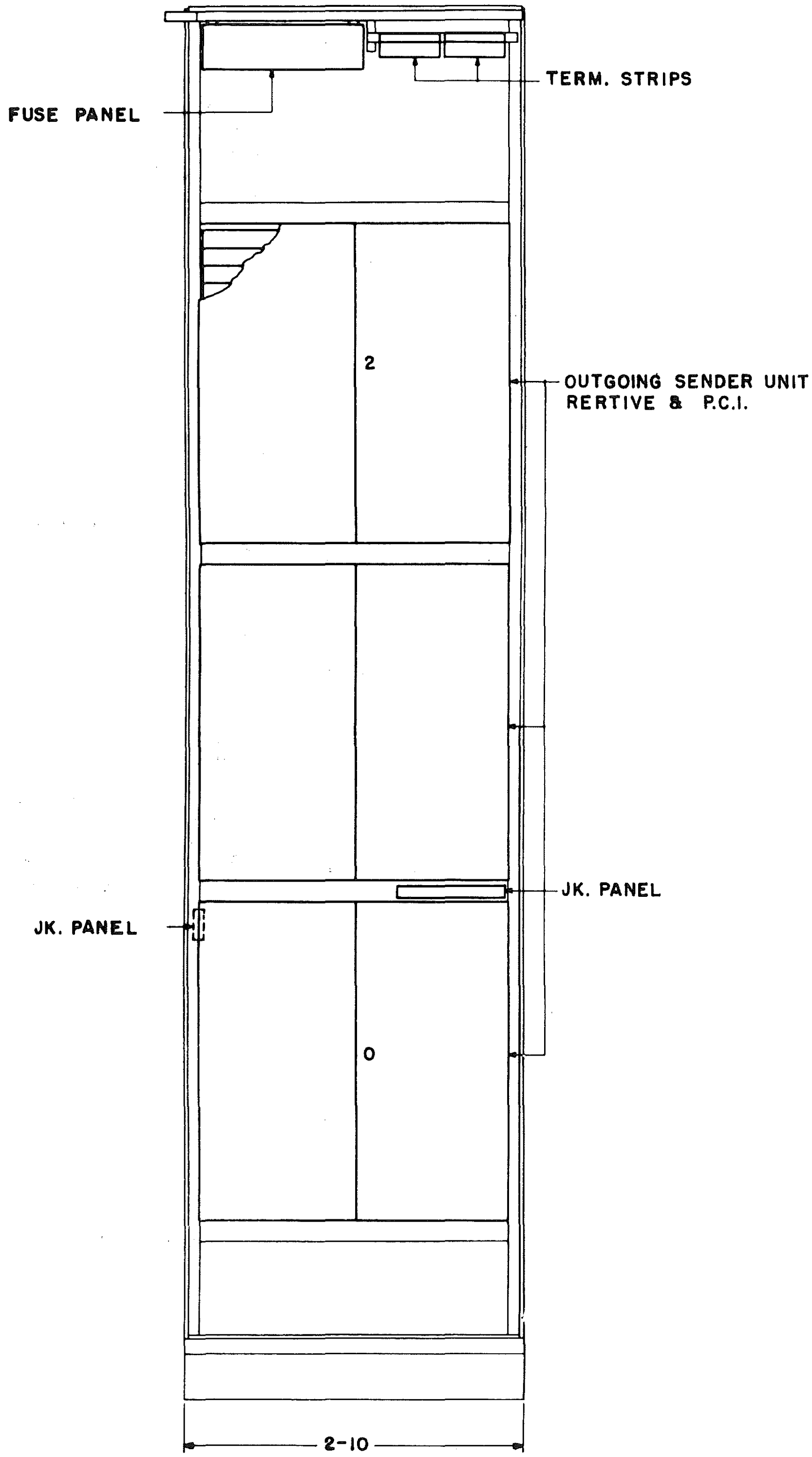


FIG. 60 - OUTGOING SENDER FRAME

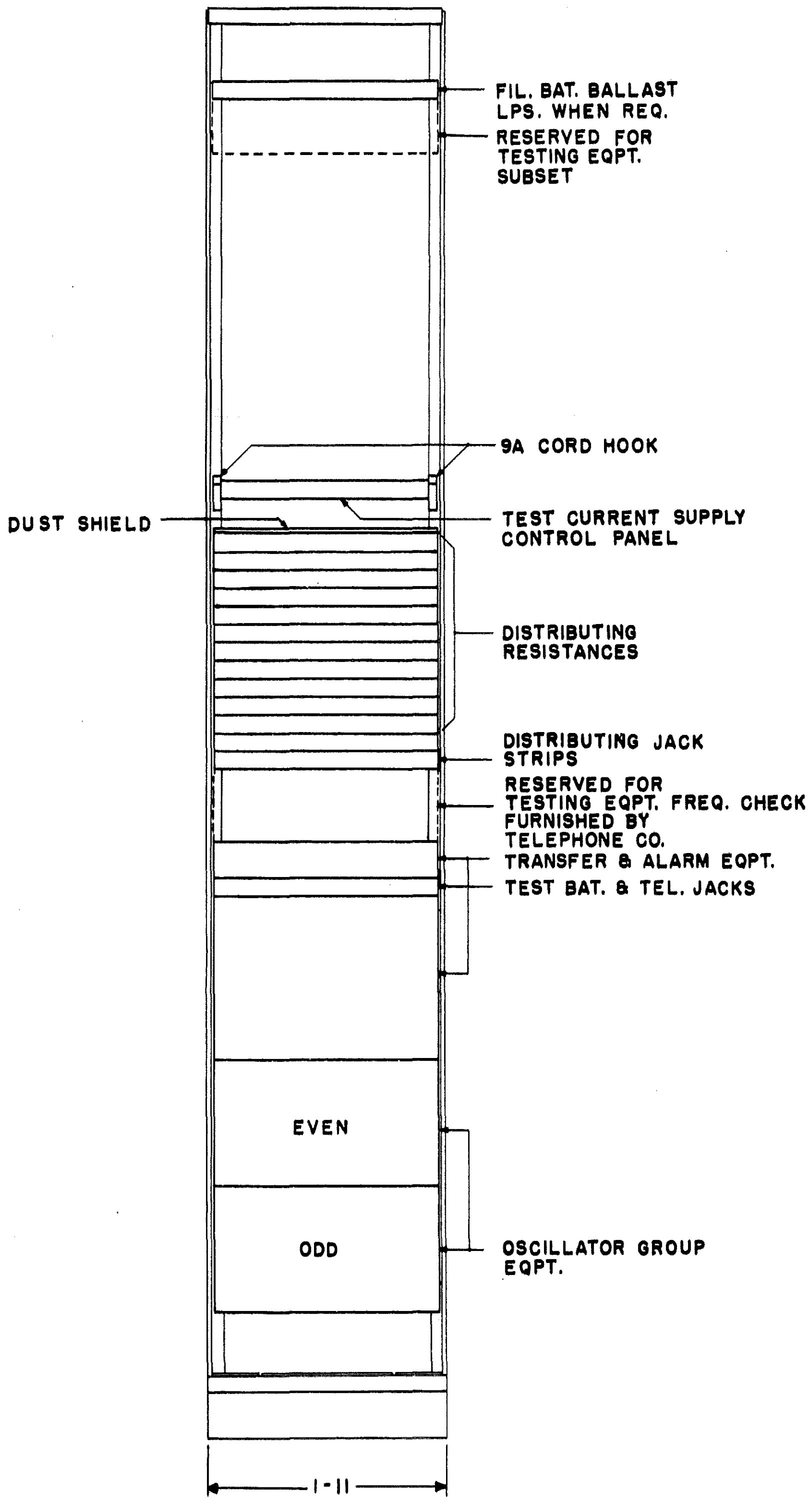


FIG. 61 – MULTIFREQUENCY CURRENT SUPPLY FRAME

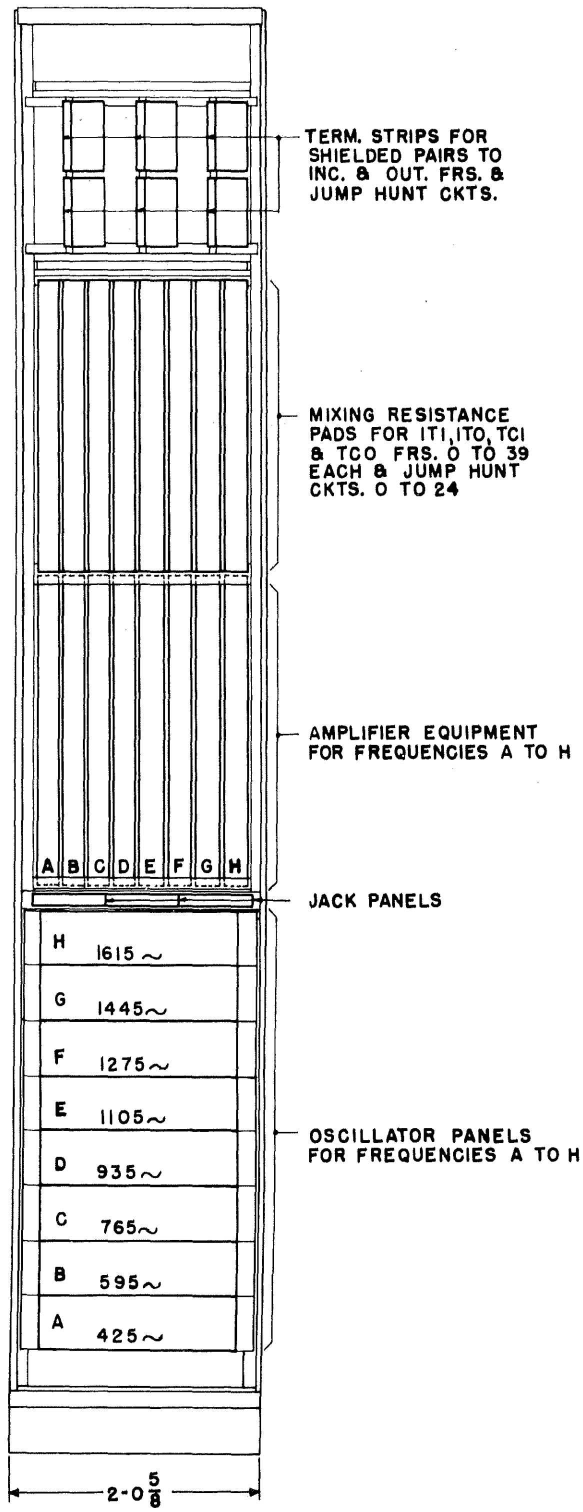


FIG. 62 – FRAME IDENTIFICATION FREQUENCY SUPPLY FRAME

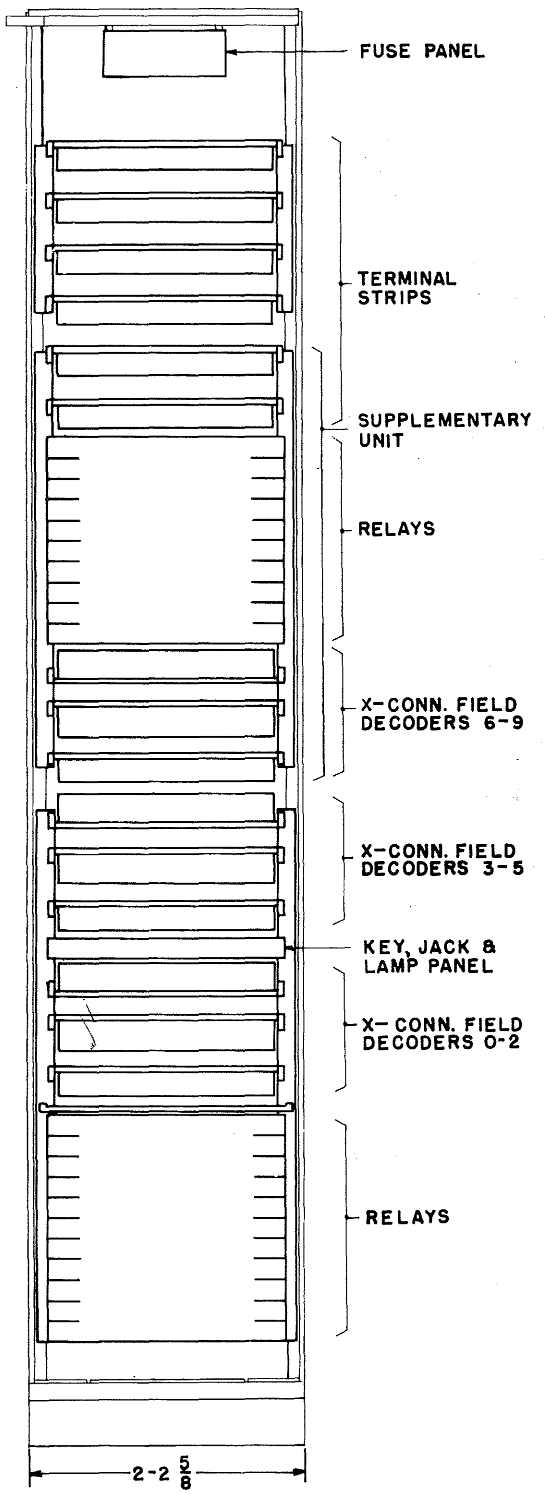


FIG. 63 — ALTERNATE ROUTE TRAFFIC CONTROL FRAME

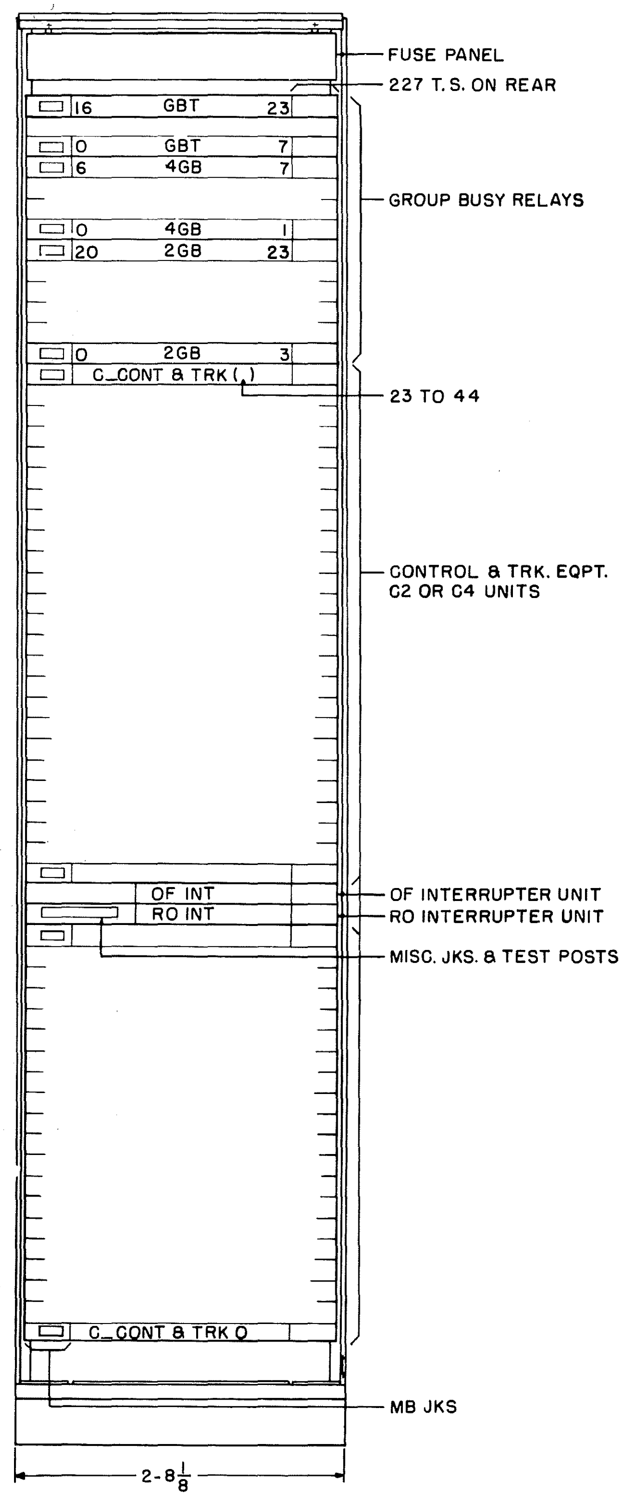


FIG. 64 - OVERFLOW TRUNK FRAME

for completion. (In some installations a No. 3CL switchboard will be used instead of a No. 5 switchboard.)

3.195 If, at the originating toll office in the connection, not only the outgoing trunks but also the overflow trunks in a group are busy, then the call is connected to a master busy trunk. This trunk sends an irregular flashing signal to the calling operator indicating a fairly long delay. The operator can ring forward over this master busy trunk and reach the delay through operator at a No. 5 switchboard in the toll office because this trunk has a jack appearance at this board. The calling operator can then leave the call with the delay through operator.

3.196 When the all trunks busy condition is encountered at an intermediate toll office, a master busy signal is returned immediately to the originating operator. She then rings forward over this trunk and learns from the delay through operator where the all trunks busy condition has occurred.

3.197 The <u>trunk group busy relays</u> are used to indicate the state of the trunk groups. There is one relay for each group of forty trunks. These relays are operated when there are any idle trunks in the group and released when all the trunks are busy.

3.198 The group busy relays are connected with the overflow control circuits. They notify the control circuits that there is an idle trunk in the group and to substitute a reorder for an overflow signal. Leads from these relays also appear at the No. 5 switchboard and, by means of lamps, inform the operator that there are idle trunks in certain trunk groups.

3.199 These relays have another important use in connection with decoders. Chain leads from the trunk group busy relays are used by decoders to check the availability of trunks during relay-to-relay and card-to-relay operation.

<u>No. 5 Switchboard</u>

3.200 A No. 5 switchboard is provided in a 4A toll switching office for handling assistance traffic for originating operators. If an originating (outward) operator encounters a trunks busy condition, she refers the call to a No. 5 operator.

3.201 For inward assistance, the outward operator keys a 121 code to reach the inward No. 5 operator. The No. 5 operator then attempts to complete the call when there are trunks available.

3.202 For through assistance, the outward operator keys a 151 code and reaches the No. 5 through operator. This operator attempts to complete the call when a circuit is available.

3.203 A No. 5 operator can also be reached by ringing forward over a master busy signal. This is an important feature because when an outward operator gets master busy signal from a distant or through office (built-up connection), she does not know where this office is. Therefore she rings forward over this signal and reaches the No. 5 operator at the office where the busy situation has occurred. The originating operator can then refer the call to the No. 5 operator located in her own toll center area.

3.204 The No. 5 switchboard also has provision for informing originating operators of the specific delay on their calls to a distant toll center. When such a situation occurs, the overflow trunks are patched to the proper delay quote trunks. The length of the delay is announced over these trunks. The delay quote trunks appear in the answering jack multiple on the No. 5 switchboard. For example, if there is a 2-hour delay on calls going through Chicago to St. Louis all these calls are put on the delay quote trunks. These trunks appear before a delay quote operator. This operator plugs into any lighted jack and quotes the delay to the originating operator.

3.205 The No. 5 switchboard differs from the conventional type because it is equipped to switch calls by 4-wire switching.

3.206 Trunks to the No. 5 switchboard terminate on twin jacks (4-wire) for use in switching calls. These twin jacks have double appearances in the multiple. They permit the operator to change cords, when necessary, and not lose the associated equipment such as the associated circuits on the incoming and outgoing frames. Each end of the cord circuits is equipped with four-wire twin plugs.

3.207 Each No. 5 position (three per section of switchboard) is equipped with ten button keysets which are used to complete calls on an MF pulsing basis.

<u>Trunks and Trunk Relay Equipment</u>

General

3.208 Two general types of trunks, intertoll trunks and toll connecting trunks carry traffic to and from a No. 4A toll switching system. An intertoll trunk, as the name implies, carries traffic between two toll offices. Examples of intertoll trunks are (1) trunks between two No. 4A toll offices, (2) trunks between a No.

4A office and a step-by-step toll office, (3) trunks between two manual toll offices. The toll offices and intertoll trunks are referred to as the toll network.

3.209 A toll connecting trunk, as this name implies, connects local offices (and outward switchboards, etc.,) with the toll network. Thus, this type of trunk carries traffic to or from a toll office. Examples of toll connecting trunks are (1) a trunk from a DSA switchboard to a No. 4A toll office, (2) a trunk from a No. 4A toll office to a No. 1 Crossbar office.

3.210 There are several categories of intertoll and toll connecting trunks. These categories are discussed here together with the functions of trunk relay equipment.

Intertoll Trunks

3.211 <u>Terminal, Via, and Common Grade Trunks</u>: Intertoll trunks carry intertoll traffic which is defined as traffic from one toll center to another. They are divided, depending on their usage, into three grades: via grade, common grade, and terminal grade. These three grades fall into two classes from the standpoint of quality of transmission, the via and common grades constituting one class and the terminal grade the other.

3.212 A terminal grade trunk provides a transmission quality which is satisfactory for connections in which only one intertoll trunk is required. Thus terminal grade trunks carry intertoll traffic which originates in one toll center and is completed in a second toll center without intermediate switching.

3.213 Via and common grade trunks have a higher transmission quality and are used when there are two or more intertoll trunks in the connection. These trunks carry intertoll traffic which originates in one toll center, is carried over two or more via or common grade intertoll trunks to a third (or fourth, etc.) toll center, and is completed in the third (or fourth, etc.) toll center.

3.214 As indicated in par. 3.211, the difference between common grade trunks and via grade trunks is one of usage. Whereas via grade trunks are used only when there are two or more intertoll trunks in a connection, common grade trunks are also used to carry overflow traffic from terminal grade trunks (see par. 3.212).

3.215 There can be various combinations of these types of trunks between two toll offices:

(1) Terminal and Via trunks

(2) Common trunks

(3) Terminal, Via and Common trunks

(4) Terminal and Common trunks

In case (3), the traffic from both the terminal and via trunks can overflow to the common trunks; in case (4) the traffic from the terminal trunks can overflow to the common trunks.

3.216 <u>Carrier trunks</u> have transmission quality equivalent to common and via grade trunks. As more and more carrier systems are introduced and the conversion of voice frequency trunks to carrier trunks is made, an ever-increasing number of intertoll trunks will be of the same transmission quality and therefore less and less grading will be required.

3.217 <u>One-Way and Two-Way Trunks</u>: Intertoll trunks are also classified according to direction of traffic flow. An intertoll trunk that carries traffic in only one direction is called a one-way trunk. For example, a trunk that carries outgoing traffic from office A to office B is called a one-way outgoing trunk at office A and a one-way incoming trunk at office B.

3.218 Some intertoll trunks carry traffic in both directions. These are called two-way trunks because they carry incoming traffic to the office and outgoing traffic from the office.

3.219 The type of intertoll trunk, from both the transmission and direction standpoint, (i.e. one-way or two-way) determines its appearances on the incoming and outgoing switching frames of a No. 4A toll switching system.

3.220 In a separate train system, a one-way incoming via or common grade intertoll trunk has two appearances, one on an incoming frame of the intertoll train and the other on an incoming frame of the toll completing train. An appearance on each of the trains is needed because this type of trunk may be connected either to other intertoll trunks (through the intertoll train) or to toll connecting trunks (through the toll completing train).

3.221 A one-way incoming terminal grade intertoll trunk has only one appearance which is on an incoming frame of the toll completing train. Only one appearance is needed because this type of trunk can only be connected to a toll connecting trunk and never to another intertoll trunk.

3.222 In general, a one-way outgoing intertoll trunk (terminal, via, or common grade) has an appearance on an outgoing frame of the intertoll train. However, if there is a heavy load on the intertoll train, some of the one-way outgoing intertoll trunks may be associated with the toll completing train in order to spread this load.

3.223 A two-way via or common grade intertoll trunk has three appearances on the frames of a separate train system. It has an appearance on an incoming frame of both trains for incoming traffic and on an outgoing frame of the intertoll train for outgoing traffic. However, in some cases in order to balance the traffic load, the outgoing appearance may be associated with the toll completing train.

3.224 A two-way terminal grade trunk requires only two appearances. It has an appearance on an incoming frame of the toll completing train and on an outgoing frame of the intertoll train. However, for the same reasons as mentioned above, a terminal grade trunk may have its outgoing appearance associated with the toll completing train.

3.225 In combined train systems, an intertoll trunk has an appearance that corresponds to its directional name. A one-way incoming (terminal, via, or common grade) trunk has an appearance on an incoming frame; a one-way outgoing trunk has an appearance on an outgoing frame; a two-way trunk has appearances on both an incoming and an outgoing frame.

3.226 Dial, Multifrequency, Ringdown, and Automatic Operation: As discussed earlier in this part a No. 4A system can receive and send both dial and multifrequency pulses. Multifrequency pulse operation is used on intertoll trunks (both one-way and two-way) between two No. 4A systems. Dial pulse operation is used on intertoll trunks (both for one-way and two-way) between a No. 4A system and a step-by-step intertoll system. In some cases, multifrequency is used from a switchboard in a step-by-step toll office in one direction and dial pulse is used in the opposite direction. Either multifrequency or dial pulse operation is used on one-way trunks from a manual toll office to a No. 4A system.

3.227 Many of the manual toll centers to which a No. 4A toll office will have trunks will not be equipped to receive and translate dial or multifrequency pulses for some time to come. The intertoll trunks between the manual toll offices in these centers and a No. 4A toll office are usually two-way trunks using either ringdown operation in both directions or automatic operation in one direction and multifrequency (or dial) operation in the other direction.

3.228 Ringdown operation permits a No. 4A system to use existing ringdown intertoll trunks between the switchboards at the No. 4A location and the switchboards at the distant manual toll office. A trunk of this type appears in the multiple of the inward and through switchboard and in the multiple of the outward switchboard at both locations. By means of a circuit known as a ringdown applique circuit, an appearance is also obtained on an outgoing frame of the No. 4A toll switching system.

3.229 When the No. 4A toll system has a call for the distant manual office, it seizes the ringdown intertoll trunk and a ringing signal is sent to the distant office. The inward operator responds to the signal and the originating operator passes the call on to her for completion.

3.230 When an operator at the distant manual toll office has a call, she seizes the trunk and rings toward the No. 4A office. At the No. 4A office, the inward operator answers the ring and is told the destination of the call. The inward operator then selects a trunk to the No. 4A switching equipment and advances the call by keying the necessary routing information.

3.231 In the automatic type of operation, the intertoll trunk does not have an appearance on the inward or outward switchboard in the No. 4A office. Instead, it has an appearance on an incoming and an outgoing switching frame. When the No. 4A system has a call for the distant manual toll center, it seizes the outgoing frame appearance and a signal is automatically sent by a composite or single frequency signaling circuit to the distant end. The inward operator answers the signal and is verbally informed of the destination of the call.

3.232 When the manual toll office has a call, the operator selects the trunk and a signal is sent to the No. 4A switching equipment. An incoming sender is then attached and the operator keys the required routing information.

3.233 In some cases there will be one-way trunks carrying traffic from a No. 4A system to a manual toll office. These will be operated on a ringdown or automatic basis. In other cases there will be one-way trunks carrying traffic from the manual office to the No. 4A system, these will be operated on a dial or multifrequency pulse basis as already mentioned.

Toll Connecting Trunks

3.234 Trunks which connect a No. 4A toll office with local offices and with switchboards are called toll connecting trunks. These include the toll tandem and the toll switching trunks.

3.235 Toll Tandem Trunks: Toll tandem trunks provide outward toll operators at a No. 4A toll office and DSA operators at local offices with access to the No. 4A toll switching system. These trunks are one-way trunks which transmit MF or DP pulses and can only be used to place calls through the No. 4A switching system.

3.236 Because they are one-way trunks they appear on the incoming switching frames only. In a separate train office two arrangements are possible. In some cases a toll tandem trunk group has appearances on the incoming frames of both the intertoll and toll completing trains. This procedure is usually followed on trunk groups from the DSA switchboards at local offices. In other cases, usually when the switchboard is in the same building as the No. 4A equipment, two separate trunk groups are provided; one group has access to the intertoll train; the other group to the toll completing train. In these cases, an outward operator selects a tandem trunk with access to the required train since her instructions direct her to use one trunk group for certain calls and the second trunk group for other calls.

3.237 Toll Switching Trunks: Toll switching trunks are used to switch calls from a No. 4A office to local and community dial offices. They can be connected to incoming toll tandem trunks or incoming intertoll trunks.

3.238 Toll switching trunks are one-way outgoing trunks and appear on the outgoing frames of an office. In a separate train office, they are usually on the toll completing train.

3.239 These trunks are arranged for dial pulsing to step-by-step offices, multifrequency or revertive pulsing to crossbar offices, revertive pulsing to panel dial offices, and panel call indicator to manual offices.

Miscellaneous Trunks

3.240 These trunks have appearances on the outgoing frames and are spread over the various trains according to the requirements of individual offices.

3.241 TX Trunks carry delayed call traffic between the No. 4A toll switching system and TX operators.

3.242 Service Trunks carry traffic between the No. 4A toll switching system and assistance operators and testboards. These include trunks to the inward operator (code 121), delay operator (code 151), testboard (code 101), and information (code 131).

3.243 Reorder Trunks are used to send a reorder signal to the outward operator. When the outward operator receives a reorder signal, she usually rechecks her routing information and originates the call again.

3.244 Overflow Trunks are used to send an overflow signal to the outward operator indicating that an all-intertoll-trunks-busy condition has been encountered in the 4A toll office in the home toll center.

3.245 Master Busy Trunks are used to send a master busy signal to the outward operator when an all-intertoll-trunks-busy and all-overflow-trunks-busy condition has been encountered at the No. 4A toll office where a connection is built up. These master busy trunks are arranged so the outward operator in the distant office can ring forward to reach an assistance operator in the toll office where the all-trunks-busy condition was encountered.

Trunk Groups and Subgroups

3.246 A trunk group is made up of all the trunks extending from one switching office to another. For example, all the trunks between two 4A toll offices like New York and Boston are a trunk group. Trunks are further identified by dividing a trunk group into subgroups according to the traffic usage and transmission characteristics of the trunks in the group.

3.247 In general, only the intertoll trunks are subgrouped on a traffic and transmission basis; therefore these are discussed here. As mentioned before, there are incoming, outgoing, and 2-way intertoll trunks which can be terminal, via or common grade. A subgroup is made up of trunks which have the same traffic and transmission characteristics. For example, in a group of outgoing trunks which contain terminal and common grade trunks, the terminal grade trunks form one subgroup and the common grade trunks form another.

3.248 On a particular call, as discussed previously under the Marker and Trunk Block Connector, a marker is directed to a suitable trunk subgroup. If this subgroup contains forty or fewer trunks, the marker can test them all at the same time. However, if there are more than forty trunks, the marker tests a maximum of forty trunks at a time. For example, a trunk group of 80 trunks has one subgroup of 57 common grade trunks and another subgroup of 23 terminal grade trunks. When a marker is directed to the terminal grade trunk subgroup, it tests all 23 trunks at one time. When a marker is directed to the common grade subgroup, it first tests forty trunks and, if these are busy, then tests the remaining thirteen.

Pads

3.249 In order to understand pads, which are used to introduce a transmission loss on certain trunks, it is necessary to understand some of the fundamental requirements of a good transmission system.

3.250 Experience indicates that a telephone user is generally neither aware of nor interested in the routing of his call, the number of switching points, etc. He is however, concerned about whether he gets a good or bad talking connection. He measures his satisfaction with a call by comparison with his experiences on other calls. He is conscious of differences in transmission on calls he makes to different telephones and especially so on calls he makes at various times to the same telephone.

3.251 One of the transmission objectives is to make these differences as small as practicable regardless of whether the call is routed over the preferred route or an alternate route or whether the call is a single switched or multiswitched call. To meet these objectives, the first step is to determine a reasonable grade of transmission. The next step is to insure, insofar as practicable, that all connections have at least as good a grade of transmission as this. The effect of this is to reduce transmission differences on different calls between the same two telephones as well as calls to different telephones made from the same telephone.

3.252 The following paragraphs discuss what is done to intertoll and toll connecting trunks in order to reach this objective. The intertoll trunks are discussed first.

3.253 Obviously, if all the intertoll trunks in a connection had no transmission loss, the received volume on all connections (assuming the same talker and neglecting the effect of the toll connecting trunks for the moment) would be the same regardless of the type or length of the connection. The reduction of transmission loss to zero is not practicable for several reasons, one of which is that if repeater gains were set high enough to do this, "singing" would occur.

3.254 However, by reducing the transmission loss of every intertoll trunk to a very low value (through the use of repeaters), the over-all loss for all practical purposes is about the same regardless of whether there is one or several intertoll trunks in the connection.

3.255 The different intertoll trunks making up a group are composed of different elements. Some are composed of carrier facilities of various types, others are composed of voice-frequency facilities; some are open wire, others cable or coaxial conductors; some are loaded, others are not; some are equipped with echo suppressors, others are not. All of these factors affect the loss of an intertoll trunk.

3.256 Regardless of the make-up of a trunk, repeater gains are set to levels high enough (with gain to spare) to give adequate transmission on the highest loss intertoll trunk plus a high loss toll connecting trunk in the connection. The spare gain is used to compensate for loss of toll connecting trunks as explained later in par. 3.260.

3.257 It is not desirable to readjust repeater gains whenever an element is changed, added to, or removed from a trunk. Nor is it desirable to have at the toll testboard and the circuit patching bay of a particular office, appearances of trunks with various transmission levels. Uniformity of levels at the toll testboard and at the circuit patching bay facilitates maintenance, makes it convenient to patch one circuit in place of another and to build up temporary circuits, etc.

3.258 This uniformity of levels is obtained by the use of adjustable pads, called "P" pads (pads are artificial conductor losses). These pads are inserted between the testboard and the circuit patching bays in both the transmitting and receiving branches of every trunk. For each trunk, these pads are adjusted to a loss which when added to the loss caused by echo supporessors, signaling units, and office cable, etc. brings the transmission level of the particular trunk into uniformity with the others appearing at the testboard and circuit patching bay. Thus, the loss introduced by "P" pads varies from trunk to trunk depending upon the make-up of the trunks. For each trunk the loss in the P pads remains fixed unless a change is made in the office layout of such a nature as to change the office loss for example, removing an echo suppressor.

3.259 The loss of a toll connecting trunk also affects the received volume. These trunks vary from very short to very long and the losses on them vary correspondingly. It is not economical to use repeaters to bring all these trunks to the same grade of transmission as is done with intertoll trunks. Therefore, what is done is to divide all the toll connecting trunks into two classes, a high loss class and a low loss class and to treat these classes differently in order to offset the higher losses and thus bring both classes closer together.

3.260 As discussed in par. 3.256 spare gain is provided by repeaters on intertoll trunks to compensate for loss in toll connecting trunks. The use of this spare gain is controlled by inserting switchable "A" pads in the transmitting and receiving branches of the intertoll trunks. The loss introduced by the "A" pads offsets the spare gain until it is required and then the pad is switched out.

3.261 Part or the whole of this pad is switched out depending upon the class of toll connecting trunk connected to the intertoll trunk. When a high loss toll connecting trunk is connected to the intertoll trunk, the full "A" pad is switched out; when a low loss toll connecting trunk is connected to the intertoll trunk, part of the "A" pad is switched out. This pad control is accomplished by the No. 4A system.

3.262 The "A" pads are switched out only at the points where the intertoll trunk connects to the toll connecting trunks. Where intertoll trunks are connected (for example, at an intermediate 4A office) the "A" pads stay in the connection.

Trunk Relay Equipment

3.263 Trunk relay equipment, as shown in Fig. 1, is associated with the incoming and outgoing ends of every trunk. This equipment performs both signaling and transmission functions. The signaling functions consist of receiving and forwarding supervisory signals exchanged by a calling office and a called or intermediate office. The transmission functions include continuation of trunk conductors, connecting 2-wire trunks to the four wires going to the switches, and passing information to the common control equipment.

3.264 Signaling Functions: Incoming trunk relay equipment receives supervisory signals, for example re-ring or disconnect, from an originating switchboard or a preceding toll system. It passes these signals to outgoing trunk relay equipment which in turn passes them on to the next office. The outgoing trunk relay equipment also receives signals such as start dialing and off-hook which it passes back to the incoming trunk relay equipment. Then this equipment passes the signals back to the originating switchboard or the preceding toll system.

3.265 Transmission Functions: Trunk relay equipment provides a transmission path for the trunks to and from the 4A switches. Intertoll trunks can be brought directly through the 4A switches without conversion. However, the toll tandem and toll switching trunks require conversion by the trunk relay equipment.

3.266 Toll tandem trunks are 2-wire when they leave the DSA or outward switchboards. A trunk of this type is converted from 2-wire to 4-wire by a repeat coil hybrid in the incoming trunk relay circuit. This circuit also contains the balancing networks needed to balance a particular trunk.

3.267 Toll switching trunks are outgoing to 2-wire local switching offices therefore the four wires from the No. 4A switches are converted to two wires in the outgoing trunk relay circuits. These circuits also contain repeat coil hybrids and balancing networks.

3.268 Passing Information to Common Control Equipment: When a call arrives at a No. 4A office, it is the trunk relay equipment which sends the signal to a link controller and tells the controller that this trunk has a call and wants an incoming sender. After the sender is attached to the trunk through the sender link frame, the trunk relay equipment passes information over the links to the sender (see Fig. 40). Class marks (VO or NVO) and how the pulses are being sent - by the loop or CX method (if the sender is a dial pulse incoming sender) are typical of the type of information passed from a trunk relay circuit to an incoming sender.

4. METHOD OF OPERATION ON TYPICAL CALLS

(A) General

4.01 This part describes the operation and some of the circuit features of the No. 4A toll switching system under specific call conditions. These calls are carried through one or more No. 4A toll offices and illustrate many of the various methods of routing calls. The descriptions make reference to the functions and sequence of operations of the various equipment elements as the calls progress.

4.02 However, the purpose of this part is to illustrate how the No. 4A toll switching system routes calls. Therefore, all the details concerning the operations and functions of the individual elements are not given since these are described in preceding parts of this section. Very little detail is given where the equipment element operates in a similar manner on every call. For example, an incoming sender receives and registers pulses on every call regardless of whether the call is to be completed in the area, sent to another area, etc. More detail, however, is given of the decoder and card translator operations because of the many variations; for example, whether this is a call requiring 3-digit translation or 6-digit translation or whether this is a call requiring an intertoll or toll switching trunk.

4.03 As discussed before, this type of information is obtained from a card dropped in a translator. In order to show how the marker and decoder use this information, the majority of the card holes (see Fig. 46) are discussed. (A complete description of the functions of all the holes and the relays associated with them is given in Section A828.121.)

4.04 The five typical calls described in this part illustrate some of the methods used by the No. 4A toll switching system to route calls. They are covered under the following headings:

1. (B) Call Illustrating Six-Digit Translation - Two Trunk Groups to an Area.

2. (C) Call Illustrating Automatic Alternate Routing.

3. (D) Call Illustrating Vacant Code Routing.

4. (E) Call Illustrating Six-Digit Translation - Terminal and Common Grade Trunks.

5. (F) Call Illustrating the Prefixing of an Area Code.

As mentioned, these are typical calls and may not represent actual application in the toll network.

4.05 To assist in studying these typical calls, Figs. 65 and 66 show the relative time that each equipment element in one No. 4A office is used as a call progresses. The relationship for the equipment used to switch a call that requires 3-digit translation is shown on Fig. 65; Fig. 66 shows this relationship for the equipment used to switch a call that requires 6-digit translation. Each equipment element is shown as a block; the element used first is at the left and the one used last at the right. The height of a block indicates the relative holding time. The top of the block indicates the time of seizure; the bottom of the block the time of release.

(B) Call Illustrating Six-Digit Translation - Two Trunk Groups to an Area

General

4.06 As explained in Part 1, under nationwide dialing, calls are switched on a destination basis rather than on a trunk route basis. This means that all of the No. 4A toll switching systems through which a call progresses know the basic numbering plan area in which the call terminates. It was also explained in Part 1 that when a No. 4A toll office has trunk groups to two or more toll centers in another basic numbering plan area, 6-digit translation is necessary. A call illustrating this condition was briefly described. In this part, a similar call is described but in more detail.

4.07 Six-digit translation is illustrated in the following call from a subscriber in New York City to a subscriber in Bar Harbor, Maine (see Fig. 67, attached).

4.08 It is assumed that at Bar Harbor there is a manual toll board and a manual local board. The Bar Harbor toll center receives traffic from New York via the Bangor No. 4A toll office. New York has direct trunks to the Bangor toll office and also to the Portland toll office which are both in basic numbering plan area 207 (area 207 includes the whole state of Maine). Therefore, when New York has a call for area 207, the No. 4A system in New York must determine (by making 6-digit translation) whether to route the call to Bangor or Portland for completion.

4.09 In the following description of the call, the operations necessary to perform 6-digit translation at New York are described. However, to give an overall picture of a call, the description continues by taking this call through the Bangor and Bar Harbor offices.

4.10 Figure 67, as the titles indicate, is also used to illustrate two other calls. The second and third calls described later under (C) and (D), are also between the same two subscribers. For the second call, it is assumed that all the New York to Bangor trunks are busy. It is therefore necessary at New York to alternate route the call to Boston which has trunks to Bangor. For the third call, it is assumed that the Bar Harbor national office code appears as a vacant code at New York. Because of the vacant national office code, it is impossible to make 6-digit translation at New York. Therefore this third call is routed via the principal city (Boston) for area 207.

4.11 For all these calls, the following assumptions are made:

(a) The outward switchboard in New York is equipped with multifrequency key sets.

(b) The No. 4A toll office in New York has separate trains. This call uses the intertoll train.

(c) The No. 4A toll office in Bangor has a combined train.

(d) The called number is Bar Harbor 6531. The national office code for the local office in Bar Harbor is 227, an arbitrary number.

(e) There is a high usage group of eight common grade intertoll trunks between New York and Bangor.

(f) Bangor and Portland "home" on the Boston No. 4A toll office. (See Part 1, par. 1.169 for definition of "home".)

(g) Boston homes on the New York No. 4A toll office.

(h) Boston is the principal city for New York traffic to the Maine area because both Bangor and Portland toll centers home on Boston.

(i) In the discussion of the third call, 227 is assumed to be a new code.

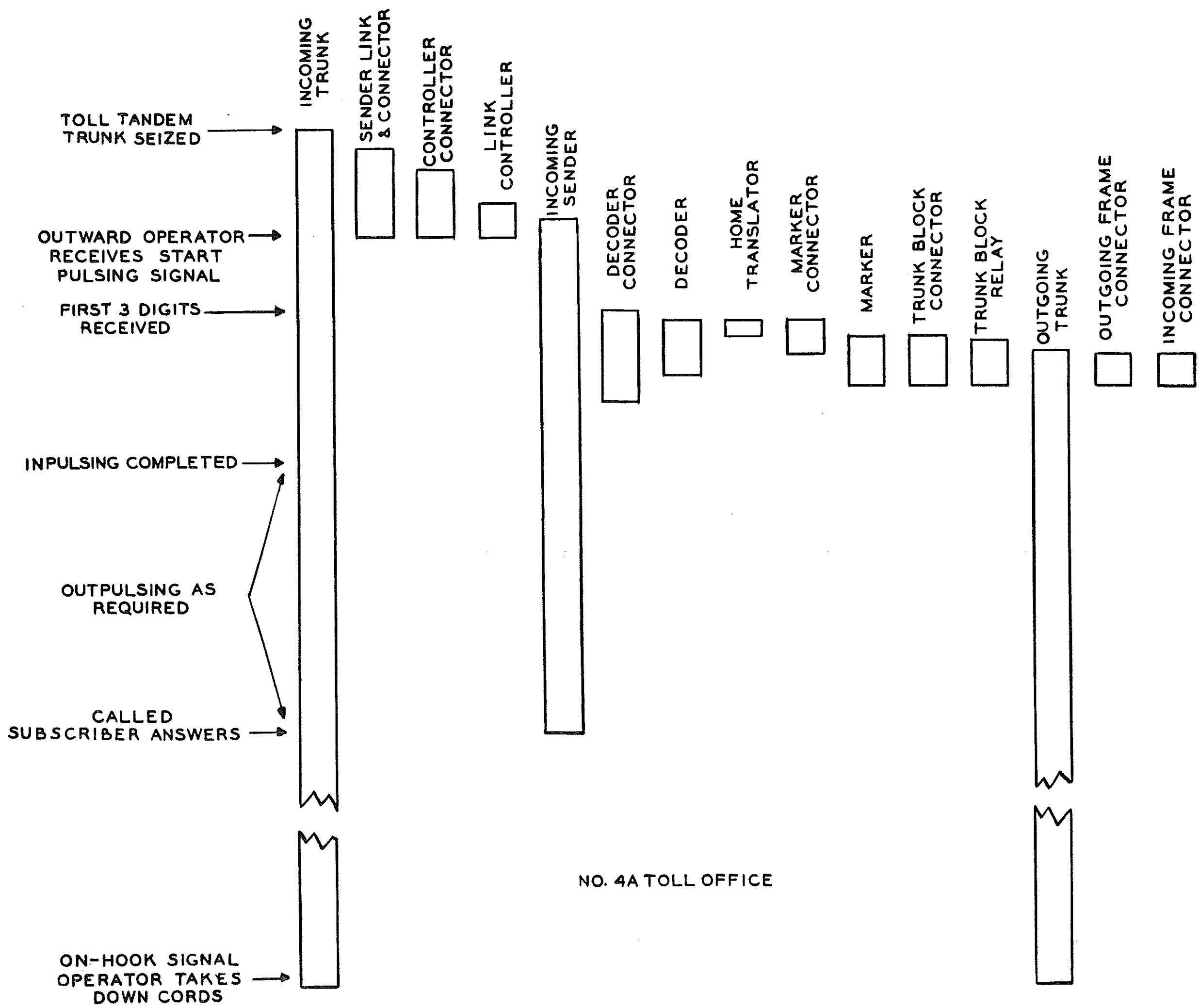


FIG. 65-PROGRESS DIAGRAM THREE-DIGIT TRANSLATION CALL

Description of Operation

4.12 The calling subscriber dials 211, reaches an outward toll operator in New York, and gives her the called number, Bar Harbor 6531. The operator then selects a toll tandem trunk which has access to the intertoll train in New York. Her routing instructions direct her to key 207 (area code for Maine) plus 227 (national office code for Bar Harbor). The numericals 6531 are not keyed because the outward operator has to pass Bar Harbor 6531 verbally when the inward operator at the manual toll board in Bar Harbor is reached.

4.13 At New York the incoming toll tandem trunk is connected to an MF incoming sender at the sender link frame by a controller connector and link controller. After the sender is attached, the controller connector and link controller release.

4.14 Then the No. 4A toll switching system signals the outward operator that a sender is attached and that she should begin keying. She keys 207-227. Upon receipt of 207, the incoming sender signals a decoder connector to seize an idle decoder. The decoder then sends the code 207-3D to its home translator where the corresponding card drops. (On this particular call, it is assumed that pretranslation takes place.)

4.15 This card has certain holes enlarged:

1. PRETRANSLATION - CA6 - (come again with six digits)

2. AREA CODE CONTROL - AC - (Area code registered in sender)

3. TRANSLATOR BOX NUMBER - (Tens and units digits of foreign translator number)

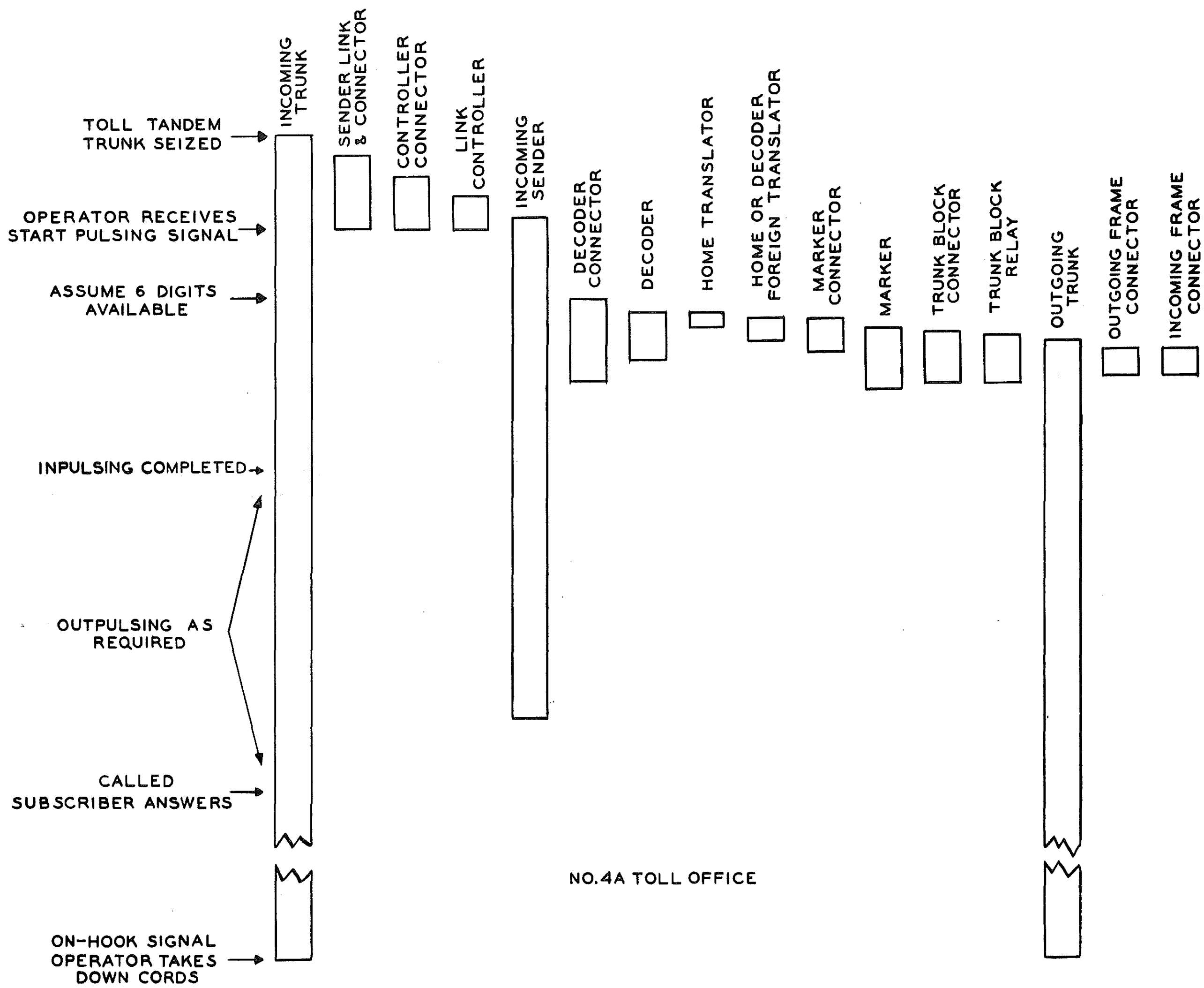


FIG.66 - PROGRESS DIAGRAM SIX-DIGIT TRANSLATION CALL

4. OGT APPEARANCE - IT - (Outgoing trunks appear on the intertoll train)

5. TRUNK BLOCK CONNECTOR, TRUNK BLOCK, GROUP START, and GROUP END - (Tens and units digits which direct the marker to the outgoing trunk group and identify the trunks it should test first and last)

6. CODE CONVERSION - CCHN, CCTN, CCUN- (No code conversion of hundreds, tens or units digits required)

7. VAR SPILL CONTROL - NSK - (Do not skip any digits when outpulsing)

8. CLASS - (Tens and units digits of class number which gives information concerning type of outpulsing required, in this case MF pulses)

9. ROUTING INSTRUCTIONS - (Follow with overflow)

Only the first three items are used to route this call; the others are used to route a vacant code call via a principal city (Boston) as explained later in <u>(D) Call Illustrating Vacant Code Routing.</u>

4.16 When the 207-3D card drops, it tells the decoder that six code digits are required (pretranslation using the CA6 hole) before a call can be switched to foreign area 207. If six code digits have not been registered in the incoming sender by the time the 207-3D card drops, the decoder, after advising the sender that six digits are needed, releases. The home translator also restores to normal and the decoder is available to serve other calls.

4.17 When the six digits (area code plus national office code) have been registered in the incoming sender, it again signals a decoder connector to seize an available decoder. When a decoder (it may or may not be the same one) is seized, it sends the code 207-3D to its home translator and an identical (or the same) card drops. By this time, the incoming sender has signaled the decoder that six digits are registered and the decoder proceeds with the call.

4.18 From the TRANSLATOR BOX NUMBER holes on the 207-3D card, the decoder now learns which foreign area translator contains the 207-227-6D card, the card which has the information for routing this call. The decoder then restores the first card (the 207-3D card) and signals a translator connector to connect to the particular foreign area translator containing the 207-227-6D card.

4.19 Now the decoder passes 207-227-6D to this foreign area translator and the corresponding card drops. This card, representing the eight intertoll trunks between New York and Bangor, has the following holes enlarged:

1. ROUTING INSTRUCTIONS - (Relay-to-relay routing)
2. ALTERNATE ROUTE PATTERN NUMBER - (Tens and units digits of a route relay number)
3. OGT APPEARANCE - IT
4. TRUNK BLOCK CONNECTOR, TRUNK BLOCK, GROUP START, AND GROUP END
5. CODE CONVERSION - CCHN, CCTN, CCUN
6. VAR SPILL CONTROL - SK3 - (Skip the first three digits when outpulsing)
7. CLASS - (MF pulsing)

4.20 With a relay-to-relay type of routing instruction, the decoder first determines that there is an idle trunk among the eight high usage trunks between New York and Bangor or among those on some alternate route before it presents a card to the marker. Therefore, the decoder immediately goes to the relay tree and operates the route relay corresponding to the number in the ALTERNATE ROUTE PATTERN NUMBER holes. By the group busy chain lead method, the decoder checks these eight trunks and, in addition, the alternate route trunks via Boston.

4.21 For this call, it is assumed that there is an idle trunk among the eight trunks to Bangor. (The next call <u>(C) Call Illustrating Automatic Alternate Routing</u>, describes the method of operation when the decoder does not find an idle trunk and must go to the Boston trunks.)

4.22 When the decoder determines that there is an idle trunk among those represented by the 207-227-6D card, it uses the information on this card to switch the call. The IT hole on the card tells the decoder that these outgoing trunks are on the intertoll train and therefore the decoder signals for an idle intertoll marker. A marker is seized through a marker connector and is then connected to the incoming sender through the decoder connector.

4.23 Next, information is passed from the decoder and the dropped card to the marker, as follows:

(a) Location of the outgoing trunks.

(b) To follow with second trial in case the marker finds all trunks busy when it attempts to select one from the information supplied by the card. (When a decoder gets a relay-to-relay routing instruction, it automatically gives a follow with second trial indication to the marker. See par. 3.120.)

(c) No code conversion is required.

(d) Skip three code digits when outpulsing. The area code (207) is skipped because these trunks terminate in that area.

(e) To outpulse on a multifrequency basis.

Items (c), (d), and (e) are transmitted to the incoming sender by the marker.

4.24 The marker checks for receipt of all information and signals the decoder to release. At this point, the card is restored and the card translator is available for another call.

4.25 The marker then seizes an idle outgoing intertoll trunk, establishes a channel between the incoming tandem trunk and this outgoing trunk, and releases.

4.26 When the outgoing trunk is seized, it sends a signal to the Bangor No. 4A toll office. Upon receipt of this signal at Bangor the trunk is connected to an MF incoming sender there.

4.27 When a sender is attached to the trunk, a signal is sent to the sender at New York. Then the New York sender outpulses 227 (Bar Harbor national office code) on a multifrequency basis. After the incoming sender at Bangor receives 227, it signals a decoder connector to seize an idle decoder. The seized decoder sends the code 227-3D into its home translator and the corresponding card drops.

4.28 The 227-3D card which drops in the home translator has the following holes enlarged:

1. PRETRANSLATION - NCA - (No come again, three code digits are sufficient)
2. AREA CODE CONTROL - NAC - (Not an area code, 227 is a national office code)
3. TRUNK BLOCK CONNECTOR, TRUNK BLOCK, GROUP START, AND GROUP END
4. CODE CONVERSION - CCHN, CCTN, CCUN
5. VAR SPILL CONTROL - SK3
6. CLASS - (No outpulsing required - manual class)
7. ROUTING INSTRUCTIONS - (Follow with overflow)

The NCA hole tells the decoder that three digits are sufficient to route this call, an example of 3-digit translation. Therefore the decoder proceeds with the call.

4.29 The decoder signals a marker connector to seize a combined marker. After it is seized, the marker is connected to the incoming sender through the decoder connector. Then the decoder passes the following information to the marker:

(a) Location of the desired outgoing trunks.

(b) To follow with overflow in case these are busy.

(c) No code conversion is necessary.

(d) No outpulsing is required because the call is to a manual toll office.

The marker passes items (c) and (d) to the incoming sender and signals the decoder to release.

4.30 The marker seizes an idle outgoing intertoll trunk, establishes a channel and releases. The incoming sender also releases because outpulsing is not required.

4.31 At the same time, a signal is sent to the inward switchboard at Bar Harbor. The inward operator at this switchboard answers the signal and obtains the called number from the outward operator in New York. The call is then completed to the called subscriber.

(C) Call Illustrating Automatic Alternate Routing

General

4.32 Automatic alternate routing is necessary for nationwide toll dialing. As described in Part 1, a No. 4A toll switching system can automatically examine and choose an alternate route for a call without requiring any additional information other than that furnished by the originating operator (or a preceding toll switching system). A second call made by the same subscriber in New York to the same subscriber in Bar Harbor (see Fig. 67), which illustrates this method of routing is now described. It is assumed that the New York to Bangor route previously used is not available because all the trunks are busy.

Description of Operation

4.33 This call progresses in the same manner as the previous one up to the point where the New York decoder checks for idle trunks to Bangor among those represented by the 207-227-6D card. This time the decoder finds all the New York to Bangor trunks busy.

4.34 The 207-227-6D card has a relay-to-relay routing instruction, as described in paragraph 4.20. This type of instruction tells the decoder to go to the relay tree and check for idle trunks among those in the direct route and those in alternate routes.

4.35 The ALTERNATE ROUTE PATTERN NUMBER holes tell the decoder which route relay in the tree to operate. As discussed in Part 3, a route relay has associated with it a maximum of 4 cards, each having information on 40 trunks. These cards are also numbered in accordance with the route relay number. For example, route relay 21 has cards 210, 211, 212, and 213 associated with it. The decoder, from information supplied by group busy chain leads, selects the first card with idle trunks. If there are no idle trunks on cards 210 and 211, but there are idle trunks on card 212, the decoder presents the information on this card to the marker as follows.

4.36 The decoder restores the Bangor card (the 207-227-6D card) and releases the foreign area translator and connector. Then it drops the 212 alternate route card (212-AR) in its home translator. This card is coded 212 in the A, B and C positions and AR in the CG position. (Actually AR is indicated by a two out of four code in the CG group of holes.)

4.37 The 212-AR card has the following holes enlarged:

1. AREA CODE CONTROL - AFA - (Alternate route this call through a foreign area)

2. OGT APPEARANCE - IT

3. TRUNK BLOCK CONNECTOR, TRUNK BLOCK, GROUP START, and GROUP END

4. CODE CONVERSION - (These holes are coded with area code 617, the area in which the trunks terminate. This code is used to provide variable spill information as described below.)

5. CLASS - (MF pulsing)

6. ROUTING INSTRUCTIONS - (Follow with second trial)

4.38 An intertoll marker is seized and then receives the following information from the decoder and the dropped card:

(a) Location of the desired outgoing trunks.

(b) To follow with second trial.

(c) To outpulse all digits registered in the incoming sender. This information cannot be provided by the variable spill control holes because an AR card furnishes information for various calls which require different spilling conditions. For example, the same AR card may be used to serve calls going both to Bangor and to Boston. The call to Bangor via Boston requires the area code digits to be forwarded (an NSK signal) while a call which terminates in the Boston area requires the area code to be skipped (an SK3 signal).

Because both indications cannot be put on the same card, the spilling information is provided by the code conversion holes in an operation called code matching. These holes are coded with the area code of the area in which the group of outgoing trunks terminate. The decoder compares the area code on the card with the area code registered in the sender. If they match, an SK3 signal is given; if they do not match, an NSK signal is given.

For this call, the decoder matches the 207 area code in the incoming sender with the area code 617 punched in the code conversion holes of the AR card. They do not match, therefore all the digits have to be outpulsed and an NSK signal is given.

4.39 After a channel is established, the New York incoming sender spills forward 207-227 to the Boston incoming sender. The Boston No. 4A toll office makes 6-digit translation and then switches the call to the Bangor No. 4A toll office where the call is advanced to the manual toll and local offices as described previously.

(D) Call Illustrating Vacant Code Routing

General

4.40 A third call between the same two subscribers can be used to illustrate vacant code routing. To illustrate this type of routing, it must be assumed that Bar Harbor is a new local office and that the 6-digit card (card 207-227-6D) representing Bar Harbor has not yet been made up at New York. Therefore the code 227 looks like a vacant code to New York and the call is routed to Boston, the principal city for area 207, by information obtained from the 207-3D card. At Boston, where the code 227 is recorded, the call is routed to Bangor.

Description of Operation

4.41 The call progresses as previously described until the decoder at New York attempts to drop the 207-227-6D card. No card drops, therefore the decoder assumes that this is a vacant code and goes back to its home translator. There it drops the same 207-3D card that was originally dropped under control of the first three digits (see par. 4.15).

4.42 As was mentioned in connection with the first call, this card, in addition to referring the decoder to a 6D card, also has specific information concerning trunks to the principal city (Boston).

4.43 A marker is seized and receives the following information from the decoder and the dropped card:

(a) Location of the desired outgoing trunks.

(b) To follow with overflow.

(c) No code conversion is required.

(d) To outpulse all digits.

(e) To outpulse on a multifrequency basis.

4.44 After the channel is established, the New York sender outpulses 207-227 to Boston. At Boston 6-digit translation is made and the call is switched to Bangor where it is advanced to Bar Harbor.

(E) Call Illustrating Six-Digit Translation - Terminal and Common Grade Trunks

General

4.45 To simplify the initial discussion of 6-digit translation, no reference was made to the grades of trunks used. In the description of the following call, the grade of trunk is considered. As explained in Part 3, there are three grades of intertoll trunks and a No. 4A switching system must make sure that it connects intertoll trunks of the proper grade. This call illustrates the selection of the proper grade of trunk using 6-digit translation.

4.46 Figure 68 shows that there are 65 intertoll trunks between Pittsburgh, Pa. (area 412) and Cleveland, Ohio (area 216). Fifteen of these trunks are terminal grade trunks: trunks which from a transmission standpoint are only satisfactory for calls originating in Pittsburgh and terminating in Cleveland. These trunks are used when there is only one intertoll trunk in the established connection between the calling and called subscribers.

4.47 The other 50 trunks are common grade intertoll trunks. Common grade trunks are of better transmission quality than the terminal grade trunks and are used when there are two or more intertoll trunks in the connection between the calling and called subscribers. For example, they can be used for calls originating in Pittsburgh and going through Cleveland to another toll center.

4.48 In order to select the proper grade trunk for a call originating in the Pittsburgh area and going to area 216, the No. 4A system at Pittsburgh must determine whether the call is to terminate in Cleveland or is to go through Cleveland to another toll center. Using 6-digit translation, the Pittsburgh No. 4A system translates the national office code on every call to area 216 and determines whether this is the code of a local office in the Cleveland area (for which the terminal grade trunks are used) or is the code of a local office reached through still another toll center (for which the common grade trunks must be used).

4.49 Of course, if a call to area 216 does not originate in the Pittsburgh area but comes into the Pittsburgh No. 4A office over an intertoll trunk, it is routed over a common grade trunk regardless of whether it terminates beyond Cleveland or in the Cleveland area.

4.50 In order to tell the Pittsburgh No. 4A switching system how the call arrived - over a toll tandem trunk from a switchboard within the area or over an intertoll trunk from another toll switching system outside the Pittsburgh area - each trunk is equipped to give a signal (called a class mark) to the incoming sender. A toll tandem trunk gives an NVO (Non Via Only) and an intertoll trunk a VO (Via Only) class mark. (Since common and via grade trunks have the same transmission qualities, the VO class mark is used for both.)

4.51 The following paragraphs describe the method of selecting the proper grade trunk for a call from a subscriber in the Pittsburgh area to a subscriber served by a No. 1 Crossbar office in the Cleveland area. For this call, the following assumptions are made:

(a) The DSA switchboard at Pittsburgh is equipped with multifrequency keysets.

(b) Both the Pittsburgh and Cleveland No. 4A toll offices have separate trains. This call uses the intertoll train at Pittsburgh and the toll completing train at Cleveland.

(c) One intertoll trunk group between Pittsburgh and Cleveland has 15 terminal grade trunks and another 50 common grade trunks.

(d) There are 50 toll switching trunks from the Cleveland 4A office to the No. 1 Crossbar office.

(e) The No. 1 Crossbar office is equipped with multifrequency terminating senders.

(f) All six code digits have been registered in the sender when the decoder in Pittsburgh is seized the first time.

(g) There is no principal city route available for this call, therefore paired foreign area translators are required at Pittsburgh (see Part 3, par. 3.119).

Description of Operation

4.52 The DSA operator at Pittsburgh receives the called number (Cleveland, Ohio LA 5-6328) from the calling subscriber. The operator then selects a toll tandem trunk which has access to the intertoll train in the Pittsburgh No. 4A toll office. This toll tandem trunk is then connected to an incoming MF sender at the sender link frame.

4.53 When the DSA operator receives a signal that the sender is connected, she keys 216-LA5-6328 into the incoming sender at Pittsburgh. The incoming sender also registers the NVO class mark of the incoming tandem trunk. Upon receipt of 216, the sender signals a decoder connector to seize an available decoder.

4.54 The decoder now transmits 216-NVO-3D to its home translator where a card coded 216-3D drops. Both the NVO and VO tabs have been removed from this card because this same card drops whether a call comes in over an intertoll trunk (VO class mark) or over an incoming tandem trunk (NVO class mark). This is true because the card merely tells the decoder that 6-digit translation is necessary and where to find the proper card.

4.55 Because in this example it is assumed that there is no principal city route available and consequently a decoder would have no reason to come back to this card, no other information such as trunk block connector, trunk block, SK3, etc. is required.

4.56 On this card, holes in only four groups are enlarged:

1. PRETRANSLATION - CA6
2. AREA CODE CONTROL - AC
3. TRANSLATOR BOX NUMBER
4. ROUTING INSTRUCTIONS - NPCR - (No principal city route available for this call)

4.57 Since six code digits are assumed to have been registered in the incoming sender by the time the 216-NVO-3D card dropped, pretranslation is not necessary and the decoder proceeds with the call. From the card the decoder learns that the 6D card is in paired foreign area translator No. 05. The decoder signals translator connector No. 05 and tells it to connect to this translator. The decoder then transmits 216-525-NVO-6D (525 = LA5) to the translator and the corresponding card drops. This card represents the fifteen terminal grade trunks to Cleveland and therefore retains the NVO tab.

4.58 Actually, because of the two grades of trunks, two different 6D cards are provided in each of the paired translators at Pittsburgh for each local office in the Cleveland area. One 6D card has an NVO tab and represents the terminal grade trunks; this card is used on the call being described. Another 6D card has the VO tab and represents the common grade trunks; this card (coded 216-525-VO-6D) is used if a call for the same local office comes into the Pittsburgh area over an intertoll trunk (VO class mark) from some other toll center.

4.59 The NVO card represents the fifteen terminal grade trunks which can be used on this call. However, if all the terminal grade trunks between Pittsburgh and Cleveland are busy, one of the common grade trunks can be used. A common grade trunk can be used instead of a terminal grade trunk because it has a higher grade of transmission. However, a terminal grade trunk can never be used in place of a common grade trunk.

4.60 Therefore, in order to be able to use a common grade trunk if necessary, the NVO card has a routing instruction which tells the decoder to check the common grade trunks also. Thus the NVO card has the following holes enlarged:

1. ROUTING INSTRUCTIONS - (Card-to-Relay)
2. ALTERNATE ROUTE PATTERN NUMBER
3. OGT APPEARANCE - IT
4. TRUNK BLOCK CONNECTOR, TRUNK BLOCK, GROUP START, and GROUP END
5. CODE CONVERSION - CCHN, CCTN, CCUN
6. VAR SPILL CONTROL - SK3
7. CLASS - (MF pulsing)

4.61 The card-to-relay routing instruction tells the decoder to go to the relay tree and check the trunk subgroups to see if there are any idle common grade trunks at the same time that it is presenting this card (216-525-NVO-6D) to a marker and the marker is checking for an idle terminal grade trunk.

4.62 If the alternate route pattern number is 19 the decoder goes to route relay 19. This relay has two cards (190-AR and 191-AR) associated with it; these cards contain the information concerning the fifty common grade trunks.

4.63 Meanwhile, the decoder signals the marker connector to seize an intertoll marker. After the marker is seized, it receives the following information from the decoder and card:

(a) Location of the outgoing trunks

(b) No code conversion is required

(c) To skip three digits

(d) To outpulse on a multifrequency basis.

The marker finds an idle terminal grade trunk and establishes a channel. It also passes items (b), (c), and (d) above to the incoming sender and releases.

4.64 When the intertoll trunk is seized, a connect signal is sent to the Cleveland No. 4A toll office. This trunk is then connected at Cleveland to an MF incoming sender at the sender link frame. When the Cleveland incoming sender is ready to receive the MF pulses, a signal is sent to the Pittsburgh sender which then spills forward 525-6328, skipping the area code.

4.65 When the incoming MF sender at Cleveland receives 525, it signals a decoder connector to seize an idle decoder. The decoder transmits 525-3D to its home translator and drops the corresponding national office code card.

4.66 The 525-3D card that drops has the following holes enlarged:

1. PRETRANSLATION - NCA
2. AREA CODE CONTROL - NAC
3. ROUTING INSTRUCTIONS - (Card-to-Card)
4. OGT APPEARANCE - TC- (Toll Completing)
5. TRUNK BLOCK CONNECTOR, TRUNK BLOCK, GROUP START, and GROUP END
6. CODE CONVERSION - CCHN, CCTN, CCUN
7. VAR SPILL CONTROL - SK3
8. CLASS - (MF pulsing)

4.67 The card-to-card routing instruction is used because there are 50 toll switching trunks between the Cleveland No. 4A office and the No. 1 Crossbar Office and this, the first, card represents only 40. The remaining trunks are on the second card, which is coded 525-RA1. (If the marker does not find an idle trunk on the first card, the decoder restores that card and drops the second card. This card includes under ROUTING INSTRUCTIONS a "follow with reorder" routing instruction. Therefore, if no idle trunks are found on the second card either, the decoder uses the follow with reorder instruction on this card to route the call to a reorder trunk.)

4.68 When the first card (525-3D) drops, the decoder signals the marker connector to seize an idle toll completing marker. This marker obtains the location of the toll switching trunks represented by the card and seizes an idle trunk.

4.69 The marker passes the following information to the incoming sender:

(a) No code conversion is required.

(b) To outpulse on a multifrequency basis.

(c) To skip three digits (national office code) when outpulsing.

4.70 The marker then establishes a channel from the incoming intertoll trunk to the seized toll switching trunk.

4.71 When the toll switching trunk is seized, a signal is passed to the local No. 1 Crossbar office. Here the trunk is connected to a multifrequency terminating sender. Then the sender in the Cleveland office outpulses 6328 to the terminating sender. The No. 1 Crossbar office then switches the call to the called line.

<u>(F) Call Illustrating the Prefixing of an Area Code</u>

<u>General</u>

4.72 As pointed out in Part 1, a No. 4A toll switching system has more comprehensive variable spilling and code conversion features than the previous crossbar toll switching systems. One of these additional features is the ability to automatically prefix the three digits of an area code to the digits registered in an incoming sender. Prefixing an area code is necessary when one subscriber calls another subscriber in the same area and the call must be routed through a foreign area and back to the home area.

4.73 Figure 69 shows a case where the prefixing of an area code is required. The Lambertville, New Jersey toll office is in area 201 but because there are no direct trunks between Lambertville and Newark, New Jersey it homes on the Philadelphia toll office in area 215. When a subscriber in Morristown, New Jersey calls a subscriber in Lambertville, the call is routed through Newark in area 201, then out of area 201 to Philadelphia, and then back into area 201 to Lambertville.

4.74 The following assumptions are made:

(a) The outward toll switchboard at Morristown is equipped with multifrequency keysets.

(b) The Newark and Philadelphia No. 4A toll systems are separate train systems. This call uses the intertoll trains.

(c) Lambertville is a manual toll center.

<u>Description of Operation</u>

4.75 The outward operator in Morristown selects a toll tandem trunk and keys 536 (the national office code for Lambertville) into the incoming MF sender at Newark. (The area code is not keyed because the call is between subscribers in the same home area.) The sender in the Newark office obtains a decoder. This decoder then sends 536-3D to the home translator where the corresponding card drops.

4.76 This card represents the trunks to Philadelphia and has the following holes enlarged:

1. PRETRANSLATION - NCA

2. AREA CODE CONTROL - NAC

3. ROUTING INSTRUCTIONS - (Relay-to-Relay)

4. ALTERNATE ROUTE PATTERN NUMBER

5. OGT APPEARANCE - IT

6. TRUNK BLOCK CONNECTOR, TRUNK BLOCK, GROUP START, and GROUP END

7. CODE CONVERSION - (Area 201 coded in these holes because this code must be prefixed as described below.)

8. VAR SPILL CONTROL - NSK

9. CLASS - (MF pulsing)

4.77 Because this card has a relay-to-relay routing instruction, the decoder immediately goes to the relay tree and tests for idle trunks among those represented on the card (the 536-3D card) and among those on any alternate route cards. Assuming there are idle trunks on the 536-3D card, the decoder signals for an intertoll marker and then passes the required information on to the marker.

4.78 In addition to telling the marker the location of the outgoing trunks, the decoder also tells the marker that the sender must prefix area code 201. This information is furnished by putting area code 201 in the code conversion holes and enlarging the NAC and NSK holes. Whenever a 3D- card has an NSK hole and an NAC hole enlarged, the decoder knows that the code in the code conversion holes must be prefixed to the digits in the sender and then all digits spilled forward.

4.79 After the marker performs its function of establishing a channel, the sender outpulses 201-536 to Philadelphia. At Philadelphia 6-digit translation is made and the call is routed to Lambertville.

5. MAINTENANCE FEATURES

(A) General

5.01 The maintenance of a toll crossbar system requires close coordination of toll line maintenance with maintenance of the switching equipment. Therefore, along with the description of the maintenance facilities provided for the 4A system, facilities used for toll line maintenance are also included.

5.02 Most of the maintenance elements used in the toll crossbar system with No. 4A switching equipment are similar to those used with the No. 4 and No. A4A systems. The most important new component is the Trouble Recorder Frame which replaces the Trouble Indicator Frame used in the previous crossbar toll systems.

5.03 This part gives a highlight description of all of the maintenance facilities which were designed specifically for the Nos. 4, A4A and 4A toll switching systems. Miscellaneous testing equipment such as the 35F Relay Test Set, 2B Signaling Test Set, 40B Transmission Measuring System, etc. which have been in use in other systems for some time are not described.

5.04 More detailed descriptions of the maintenance test frames, including block diagrams of typical test set-ups are covered in several Sections in the A700 series.

5.05 Maintenance facilities are located in two equipment areas, the toll test and terminal room and the No. 4A system switch rooms.

5.06 The 4A switching system maintenance equipment is generally concentrated in a section of the floor called the "maintenance center".

5.07 To permit coordination of the activities in the toll test and terminal room and the maintenance center, intercommunicating trunks are provided. Trunks required for communicating with other points are also provided in the toll test and terminal room and in the maintenance center.

5.08 Following is a summary of the maintenance components provided in the toll crossbar system which are described here.

Switching Maintenance Equipment

Test Frames Located in Maintenance Center

(a) Trouble Recorder Frame

(b) Incoming Sender Test Frame

(c) Outgoing Sender Test Frame

(d) Sender Make Busy Frame

(e) Automatic Outgoing Toll Connecting Trunk Test Frame

(f) Manual Outgoing Toll Connecting Trunk Test Frame

Toll Line Maintenance Equipment

Equipment Located in Toll Test and Terminal Room

(a) 17C Toll Test Board

(b) Patching Bays

(c) Automatic Outgoing Intertoll Trunk Test Frame

Miscellaneous Test Sets - Portable, Semi-Portable and Frame-Mounted

Switching Maintenance

(a) Incoming, Outgoing and Intertoll Trunk Test Set

(b) Incoming Trunk Test Line

(c) Frame Identification Frequency Test Set

(d) 100A Test Set

Toll Line Maintenance

(e) Test Line Circuit for Making Balance and Noise Tests

(f) Test Line Circuit to Milliwatt Distributing Circuit

(B) Switching Maintenance Equipment

Trouble Recorder Frame

General

5.09 The primary functions of the circuits located on the Trouble Recorder Frame are:

1. Production of card records on service calls encountering trouble and test calls.

2. Testing of decoders, markers, translators and link controllers.

3. Electrical control of translator circuits to permit certain manual operations to be performed.

5.10 This frame mounts the perforator test unit and is also a central location for circuit busy indicating lamps, make busy jacks, alarm lamps and keys, and the jacks which are used to put the emergency translator in service in place of a regular translator.

5.11 All of the functions listed in 1, 2 and 3 are performed by two circuits: the Decoder-Marker Test and Trouble Recorder Circuit and the Link Controller Test Circuit. The miscellaneous lamps and jacks are included in the Miscellaneous Circuit for Trouble Recorder Frame.

5.12 One trouble recorder frame (Fig. 70) is provided in each 4A installation.

Production of Card Records on Service Calls and Test Calls

5.13 The trouble recorder mechanism which is located on the Trouble Recorder Frame perforates card records on service calls which encounter trouble as they are being set up by the common control equipment. When desired, card records are also perforated on test calls. The same circuit and perforating mechanism is used to perforate both types of records. A single trouble recorder is mounted on the frame. It can perforate one card at a time.

5.14 On service calls encountering trouble, the trouble recorder may be summoned by a decoder, a marker or a link controller, depending on where the failure occurred.

5.15 On test calls the trouble recorder may or may not be called in depending on the setting of keys on the test frames. When the keys are set to make card records on test calls, the test circuits compete with service calls for the use of the trouble recorder. Whether it is seized by a service call or by a test call, it is made busy until the record on that call is completed.

5.16 If a service call cannot get the recorder, the circuits in trouble are released without waiting to make a record. In such cases a "display lost" lamp is lighted, an alarm sounds, and a register counts the failure to make a record.

5.17 While test calls compete with service calls for the recorder, the maintenance force can control this competition. Test calls are set up one at a time by the test frame attendant. Therefore the number of test calls can be regulated so that interference with the demands for card records by service calls can be controlled.

5.18 As has been indicated when trouble is encountered in the common control equipment during the switching of a call, a decoder, a marker or a link controller puts in a bid for the trouble recorder (which one puts in the bid depends on how far the call had progressed when the failure occurred). When the trouble recorder is seized, multicontact relays in these circuits operate and extend trouble indicating leads to the recorder perforator circuit. In addition, multicontact relays are operated in the incoming sender, decoder connector, card translator and incoming frame which also extend leads to the perforator so that a complete story on the failure can be recorded. These latter frames cannot summon the trouble recorder.

5.19 The decoders, markers and link controllers are equipped with timing circuits which permit reasonable intervals for completing certain functions or series of functions. If any of these intervals are exceeded, because of some circuit failure, the trouble recorder is summoned by the circuit involved.

5.20 There are four stages in the setting up of a call during which the common control equipment may call for the trouble recorder.

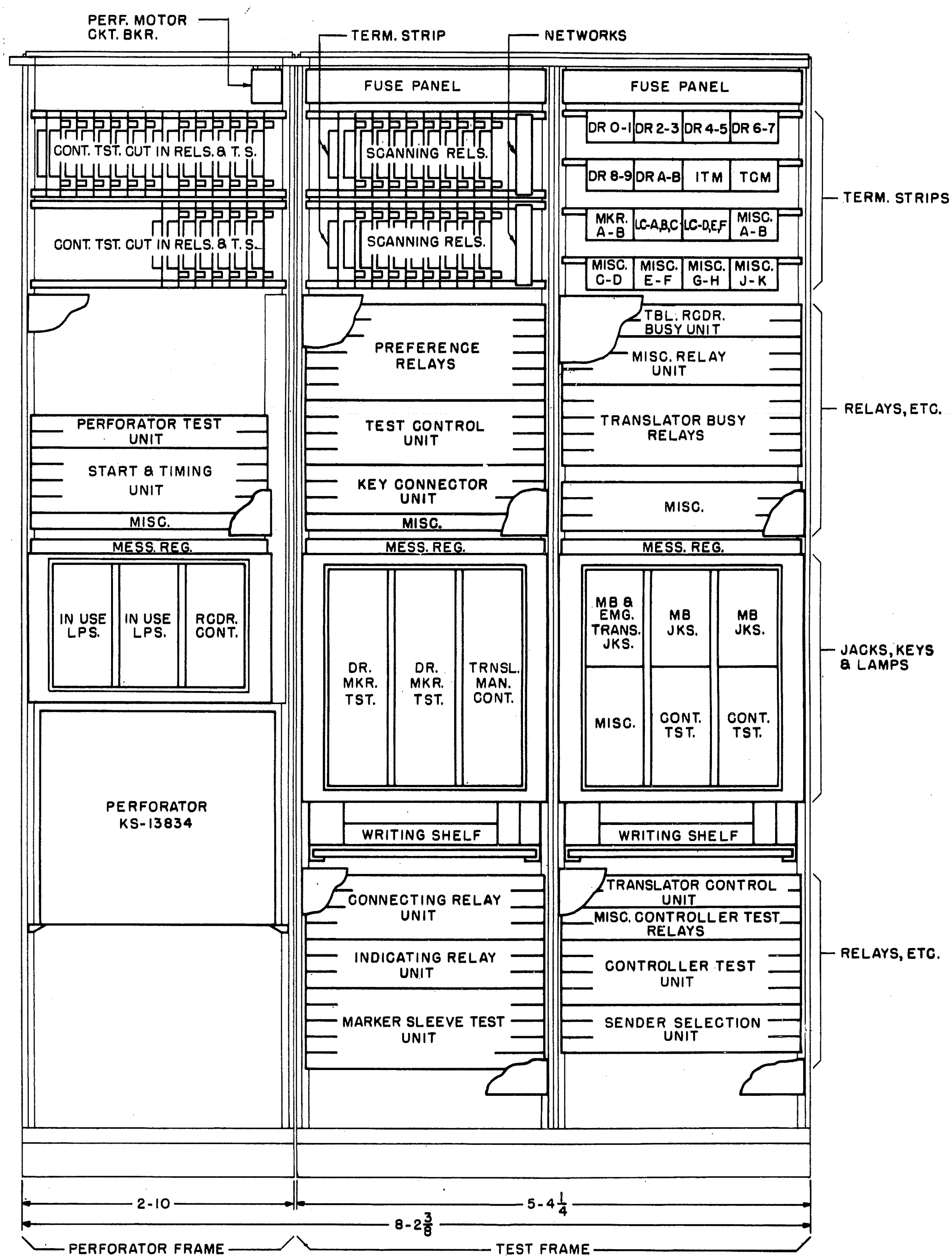


FIG. 70-TROUBLE RECORDER FRAME

5.21 The first, or controller stage, is when the link controller is connecting the incoming trunk to an incoming sender. In this stage the link controller summons the trouble recorder.

5.22 The second is the decoder stage, which is from the time the decoder is seized until a marker is connected. The third is the decoder-marker stage, which is the interval during which both the decoder and marker are engaged on the call. During these stages the decoder calls for the trouble recorder.

5.23 The fourth, or marker stage, is when the decoder has released and the marker is connected to the incoming sender. The marker summons the trouble recorder at this stage.

5.24 As previously noted, when the trouble recorder is seized during any of these stages, other common control equipment may be called in to complete the trouble record.

5.25 A trouble record on a service call or a test call includes the following typical kinds of information.

1. The identity of the circuit which seized the trouble recorder, that is, the decoder, link controller, decoder-marker test circuit, etc.

2. The identity of the major equipment units used on the call, for example, the decoder, marker, incoming sender, link frame, connector, etc. The identity of the switching channel is also recorded.

3. How far the decoder, marker and controller had progressed at the time of failure. This is indicated by making a record of the relays which were operated at that time.

4. The kind of trouble that caused the failure. For example, failure of the "2 out of 5" check, which is made when the number of the trunk block relay is transmitted to the marker.

5. The results of cross detecting and continuity tests which the decoder and marker make on certain leads.

5.26 A card is always in position in the trouble recorder perforator, ready to receive a record. Figure 71, attached, shows a card blank and a card which has been perforated with a trouble record.

5.27 It will be noted that the card is divided into 18 horizontal rows intersected by 60 vertical columns. One intersection of a horizontal row with a vertical column is reserved on the card for each of the trouble indicating leads from the switching units which can be connected to the trouble recorder. Each of these intersections has a number or letter, or a combination of numbers and letters which tell what the trouble indicating lead has to say. For example, under "SOURCE OF RECORD", a perforation above D means that a decoder had seized the recorder, a punch above 3 under "DECODER" indicates that it was decoder number 3. Similarly, a perforation above DCB on row R1, vertical 0 under "DECODER PROGRESS", indicates that the DCB relay in the decoder was operated at the time of the failure. A perforation above FTD on row S8, vertical 52, under "DECODER TIME-OUT" indicates that the decoder had not been connected to a foreign area translator in the time allowed for this job.

5.28 The following tabulation gives a general idea of the information punched on the card shown in Fig. 71. The meanings of all of the designations on the card and several typical trouble records are discussed in detail in Section A828.131.

Designation	Hor. Row	Vert. Col.	Meaning
M	S8	1	Record was made during marker stage and therefore the marker seized the recorder.
TR1	S8	8	Record was made during marker first trial.
0	S8	20	Marker No. 0.
0 0	S6 S6	0) 8)	Sender frame No. 00.
1	S6	19	Dial pulse sender No. 1.
TO UO	S5 S5	15) 17)	Decoder connector frame No. 00.

Designation	Hor. Row	Vert. Row	Meaning
CO	S5	27	Decoder connector No. O.
Perforations in horizontal rows SO, and R4 to R7 (verticals 0 to 29)			This is routing information received by the marker, either directly or indirectly from the card translator.
Perforations in horizontal rows RO and R1 (verticals 0 to 29)			Show what relays were operated in the marker at the time the record was made.
TMZ	S8	58	Indicates that too much time elapsed between connection of the marker to the incoming frame and the release of the marker. (See par. 5.19.)
TO U1	S6 S5	30) 31)	Trunk block connector frame No. 01.
0 2	S6 S6	35) 37)	Trunk block relay No. 2. (This is a "2 out of 5" indication. 0+2 = 2.)
5	S4	35	Incoming frame group No. 5. (Includes incoming frame Nos. 10 and 11.)
0	S1	31	Odd incoming frame, therefore No. 11.
0	S1	35	Odd trunk block connector was connected to the marker.
CNO	S1	40	Odd connector relay, (CNO) was operated in marker. Therefore, odd connectors on trunk block, incoming and outgoing frames were tried first.
RTB	R8	57	Junctor walking circuit was in position to test second subgroup of junctors when recording was made.

5.29 The trouble recorder can perforate about thirty cards per minute. However, this rate might result in excessive decoder or marker holding time due to repetition of records on the same trouble. It might also rapidly exhaust the card bins. For this reason, a key is provided which can be operated to limit the number of records that can be made in a given time. For example, the number of records taken in a minute can be reduced from thirty to as few as five.

Test Circuits on Trouble Recorder Frame

5.30 <u>General</u>: The test circuits on the trouble recorder frame are manual in the sense that they cannot automatically progress from one circuit unit under test to the next. The keys must be manually set for each unit to be tested. The circuit tests this unit, gives a visual indication as to whether the test was successful or not and if the test was successful it releases. If the test encounters a failure the test circuit stops.

5.31 Keys are provided in each test circuit by means of which card records can be made on all test calls, or only on those encountering trouble, or so that no card records will be made on any test calls.

5.32 The decoder, marker and translator tests cannot be made simultaneously because they are made by the same test circuit (the decoder-marker test circuit) and some of the equipment and paths are used in common.

5.33 On the other hand, the link controller test circuit and the decoder-marker test circuit can be operated at the same time, but with certain limitations. If the keys in both test circuits are set up to make card records, they compete with each other and with service calls for the use of the trouble recorder. Under this condition, that is, where both test circuits are making card records, if the recorder is busy on a test call, or on a service call, another test call cannot be started until the recorder is available to it. The test keys can be set up and the start key operated but the tests will not begin until the test circuit has seized the recorder. When it does, it holds the recorder busy until its tests are completed and a card record is made.

5.34 Link controller tests can proceed at the same time that the decoder-marker test circuit is working, provided that the key in the link controller test circuit is operated to cancel the card recording feature. In this case, the link controller does not seize the trouble recorder circuit but operates independently of it and the results of the test are determined solely from the end result lamps.

5.35 However, the reverse is not true, because even though the key in the decoder-marker test circuit is operated to cancel card records, this test circuit must still seize the recorder circuit before it can start a test call. This is because the leads by which the decoder-marker test circuit gains access to decoders and markers for testing are also used in making card records.

5.36 Decoder, Marker and Translator Verification Tests - Manual Operations Control of Translator: Decoder, marker and translator verification tests are performed by one circuit - the Decoder-Marker Test and Trouble Recorder circuit. The setting of a three-position key on the trouble recorder frame determines which class of test is made. The decoder-marker test circuit has direct access for testing, to decoders, markers and card translators. This access is through the same relays that are used for trouble recording since most of the leads are used for both functions. For this reason, on test calls the decoder-marker test circuit must obtain the trouble recorder before the test call can proceed, whether or not a card record is made.

5.37 The test circuit simulates normal service sequences and operations. In all classes of tests a decoder is selected and the test circuit primes it with information normally received on various types of service calls. The decoder can be made to pick a particular marker, or to select one on a service basis.

(a) Decoder Test

The test call is stopped after the marker has received all the information from the decoder and the decoder has released. This checks the operation of the decoder and card translators and verifies the successful transmission of information from decoders to markers.

(b) Marker Test

The test call proceeds until the marker completes all of its functions including the selection of an outgoing trunk. This test checks the marker's functions, including connections to the trunk block connectors and to the incoming and outgoing frames.

(c) Translator Verification Test

The test call is interrupted at the point where the marker has checked the integrity of its information from the decoder. The card translator is held operated until a complete record of the information on the translator card is perforated by the trouble recorder.

By operating the proper keys, the test circuit can pick any card in the translator and have the trouble recorder make a complete record of its information. This feature is useful when new translator cards are put into service.

A test of all of the 116 output channels in the translator can be made simultaneously. This checks the operation of the phototransistors and translator amplifiers under worst circuit conditions. A lamp indicates that all 116 channels are satisfactory. If the lamp fails to light, a card record can be made of the particular channel that failed on the test.

(d) Manual Operations Control of Translator

A circuit is provided on the trouble recorder frame which performs electrical functions that are necessary when translator cards are added or removed. This circuit is also used when certain types of maintenance jobs must be done, such as replacing a selector bar unit. Keys permit any one of the card translators to be selected. The selected translator is then made busy and the emergency translator is substituted for it while the manual operations are being performed.

No records are perforated in connection with these operations.

(e) End Result Lamps

In addition to the perforated card records which give a complete record of test calls, the important end results of the tests are always recorded on locked-in "end result" lamps. The indications given by these lamps will make it feasible to dispense with card records on test calls when this is desirable.

5.38 Link Controller Tests: The link controller test circuit unlike the decoder-marker test circuit, busies only the actual circuit under test - the link controller circuit. It can simulate any desired combination of incoming trunk, sender link and sender found in the office by means of keys located on the trouble recorder frame. The test circuit furnishes all the information the controller would normally receive through the sender link.

5.39 As in the case of the decoder-marker test circuit, certain end result lamps are provided which give some information as to the results of the test. As has been noted, provision is made for making card records on all test calls, only on test calls encountering trouble, or for making no cards at all. This test circuit is optional equipment.

5.40 Miscellaneous Alarm and Make Busy Features: The trouble recorder frame is a central location for lamps, audible alarms, make busy jacks and plant registers associated with miscellaneous maintenance features. Many of these have no direct association with the trouble recorder and test circuits on the trouble recorder frame.

5.41 Some of the miscellaneous features are:

1. Audible and visual alarms to indicate 48-volt fuse operation, failure of perforator motor, seizure of trouble recorder due to a trouble on a service call, failure to obtain the trouble recorder on a service call, etc.

2. Make busy jacks for making trouble recorder busy to any one or all of the decoders, markers, and translators, for making link controllers busy, etc.

3. Test battery supply jacks and terminals, frame line jacks, jacks for putting emergency translator in place of any other translator, etc.

4. "In use" lamps to show what decoders, markers, connectors, or link controllers are in use.

5. Plant registers to count the number of "lost display" calls, the number of decoder and marker first trial calls and second trial calls, etc.

6. Sender link delay lamps.

Incoming Sender Test Frame

5.42 The incoming sender test frame is used to make routine and trouble location tests of incoming senders. The sender is seized by the test frame and selected codes are transmitted to it on either a multifrequency or a dial pulse basis. The output of the sender is then automatically checked against the input. Lamps are provided to indicate the progress of the tests and to indicate any failure of the sender on specific tests.

5.43 The test frame can be operated on an automatic progression basis or on a particular circuit basis.

5.44 This frame is shown on Figure 72.

Automatic Tests

5.45 When the frame is operated on an automatic basis, it automatically progresses from one sender to another until all the incoming senders in the office have been tested, or, on certain tests, until all the senders of a class, that is, dial pulse or multifrequency, have been tested. If trouble is encountered the test frame stops and an alarm is operated.

5.46 Senders that are busy may be passed over automatically. The sender under test is identified by lamps at the test frame. Lamps are also provided to indicate the progress of the various tests, and on test failure to indicate the point of failure.

5.47 The test frame can be operated so that it will automatically progress through all the MF senders and DP senders with one key setting. This is useful when no tests of features peculiar to MF or DP are desired. On this type of test the test frame simulates service calls which may be to any point, and which are carried to completion.

5.48 Where distinctive features peculiar to MF or DP operation are being tested the test frame progresses through one class of sender and then stops.

5.49 Various combinations of input and output conditions are checked, many on a marginal basis. The test frame is equipped with a full keyset and a number of lever type keys for establishing the various test conditions.

Manual Tests

5.50 When desired, for example, for trouble location tests, a particular sender can be selected. This sender can then be tested under manual control, or repeated tests can be made automatically. The repeated test feature is of particular value in locating an intermittent trouble condition or for insuring satisfactory operation of a sender before returning it to service.

5.51 The test circuit is arranged for remote control from the sender locations so that the sender operation may be observed under controlled conditions.

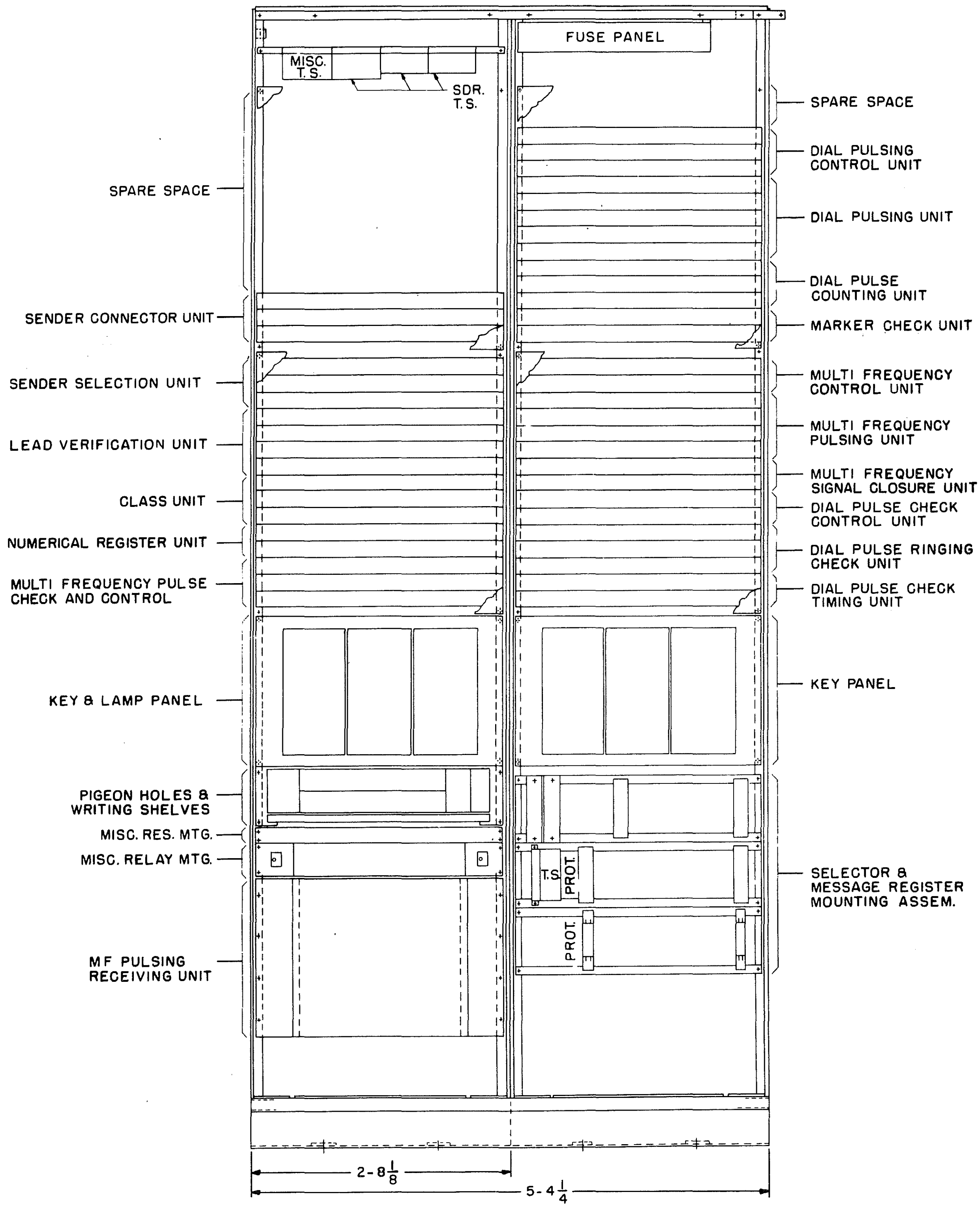


FIG. 72 - INCOMING SENDER TEST FRAME

Outgoing Sender Test Frame

5.52 This test frame has general functions similar to those of the incoming sender test frame, that is, automatic progression over the outgoing senders, or individual circuit testing; comparison of input with output information, indicating lamps, etc.

5.53 This frame is shown in Fig. 73.

Sender Make Busy Frame

5.54 There is a make busy jack on this frame for each incoming and outgoing sender in the office. These jacks are used to remove senders from service. Associated with each make busy jack is a "cancel timed release" key, a stuck sender lamp and a priming jack.

5.55 When a cancel timed release key is operated, it cancels the timed release feature in the associated sender and causes it to stick after it times out on the next trouble it encounters. This in turn causes an individual stuck sender lamp to light and an audible and visual alarm. A peg count register records the number of these stuck senders. If it is desired to free a stuck sender a make busy plug is momentarily inserted in the priming jack. This primes the sender and causes it to make a normal release.

5.56 For each group of senders a group busy alarm lamp is provided which locks in and operates an alarm when all the senders of a group are busy.

5.57 Also included on this frame is a peg count register which counts the number of times trouble occurs in any of the link controllers.

5.58 A telephone circuit with associated keys and lamps is provided for connection to intercommunicating trunks to other frames.

5.59 The sender make busy frame is shown in Fig. 74.

Automatic Outgoing Toll Connecting Trunk Test Frame

5.60 This frame is used to make over-all circuit tests of toll switching trunks to local dial and manual offices, trunks to TX and other operators, and miscellaneous trunks and terminals such as master busy, overflow, reorder, information trunks, etc. (See Fig. 75.) Like other automatic test frames, it can be operated on an automatic progression, particular circuit or manual basis.

5.61 Toll switching trunks to local dial offices and certain service trunks such as reorder, master busy, etc., can be tested automatically or manually as desired.

5.62 Toll switching trunks to manual local offices as well as miscellaneous trunks which appear in front of an operator at the distant end are tested on a manual basis.

5.63 A particular circuit feature on the test frame permits the attendant to select any toll switching trunk and make single tests or repeated tests as desired. A remote control feature is provided so that tests can be made from the position of the trunk relay circuits.

5.64 The test frame obtains access to the outgoing trunks through the regular switching train. A service marker is used to route the call through the incoming and outgoing links to the trunk. The marker is then released and the test frame goes ahead with the test.

5.65 Lamps are provided on the test frame which indicate the progress of the tests. When a failure occurs on a trunk, lamps indicate the general nature of the trouble which caused it.

Automatic Tests

5.66 When the test frame is operated on an automatic basis, it progresses from one trunk to another in a predetermined sequence, testing every toll switching trunk to dial local offices and certain service trunks, stopping only when it has tested all the trunks or when it encounters a trouble.

5.67 On these automatic tests, the test frame directs the toll switching trunk to a test line or a busy line in the distant office (both of which appear as subscribers' numbers) by pulsing out the appropriate standard line number. No provision is made for changing these numbers during the course of the testing and therefore if the standard line number is not used at a given distant office the group of trunks to that office must be tested manually.

5.68 When a test frame encounters a trunk to a manual office or any operator trunk it makes a simple continuity test of the four trunk wires as far as the trunk relay circuit and then steps to the next trunk. It does the same thing on trunks which cannot be automatically connected to a test line or to a busy line.

5.69 By means of keys the test circuit can be set either to wait a predetermined interval for busy trunks to become idle, or to pass by them, as desired.

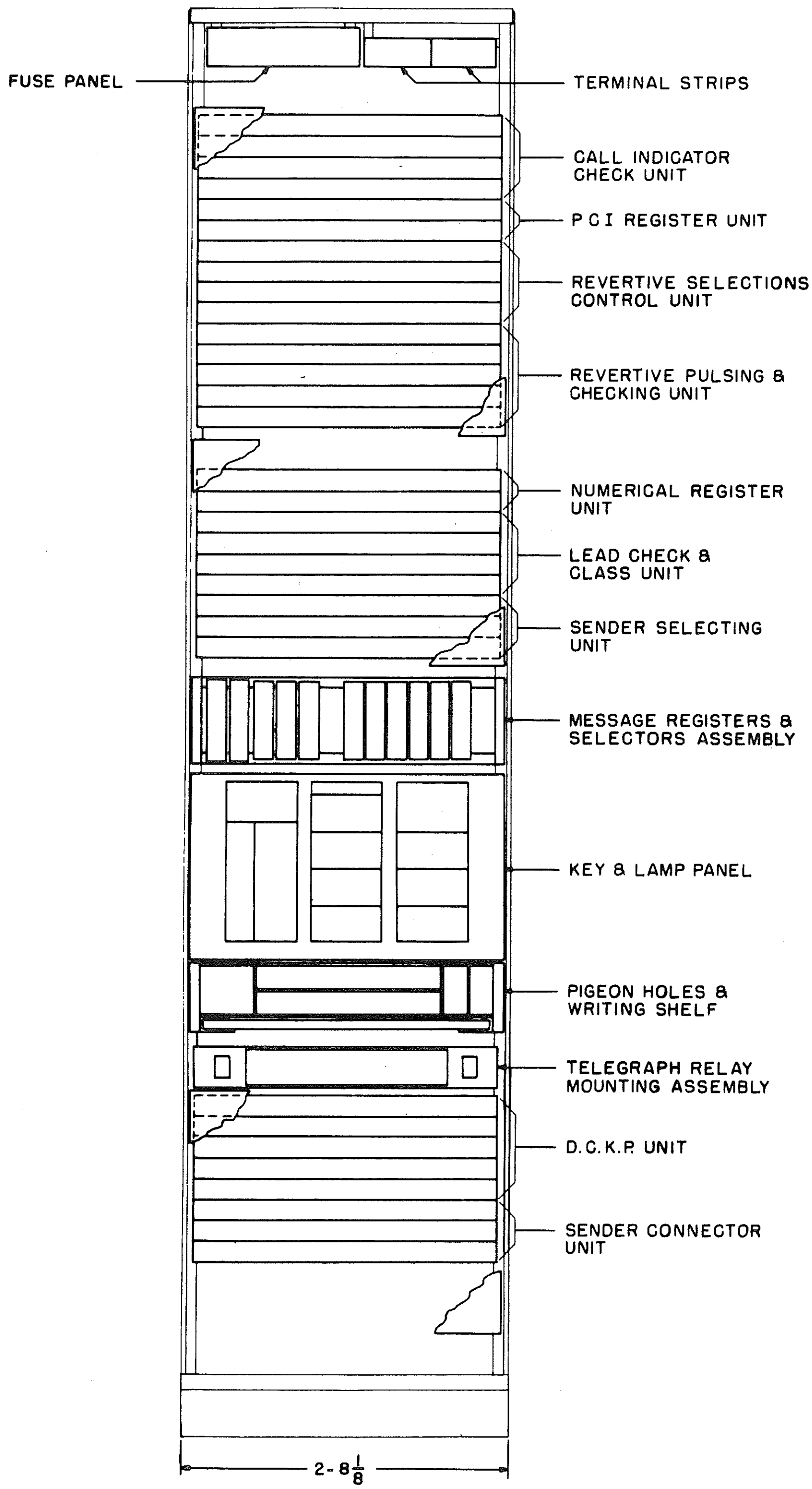


FIG. 73-OUTGOING SENDER TEST FRAME

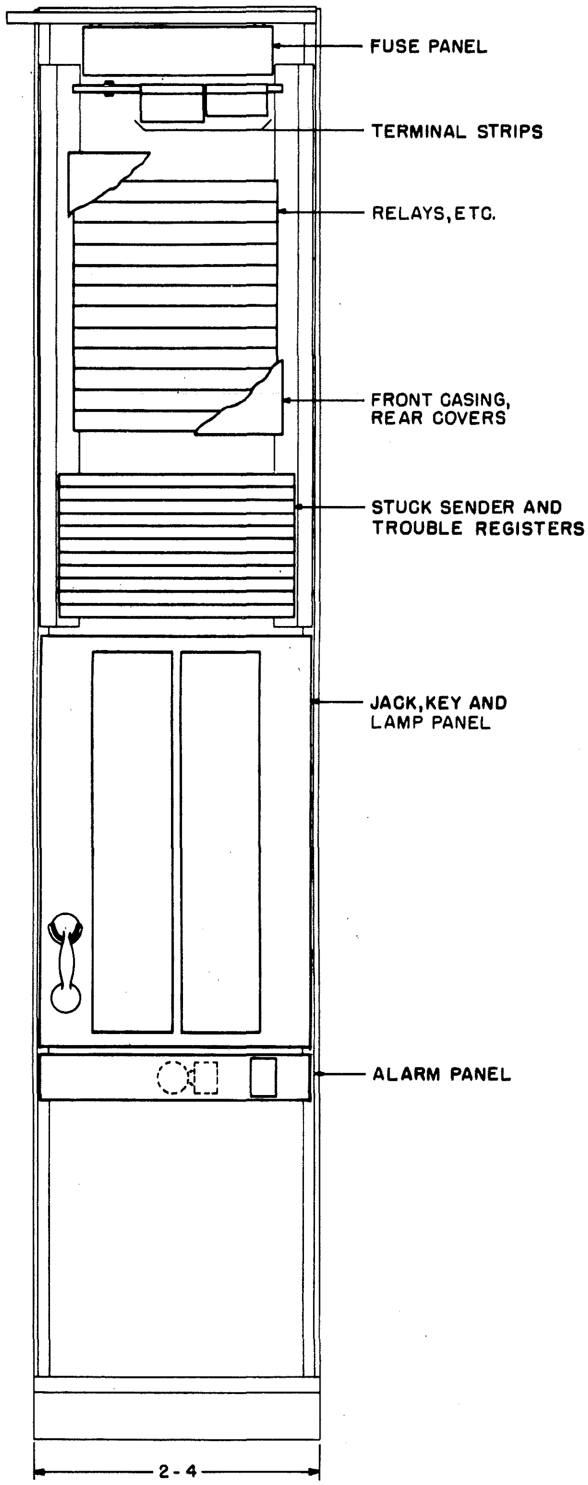


FIG. 74-SENDER MAKE BUSY FRAME

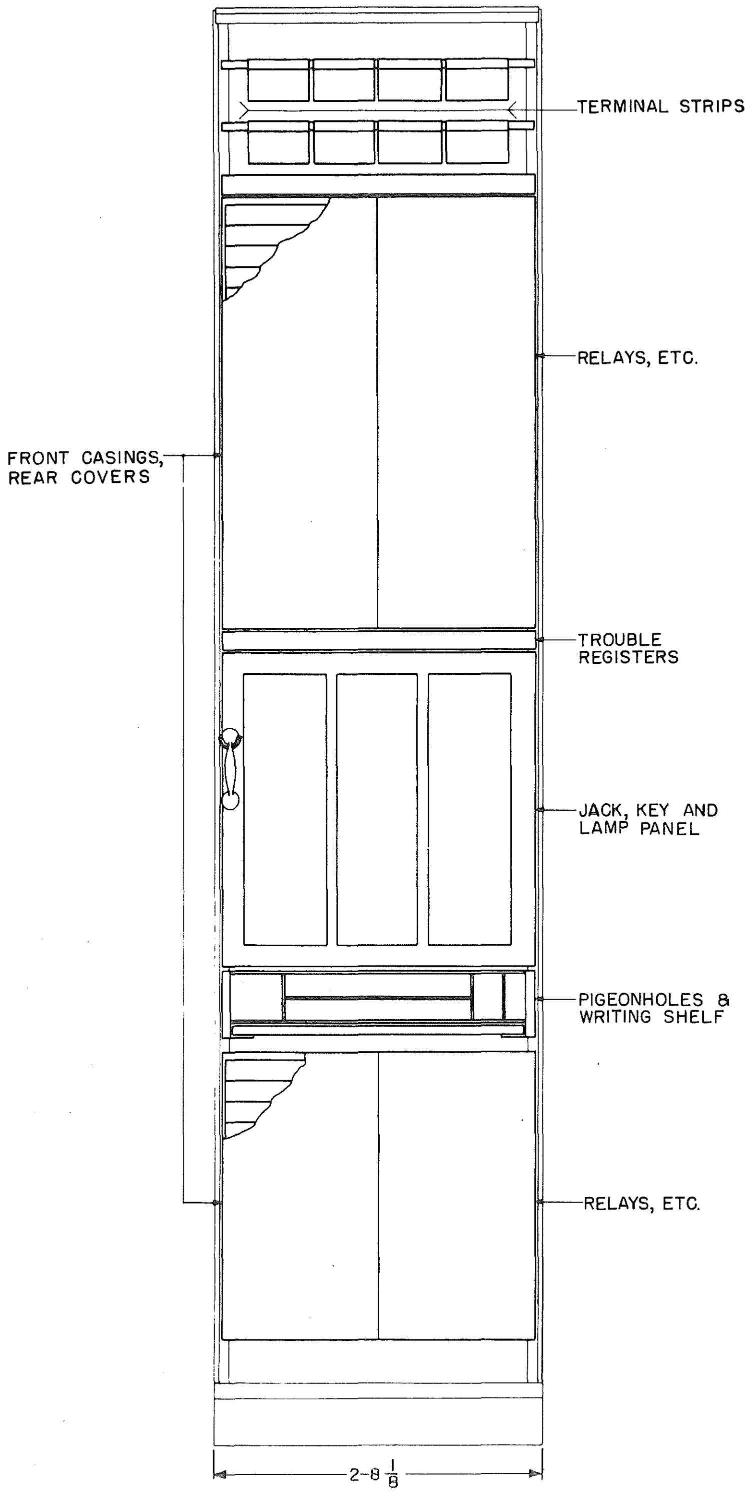


FIG. 75 - AUTOMATIC OUTGOING TOLL
CONNECTING TRUNK TEST FRAME

5.70 The test circuit transmits the trunk test line (or busy line) number to the incoming trunk or terminating sender in the distant office, which causes the distant incoming trunk to be connected to the proper one of these lines through the local switches. The tests are made by an exchange of signals between the test frame and the test line.

5.71 Tests to a busy line include a continuity test and a test of the ability of the trunk supervisory relay to follow busy back flashes.

5.72 Tests to a trunk test line are more complete and include tests of ringing, tripping and supervisory features of the No. 4A outgoing trunk and the distant incoming trunk.

Manual Tests

5.73 A ten button MF keyset and a dial are provided at the test frame for making manual tests. The attendant operates the proper keys to select the trunk for test and then obtains the operator at the distant office on a straightforward basis or by dialing or key pulsing. The attendant makes the test in cooperation with the operator.

5.74 Manual tests can be made on toll switching trunks to local dial offices as well as on trunks to manual offices. On such tests an outgoing trunk is selected, automatically, or by the attendant. Continuity and other tests proceed automatically up to the point where the trunk (SL) relay has been tested and the outgoing trunk is connected to the distant incoming trunk or terminating sender for pulsing. The test frame then stops and the attendant can dial or key pulse any desired subscriber number. When the off-hook condition occurs at the called number, a lamp lights at the test frame. This test can be used to check the supervisory and transmission performance of the trunk. The attendant manually releases the test frame. If it is set for automatic testing, it will immediately select the next trunk and go through the tests up to the test of the (SL) relay when it will again stop and wait for the attendant to complete the test.

Transmission Measurements

5.75 For making transmission measurements the outgoing trunk is connected to a test line, which provides a one milliwatt source of 1000-cycle tone. (See par. 5.143.) On trunks to dial offices, the trunk can be directed to a transmission test line on a pre-set number basis.

5.76 On trunks to manual offices, the test frame attendant obtains an attendant at the distant office over the outgoing trunk and requests him to connect it to a transmission test line.

5.77 In either case, the control of the test frame and the transmission measurements are manually supervised.

Miscellaneous Features

5.78 A telephone circuit is provided for communication with operators when toll switching or miscellaneous trunks to operators or desks are being tested.

5.79 When two outgoing test frames are provided in an office, the 8000 trunks associated with each test frame can be interchanged by means of a transfer arrangement on the test frames so that either frame may have access to all of the trunks appearing on the other test frame.

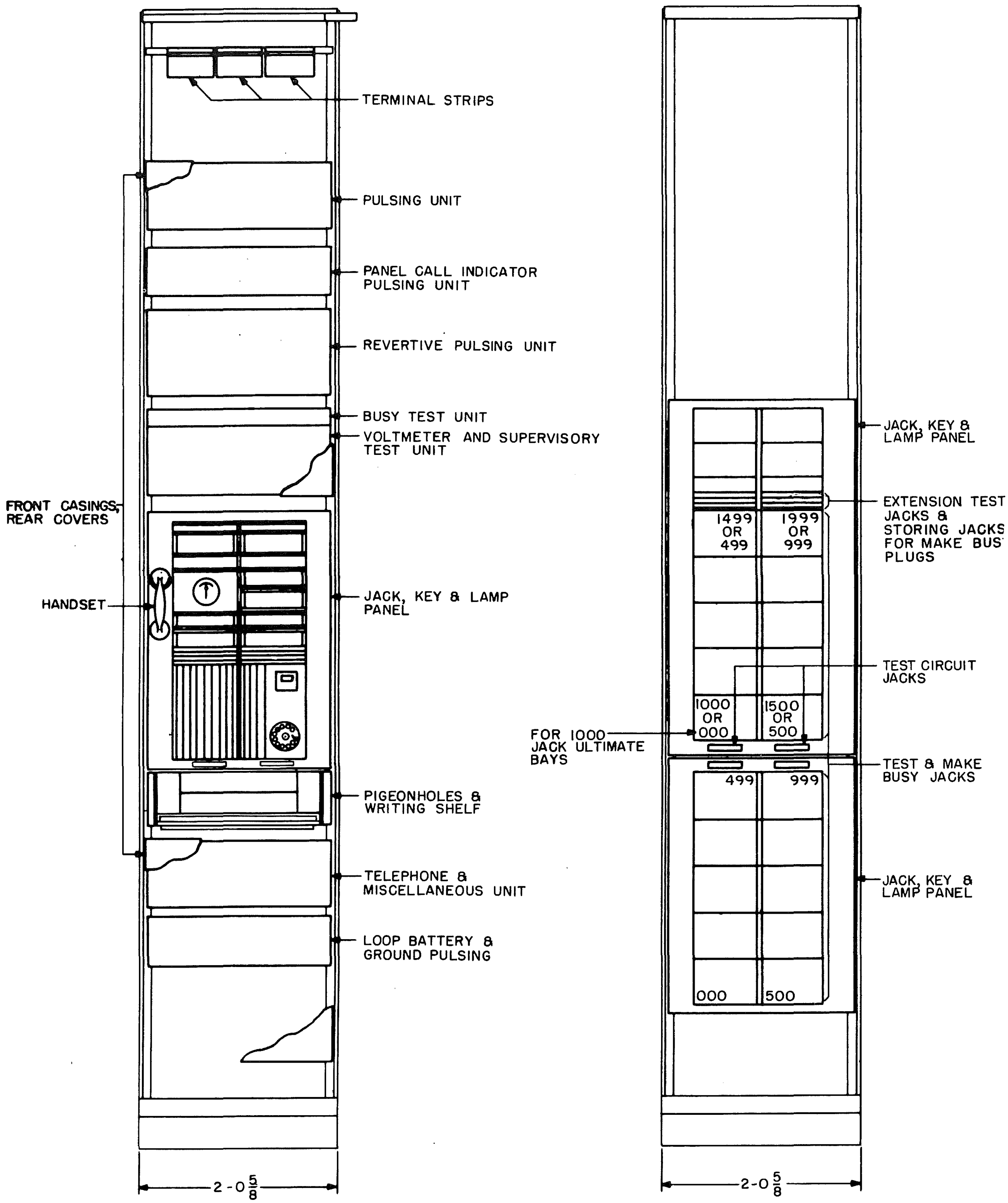
<u>Manual Outgoing Toll Connecting Trunk Test Frame - Test and Make Busy Frames</u>

5.80 In addition to the test facilities of the automatic test frame just described, a manual test frame is provided which has facilities for making additional types of tests on outgoing trunks. For making these tests, the outgoing trunks are equipped with test and make busy jacks which can be used to patch the trunks to the test frame. These jacks appear on one or more test and make busy frames which are located adjacent to the outgoing toll connecting trunk frame. (See Fig. 76.)

5.81 The test jacks are bridged to the cable side of the outgoing trunks, thus bypassing the outgoing trunk relay equipment. This permits voltmeter, transmission and continuity tests to be made directly out on the cables. This type of test is of considerable assistance in locating cable troubles. Other tests can be made which are of value in localizing trunk troubles, that is, determining whether they are in the 4A switching equipment or in the terminating office equipment. These include tests of the incoming trunk and selector equipment in the distant office.

5.82 The test circuit includes a voltmeter circuit, a telephone circuit and sender and supervisory features. Two trunks can be patched to the test frame at a time but only one of them can be set up for testing. The other trunk can then be used for communicating with an attendant at the distant office, or for making interference tests, by operating a hold key on the first trunk at the proper time.

5.83 Each test and make busy frame has a capacity for 2000 jack circuits for 2-wire trunks. It has smaller capacities for different combinations of two-wire, three-wire and four-wire trunks. The jacks are arranged for cross-connection to the



MANUAL OUTGOING TOLL CONNECTING TRUNK TEST FRAME

FIG. 76

OUTGOING TOLL CONNECTING TRUNK TEST AND MAKE BUSY FRAME outgoing trunks to permit grouping by office designations. As many jack bays as are required may be provided. Additional test frames may also be furnished.

(C) Toll Line Maintenance Equipment

5.84 The toll test and terminal room equipment for testing and maintaining the intertoll trunks which are part of the toll crossbar system is similar in general to that used in other toll systems with the exception of some changes that have been made to work with crossbar automatic switching.

No. 17C Toll Testboard

5.85 The No. 17C toll testboard is the principal point of access for testing intertoll trunks. From this testboard operational tests can be made on a complete incoming and outgoing trunk, from one end to the other. It serves to centralize the over-all maintenance of these trunks, to localize troubles in the toll circuits, and to expedite the restoration of service when failures occur.

5.86 This testboard is also the central point in the toll crossbar system for receiving trouble reports from outward operators and from maintenance personnel in this and other offices. For this purpose from four to six incoming trunks are provided from the switching equipment to the testboard. These are the code "101" trunks. These trunks are also used in connection with certain types of talking, transmission and supervisory tests on intertoll trunks.

5.87 About the same number of outgoing trunks (i.e. four to six), are provided from the testboard to the switching equipment for the purpose of gaining access to the outgoing intertoll trunks. This access is on the same basis as a service call. These trunks are used for communication with other toll offices. A ten button keyset and dial are provided for pulsing the desired codes.

5.88 All intertoll trunks have jack appearances at the testboard. There is a receiving and a transmitting jack for each trunk since transmission is on a four-wire basis. The jacks are in multiple with the link frame side of the trunk relay equipment. Talking, monitoring, signaling, transmission, noise and balance tests are made from these jacks. The testing path is through the trunk relay equipment, toll line equipment, the toll line itself, and through similar equipment at the far end to the testboard there.

5.89 Outgoing intertoll trunks are made busy by plugging into the associated test jacks and operating a lockout key. A lamp associated with the jack circuit lights to indicate the busy condition. These lamps are also used in connection with trouble tracing, to identify outgoing intertoll trunks held through the switching train by an incoming intertoll or toll tandem trunk. The operator who reports trouble on such a connection knows the number of the incoming trunk and she gives this number to the attendant at the testboard.

5.90 If it is an intertoll trunk, the attendant simply plugs into the test jack associated with this trunk and operates a lockout key. This lights the lamp associated with the outgoing intertoll trunk and removes the trunk from service.

5.91 Incoming tandem trunks do not have an appearance at the testboard. To identify an outgoing trunk held by one of these trunks, the attendant dials the number of the tandem trunk which was reported by the operator into the Trouble Tracing Selector Equipment, using a dial located on the testboard. This is a selector arrangement with the tips and rings of the tandem trunks' transmitting paths appearing on the banks of the second selectors. The selector equipment locates the outgoing intertoll trunk and causes the associated lamp at the testboard to light. It also operates a lockout feature which removes the outgoing trunk from service.

Patching Bays

General

5.92 There are many types of patching bays in the toll test and terminal room of a crossbar toll switching office. These bays are used for building up toll lines from facilities located in the office, and for increasing the size of trunk groups or rearranging them, to care for emergencies or for changes in traffic requirements and to permit ready access for testing. They are also used for substituting spare outside plant cables, and inside plant equipment, such as signaling circuits, repeaters, trunk relay circuits, etc., when failure occurs.

5.93 Tests are made at these bays to localize troubles between the line and drop sides of the toll circuits and to determine the nature of such troubles.

5.94 It is not within the scope of this section to go into any detail on the great variety of patches and tests which can be made using the jack facilities just mentioned. However, the following short descriptions will give a general idea as to their place in the toll system.

5.95 Figure 77, attached, is a simple diagram which shows a carrier cable entering a toll crossbar office. It shows a voice frequency circuit derived from the carrier channels and the various inside plant facilities which may be used on a toll line through the office, including the 4A switching system. Carrier has been selected for this example because of its extensive use in the toll plant.

5.96 The cable carrying the carrier frequencies enters the toll crossbar office at cable terminals, such as the sealed test bay. (Voice frequency cables appear on jacks at the primary testboard.) Here jacks are provided for testing and for substituting spare carrier groups when a failure occurs. On its way to the high frequency patching bay, carrier elements such as repeaters, filters, equalizers, etc., are connected to the circuit.

5.97 Jacks in the high frequency patching bay are provided for testing and for substituting spare carrier elements of the types just mentioned.

5.98 From the high frequency patching bay the carrier circuit enters the channel bank equipment where the voice frequency circuits are derived from the carrier channels.

5.99 (It is necessary to change to voice frequency in the toll office for many reasons. One is that we must be able to terminate calls coming into the toll office on carrier to local offices in the area, or to switch or patch them to voice frequency circuits going to other toll offices. Another reason is that many of the toll connections are switched through the 4A system and it is impractical to switch carrier frequencies with standard switching equipment with its high unshielded capacities.)

Four-Wire Voice Frequency Bays

5.100 The derived voice frequency circuits are carried through series jacks in these bays. These jacks are provided for making tests on carrier channels between carrier terminal points. They are also used for patching in spare voice frequency channels to replace those in trouble.

5.101 Spare pads are also terminated on this bay. Using one of these pads, the channels of two terminating circuits can be patched together to make a through circuit. (Pads are devices for adjusting transmission levels so that different level transmitting and receiving branches of a toll circuit can be connected together.)

5.102 Jack-ended trunks are provided from these bays to the patching trunk bays and tandem patching trunk bays which are described later on.

Circuit Patching Bays

5.103 On its way to the circuit patching bay the voice frequency circuit picks up a single frequency signaling circuit and a pad.

5.104 The circuit patching bays (see Fig. 78, attached) are provided mainly for rerouting circuit groups, or for increasing groups to care for temporary traffic demands. They are also used for substituting drop circuits or replacing those on which trouble has occurred. (Drop circuits include the intertoll trunk relay equipment and the switching paths to the 4A system incoming link frames.) The line and drop circuit transmitting and receiving patching jacks, and the line and drop circuit signaling patching jacks appear in these bays. These jacks are in series between the line and drop circuit sides of the intertoll trunks.

5.105 The patching jacks can also be used for trunk testing with the wagon type incoming, outgoing and intertoll trunk test set and as an aid in sectionalizing troubles between the line and drop circuit sides of the trunk.

5.106 The signaling patching jacks are used for making signaling and supervisory tests towards the drop circuits or towards the lines.

5.107 These bays also include jacks for spare pads and relay type auxiliary pulse links. These jacks are used with the intertoll patching jacks for patching two intertoll trunks together to make a through connection.

5.108 Auxiliary pulse links are required when two composite signaling circuits, or a composite signaling circuit and a single frequency signaling circuit are connected in tandem. They are also required when a two-wire and a four-wire single frequency signaling circuit are connected in tandem. If both are four-wire they can be patched at the voice frequency bay without using a pulse link.

5.109 Local trunks to other maintenance points in the office and a telephone set are provided as required. Trunks are also provided to permit patching between the circuit patching bays and the patching trunk bays and the tandem patching trunk bays.

Patching Trunk Bays

5.110 The patching trunk bays contain jacks for terminating patching trunks to the various line facility bays, such as the voice frequency patching jacks of the carrier systems and the voice frequency repeater jack bays. Jack-ended patching trunks are also run to the circuit patching bays.

5.111 In addition to the jacks for patching trunks, jacks connected to spare equipment such as pads, signaling units and echo suppressors are located in the patching trunk bays.

5.112 The patching trunks are used for substituting new outside plant and for rearranging line equipment to take care of outside plant changes. They are also used for connecting together two intertoll circuits (derived from widely separated line facilities) to form a through connection.

5.113 New toll circuits can be made up by patching the jack-ended spare equipment at the patching trunk bays to the patching trunks to the line facility and circuit patching bays.

5.114 The patching trunk bays greatly reduce the number of interbay trunks required between the line facility and circuit patching bays and simplify patching procedures.

5.115 Local communication trunks, order wire circuits and talking facilities are provided as required.

Tandem Patching Trunk Bays

5.116 Ordinarily, tandem patching trunk bays are provided only when there are more than two groups of patching trunk bays. In such cases tandem patching trunks are provided from the tandem patching trunk bay to each of the groups of patching trunk bays.

5.117 These bays are similar to the patching trunk bays in many ways. Like them, jack-ended spare equipment, local communication trunks, order wire circuits and talking facilities can be provided as required. The bays may also include patching trunks to various groups of widely separated line equipment facility bays and circuit patching bays.

Trunk Assignment Patching Bays

5.118 These bays (see Fig. 78) are provided for use in conjunction with the circuit patching bays, for temporarily increasing the size of outgoing intertoll trunk groups and for substituting or replacing trunk relay circuits when failures occur.

5.119 For these purposes, as many working outgoing intertoll trunk relay circuits as desired are cross connected to jacks in the trunk assignment patching bays. In addition, spare jack-ended trunk relay circuits are provided. Both the working circuits and the spare circuits appear on two jacks each, a trunk block jack and an out trunk jack.

5.120 Generally some of the spare trunk relay circuits are preassigned to each (or most) of the outgoing trunk groups. This is done by cross-connecting the trunk block jacks of the spare circuits to the trunk block relays of the desired outgoing intertoll trunk groups. Normally there are dummy plugs in the trunk block jacks of the spare trunk relay circuits and this causes them to test busy to the marker. When additional trunk relay circuits are required they are cut into service by patching them at the circuit patching bay to line equipment connected to the proper distant office and then removing the dummy plugs.

5.121 If desired, spare trunk block jacks without relay equipment can be preassigned to some or all of the outgoing trunk groups. With this arrangement, any spare trunk relay circuit appearing on the trunk assignment patching bay can be patched to these jacks to increase the size of the associated trunk groups. It is necessary, of course, to patch the spare trunk relay circuits to the proper line equipments at the circuit patching bay.

5.122 Faulty trunk relay circuits in any outgoing trunk group can be replaced by patching in a spare trunk relay circuit, or by borrowing one from another group of trunks.

Automatic Outgoing Intertoll Trunk Test Frame

5.123 This test frame (see Fig. 79) is provided to make over-all tests of outgoing intertoll trunks and the outward paths of two-way intertoll trunks to other toll offices. The tests are made automatically or manually, depending upon whether or not the trunks can be terminated on an intertoll trunk test line.

5.124 The general operation and arrangement of the test frame is similar to that of the automatic outgoing toll connecting trunk test frame which has already been described (par. 5.60 and following pars.). As on that frame, access to the outgoing trunks is through the regular switch train. The same general types of tests are made, with the exception that there is no equivalent of the test to a busy line in the distant office.

Automatic Tests

5.125 On automatic tests, a three-digit code 103, is pulsed forward to reach the intertoll trunk test line termination (see par. 5.135) at the distant office. No provision is made to change the

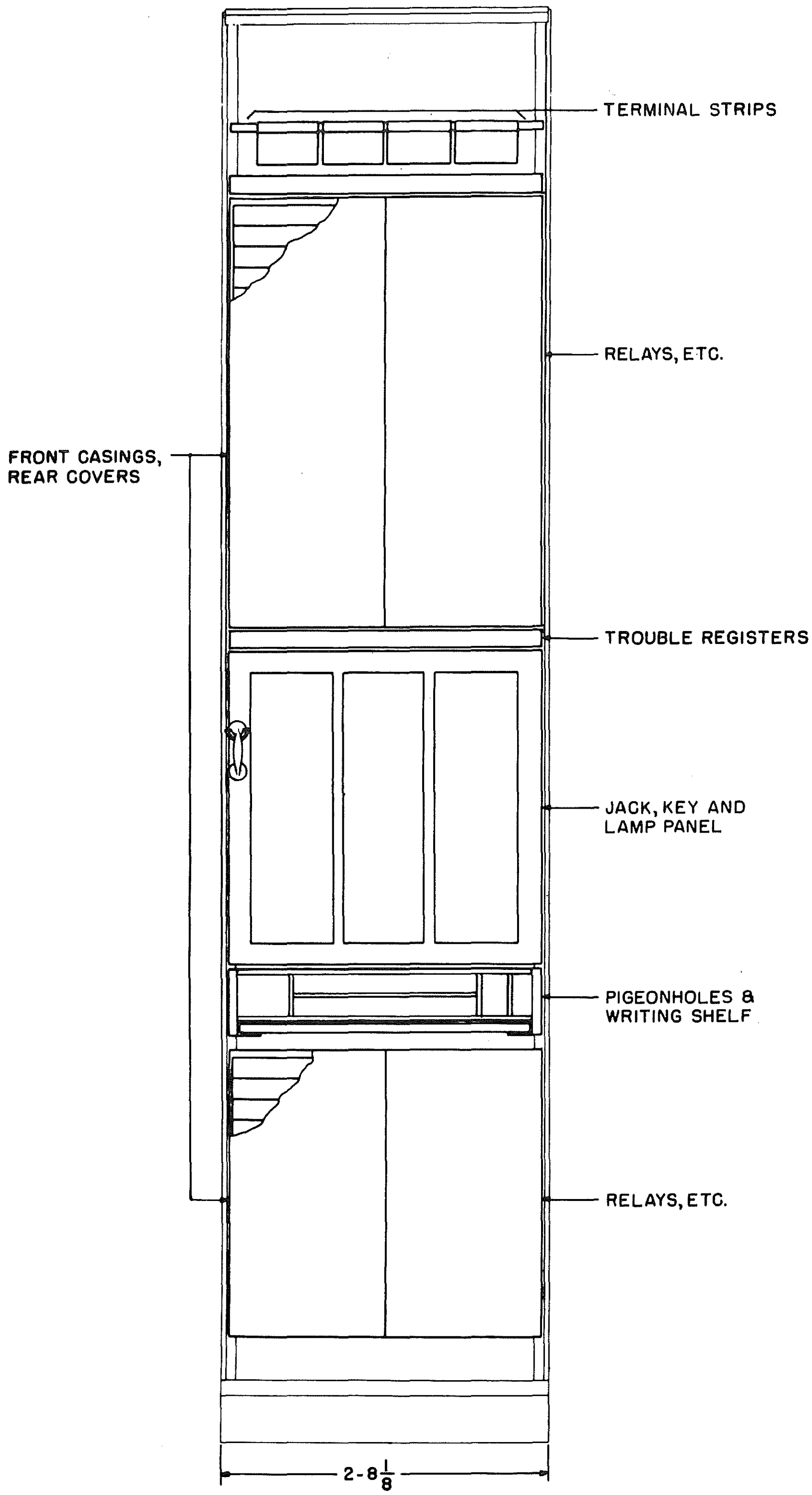


FIG. 79 -AUTOMATIC **OUTGOING** INTERTOLL TRUNK TEST FRAME

code during the course of the test cycle and therefore the test line termination must have the same code at all distant offices. Where a distant office has no test line, or uses a non-standard code, automatic tests cannot be made.

Manual Tests

5.126 A manual key is provided for testing trunks to such offices and to care for intertoll trunks which appear in front of an operator at the distant office. On DP or MF trunks the attendant dials or keys the code to reach an operator or the distant toll testboard. On straightforward trunks he operates a key to reach the distant operator. In either case the tests are made in cooperation with the operator or testboard attendant in the distant office.

5.127 A particular trunk can be selected for test and tested repeatedly as many times as desired. This feature is of value in locating a trouble or in testing a new trunk prior to putting it into service.

5.128 Transmission tests are made manually, using the 40B transmission measuring system.

5.129 The test circuit has been designed to anticipate the later addition of facilities for automatically making transmission measurements.

(D) Miscellaneous Test Lines and Test Sets - Portable, Semi-Portable and Frame Mounted

Incoming, Outgoing and Intertoll Trunk Test Set

5.130 Reports of trouble encountered by operators in the use of tandem or intertoll trunks, or troubles picked up in intertoll trunk relay equipment as a result of tests made by the toll testboard men, may be referred to the switching maintenance force for test and clearance. A portable trunk test set is provided in order that the trunk relay equipment may be tested under such conditions. The test set can also be used to test trunk circuits outgoing from the No. 5 toll switchboard.

5.131 The test equipment consists of a tea wagon-type test set which works in conjunction with a relay rack unit and with patching and test line jack appearances at the trunk relay bays, the toll test and terminal room patch bays, and the 17C toll testboard. The test wagon may be used near the relay equipment, and after completing patches to the test lines and relay rack test unit, the functions of the trunk equipment may be exercised and observed. The purpose of the relay rack mounted portion of the test equipment is to provide the various forms of pulsing and signaling required to satisfy the trunks, and to work as a return test line, as mentioned later. In all cases the relay rack unit is remotely controlled by the test wagon, and its signal translations are returned to the test wagon for observation. The test wagon unit contains all operating keys, a keyset, a dial, lamps, and a precision timer (S1 type) for measuring trunk timing intervals. A telephone set is also provided for talking on a two-or four-wire basis as required.

5.132 Tandem trunks are equipped with jacks at the relay rack on the line side of the trunk into which the test unit may be patched. Operation of the test set causes the trunk to be connected through the regular switching train to a return test line, which is patched into the test set. Subsequent testing of the trunk is accomplished by an exchange of signals between the test set and the return test line.

5.133 Incoming intertoll trunks are tested in a similar manner. However, access to the line side of the trunk is obtained over a system of test lines and patching trunks to the toll test and terminal room.

5.134 Outgoing intertoll trunks are reached for test by the test set by gaining access to the drop (switch) side of the trunk via a test line to the 17C toll testboard. At this point the test line is patched to the required trunk. The line side of the trunk is reached as described above for incoming trunks.

Incoming Trunk Test Line

5.135 A test line circuit is available for rapid testing of incoming tandem and intertoll trunks (see par. 5.125). The test line is similar in general functions to that used in local crossbar systems. Over-all tests may be originated at outward switchboards over tandem trunks to the 4A system, or from distant toll offices over intertoll trunks. The test call is directed to the test line by keying the three-digit universal code 103, and when the test line is reached a signal is returned to the originating test point. The tests are relatively simple and do not check all functions of the trunks, but they have the advantages of being rapid and not requiring assistance at the terminating end, and they provide reasonable assurance that the switching, signaling and supervisory features of the trunks are in operating condition.

Frame Identification Frequency Test Set

5.136 A portable test set (box type) is provided to test the multifrequency supply and distribution system used for link frame identification purposes and to facilitate the location of circuit troubles involving crosses or attenuated (lowered level) signals. The test set consists of eight filters corresponding to the frame identification frequencies, an amplifier, and a rectifying meter. Keys are provided so that with a given input signal of one or more frequencies the meter may be associated with any one of the filter circuits thereby providing an indication of the magnitude and frequency components of the input signal.

100A Test Set

5.137 This portable test set is used to check the output of the phototransistors and the transistor amplifiers in the card translators.

5.138 In testing the phototransistors used on the "regular" channels (there are 116 in each card translator) the plug-ended transistor amplifier associated with the channel under test is removed and the test set is plugged in its place. The test set applies a load on the phototransistor equivalent to the worst transistor amplifier. The output of the phototransistor under this worst circuit condition can then be measured using a high impedance voltmeter.

5.139 In the test of the phototransistors used on the "index" channels (two in each card translator) the dummy plug normally in place in the channel under test is removed and the test set is plugged in its place. The output of the associated phototransistor can then be measured.

5.140 A transistor amplifier is tested by removing the cold cathode tube in the channel under test and plugging in the test set in its place. The output of the transistor amplifier (that is, the voltage it delivers to the cold cathode tube) can then be measured.

Test Line Circuit For Making Balance and Noise Tests

5.141 This test line is used for terminating calls from intertoll trunks when balance and noise tests are being made. On trunks to dial offices the test call is directed to the test line by keying the three-digit universal code 100, and when the test line is connected a signal is returned to the originating test point. The tests can be made from any of the test appearances of the outgoing or two-way intertoll trunks - for example, from the toll testboard or the outgoing trunk test frame.

5.142 On trunks to manual offices the test frame attendant obtains an attendant at the distant office over the outgoing trunk and requests him to connect it to the test line.

Test Line to Milliwatt Distributing Circuit

5.143 This test line provides a one milliwatt source of 1000-cycle tone which is used for making transmission measurements on intertoll trunks. The test call is directed to this test line by means of a universal three-digit code 102, pre-set in the Automatic Outgoing Toll Connecting Trunk Test Frame in the distant office. The number can also be keyed from this frame.

5.144 On trunks to manual offices the connection to the test line is made manually in a manner similar to that just described in par. 5.142.

Other Miscellaneous Test Sets

5.145 In addition to the test lines and test sets just described, which were designed for toll crossbar switching systems, other test sets are provided for the 4A system which have been in use for some time in other switching systems. These include:

(a) Test Set for Testing 275 and 276 Type Relays.

(b) Pulse Repeating Test Set

(c) Pulse Checking Test Set for Checking Pulsing Speed and Per Cent Break of Interrupters

(d) Test Set for Timing Tests

(e) Test Set for Testing 209FF, 209FK, 209FL and 209FM Relays

(f) Continuity Test Circuit

Alarms

5.146 Alarm features in addition to the trouble indicator previously described are provided in a manner similar to other crossbar switching systems. These alarms consist of fuse alarms, time alarms for the sender link and control circuits, markers, marker connector, etc. Directing pilot lamps, namely frame aisle pilots, main aisle pilots, floor pilots and exit pilots are provided together with distinctive audible alarms. These lamps and signals are so arranged as to indicate audibly the severity of the alarm condition (major, minor or power failure) and to show visually the type of failure (fuse, time alarm or test frame alarm) and the aisle location of the individual circuit alarm lamp. Arrangements are provided to extend the alarms from one floor to another.

6. EQUIPMENT

(A) General

6.01 As in every telephone office, the equipment in a No. 4A toll office is laid out for efficiency in the operation and maintenance of the office. Of course, the actual arrangement of equipment may vary from office to office because the number of trunks and the kind of traffic an office handles determines the types and amount of equipment necessary. The shape of the building also influences the equipment layout.

(B) Frames

6.02 The basic framework, the height and depth of the frames, is the same throughout the 4A toll switching system. The bays are 11-1/2 feet high, 10-1/2 inches deep and their width varies from 22 to 55 inches. Generally, they are arranged with the apparatus sides of two lineups facing each other with a three-foot aisle between them. The wiring aisles between the backs of the frames are two feet wide. Protection against dust is provided by cabinet doors for the front and removable covers for the back of certain frames. A-c outlets are provided on some frames and are located so that all frames may be serviced from them.

6.03 Aisle pilot lights for the alarm system are mounted on end guards at the main aisle end of a lineup. An end guard is a metal panel which is placed on the side of the frame at the end of a frame lineup. Frame distributing fuses are also mounted at the top of the end guard panel.

6.04 To identify the frames in a lineup, the end guard has a card holder which contains frame designation cards. Each card has the name and number of one of the frames in the lineup. Also, each frame is stamped with its name and number.

6.05 Another type of card, a tracing designation card, is provided on individual frames to show their interconnection with other frames. This card is mounted on a particular frame and contains the designation of this frame and that of the frame to which it interconnects. If a frame has interconnections with several frames then other cards are provided. These cards provide information for tracing a call or a trouble through an office.

6.06 There are blank spaces for filling in various types of information such as the trunk numbers, link numbers, switch numbers, etc. at an individual office. For example, each sender link frame has a designation card which contains the number of each incoming trunk that appears on this frame and the number of the switch and the number of horizontal where it appears.

6.07 Distributing Frames: In addition to switching and common control frames, distributing frames are provided for making cross connections between frames where flexibility is required.

6.08 The intermediate distributing frame (IDF) provides means for cross connecting:

(a) Toll terminal equipment with the circuit patching bay.

(b) Intertoll trunk relay equipment with the circuit patching bay.

(c) Toll connecting trunk relay equipment with trunks to local offices.

(d) No. 5 switchboard with incoming and outgoing frames.

6.09 The trunk distributing frame (TDF) provides means for cross connecting:

(a) Trunk relay equipment with incoming and outgoing frames.

(b) Intertoll trunk relay equipment with the 17C testboard.

(c) Incoming toll tandem trunks with second trouble tracing selectors.

6.10 The assignment distributing frame (ADF) provides means for cross connecting:

(a) Outgoing frames and outgoing trunks with assignment patching jacks and trunk block relays.

(b) Outgoing trunks with assignment patching jacks and overflow trunk circuits.

(c) Outgoing trunks with test and make busy jacks.

6.11 The junctor grouping frame, as described in Part 2, provides means for making cross connections between some incoming and outgoing links (see Figs. 23 and 24).

6.12 The traffic register distributing frame provides means for cross connecting:

(a) The traffic registers with the traffic register relays.

(b) The traffic register relays with the trunks requiring group busy registrations.

FIG 2

BASIC NUMBERING PLAN AREA MAP

NUMBERING PLAN FOR NATIONWIDE TOLL DIALING

SUBSCRIBER'S NATIONAL TELEPHONE NUMBERS

NUMBER OF DIGITS DIALED OR KEYED TO REACH CALLED SUBSCRIBER FROM ANOTHER NUMBERING AREA (NOTE 1)

NO. 4A SYSTEM

1 2 3	4 5 6	7 8 9 10	11
AREA CODES (NOTE 1)	NATIONAL OFFICE CODES	NUMERICALS	PARTY DIGIT
A0X or A1X (NOTES 2 & 3)	ABX (NOTES 2 & 4)	0 To 9	0 To 9 or J(5), M(6), R(7) or W(9)

NOTES:

(1) When toll calls are completed within the same numbering area, the area code is not usually dialed.

(2) Code legend

A, B, C - Any digit except 1 or 0
D - Any digit except 1
E - Any digit except 0
X - Any digit

(3) The 0 digit is not assigned as the 1st digit of the area code because it would interfere with the subscriber obtaining the zero operator when customer national toll dialing comes into effect.

The 1 digit is not assigned as the 1st digit of the area code because the equipment recognizes this digit as the start of either a toll service code (1D1) or a TX code (11EX).

The digits from 2 to 9 inclusive are not assigned as the 2nd digit of the area code. The use of either 0 or 1 distinguishes it from a national office code.

Digit 0 Indicates a single-area code, i.e., one numbering area covers the entire state area.

Digit 1 Indicates a multiarea code, i.e., two or more numbering areas may be required to cover the state.

TYPICAL EXAMPLES OF NATIONAL OFFICE CODES BUILT UP FROM LOCAL DIRECTORY LISTINGS

CITY	LOCAL DIRECTORY LISTING	LOCAL CUSTOMER WILL DIAL	TOLL DIRECTORY LISTING (NATIONAL OFFICE CODE)	TOLL OPERATOR WILL DIAL
Newark, N.J.	MArket 2-1234	MA2-1234	MA-2	MA2-1234
Montclair, N.J.	(5)MOntclair 2-10214	MO2-10214	MO-2	MO2-10214
Salem, Ore.	5678	5678	(6)725	725-5678
Denver, Colo.	TAbor -1234	TA -1234	TAB	TAB-1234
Spokane, Wash.	Broadway -1234	B -1234	BRO	BRO-1234
Richmond, Va.	4 -1234	4 -1234	RI-4	RI4-1234

NOTES: (Contd.)

(4) The digits 0 and 1 are not used as the first two digits of office codes in 2-5 numbering areas (two letters and 5 numericals, MA2-1234). The national and the local office codes are identical for these offices.

(5) This is a manual office which will be straight 2-5 numbering when converted to dial.

(6) This is a flexible type of code and may not necessarily bear any relationship to the letters of the city name since the codes will be furnished by bulletin or route operator, rather than secured from the number passed by the customer.

FIG. 8

NUMBERING PLAN FOR NATIONWIDE TOLL DIALING

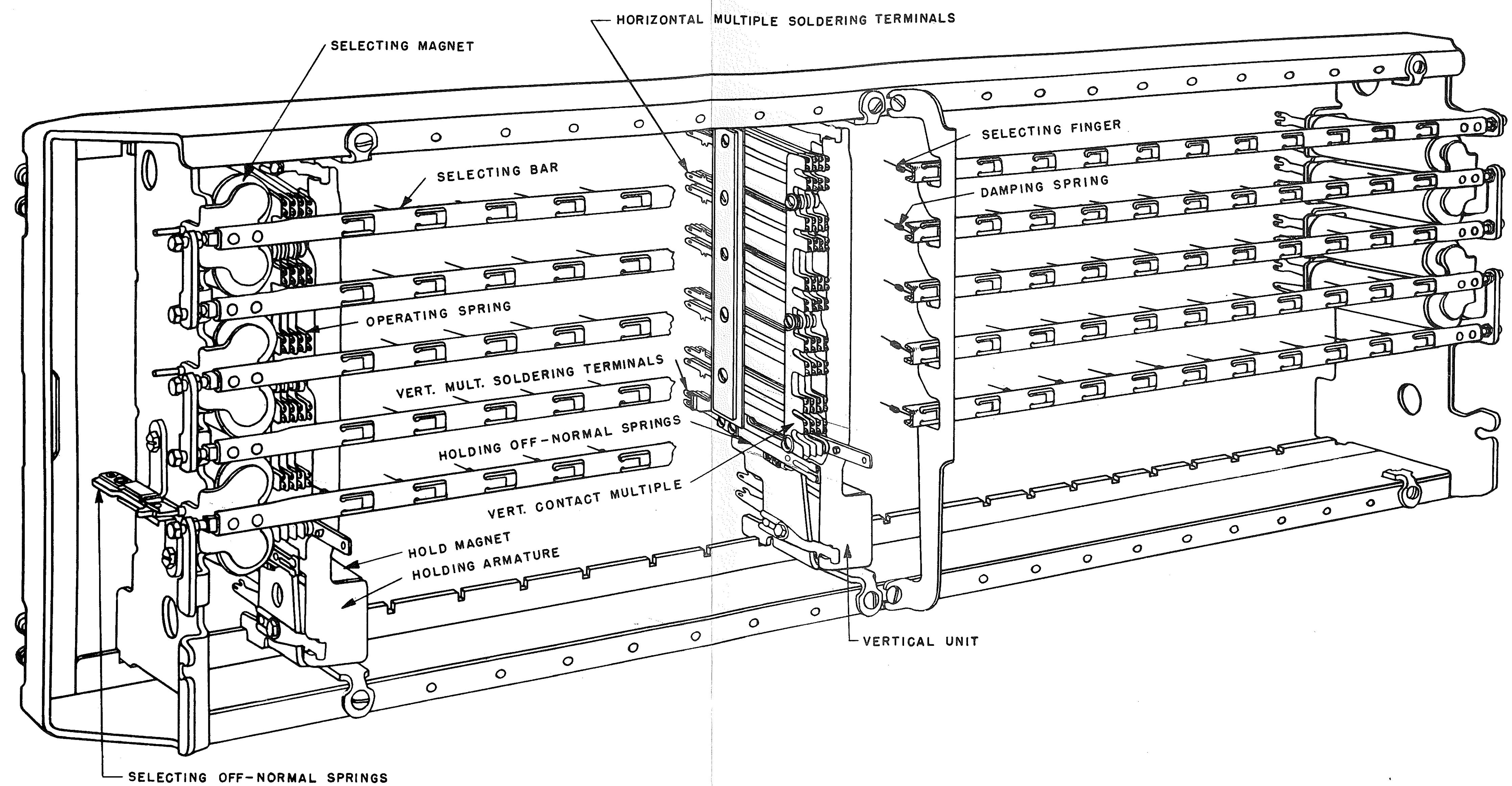
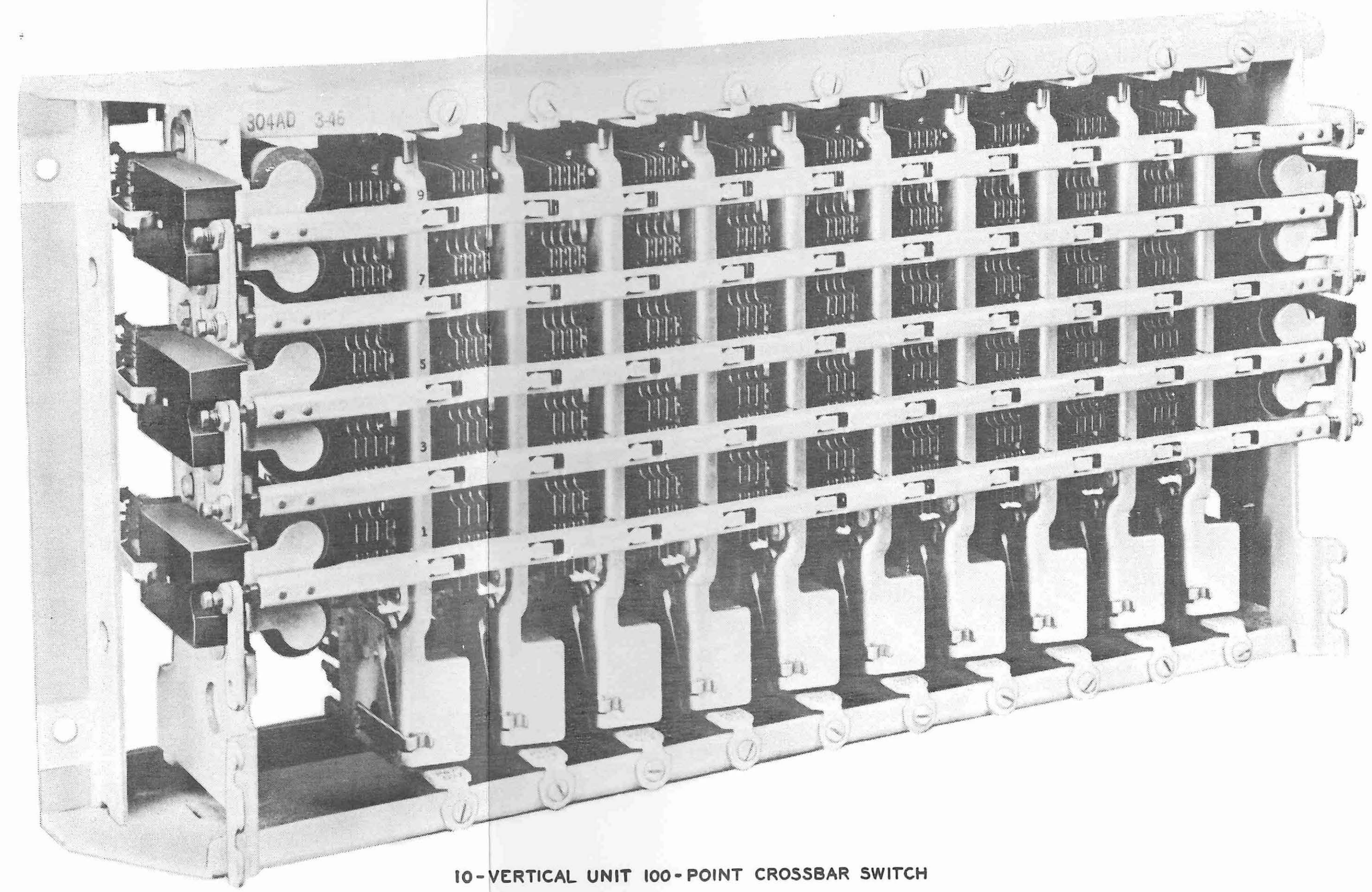
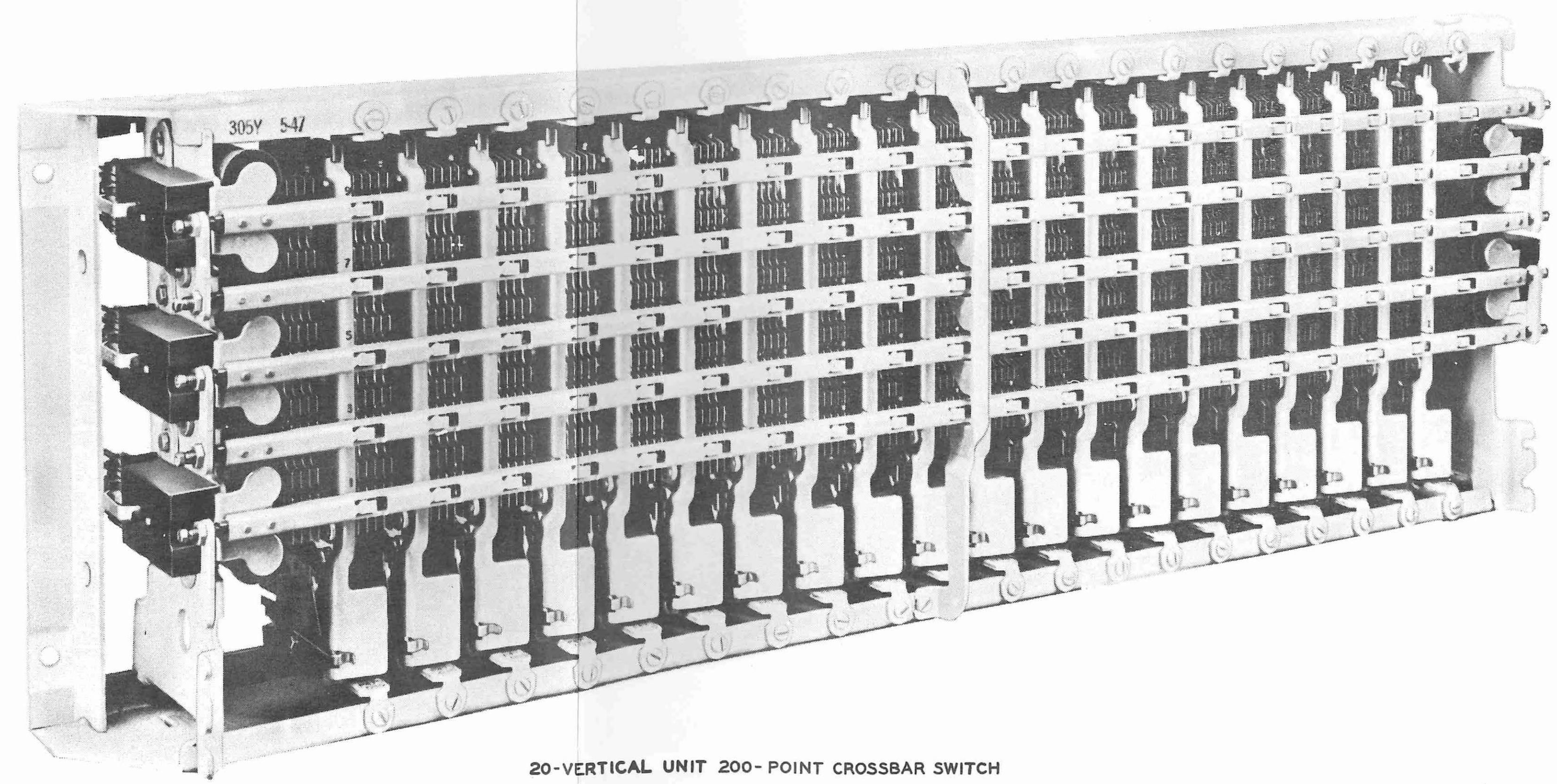


FIG. 14
PARTIAL PERSPECTIVE VIEW OF 20 – VERTICAL UNIT CROSSBAR SWITCH (200 POINT)



10-VERTICAL UNIT 100-POINT CROSSBAR SWITCH



20-VERTICAL UNIT 200-POINT CROSSBAR SWITCH

FIG. 18
CROSSBAR SWITCHES

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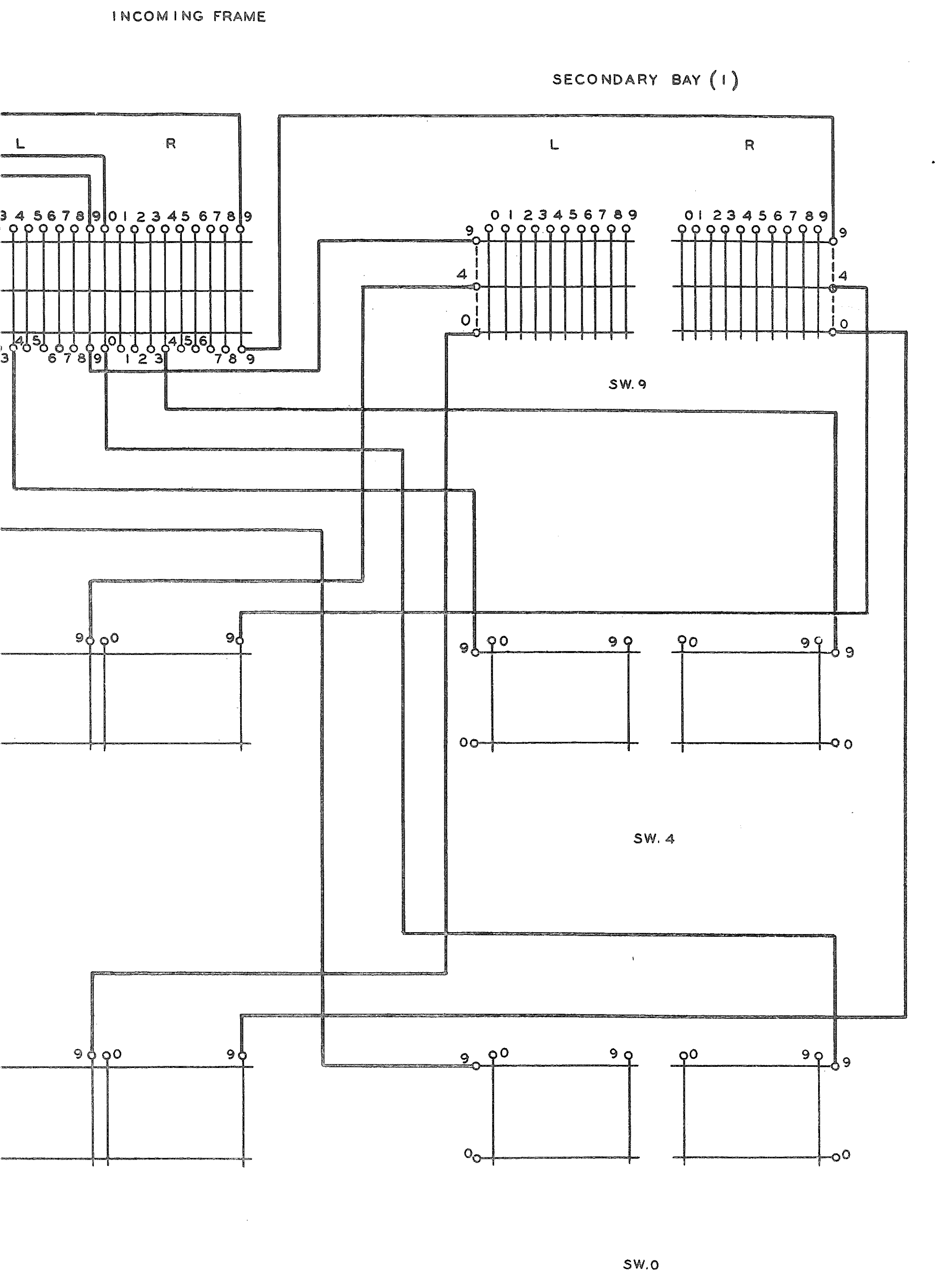


FIG. 20A

DISTRIBUTION OF INCOMING LINKS.

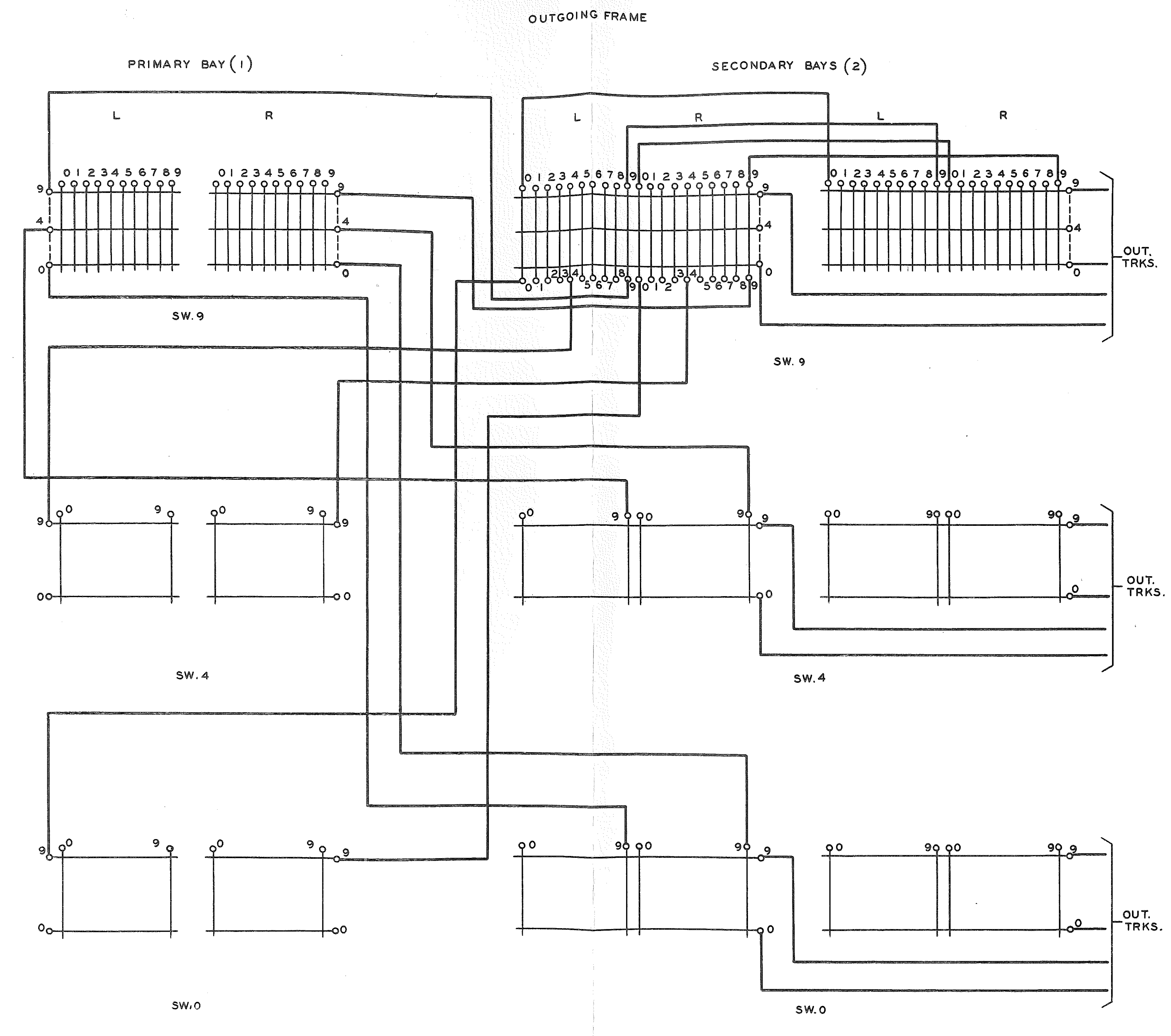
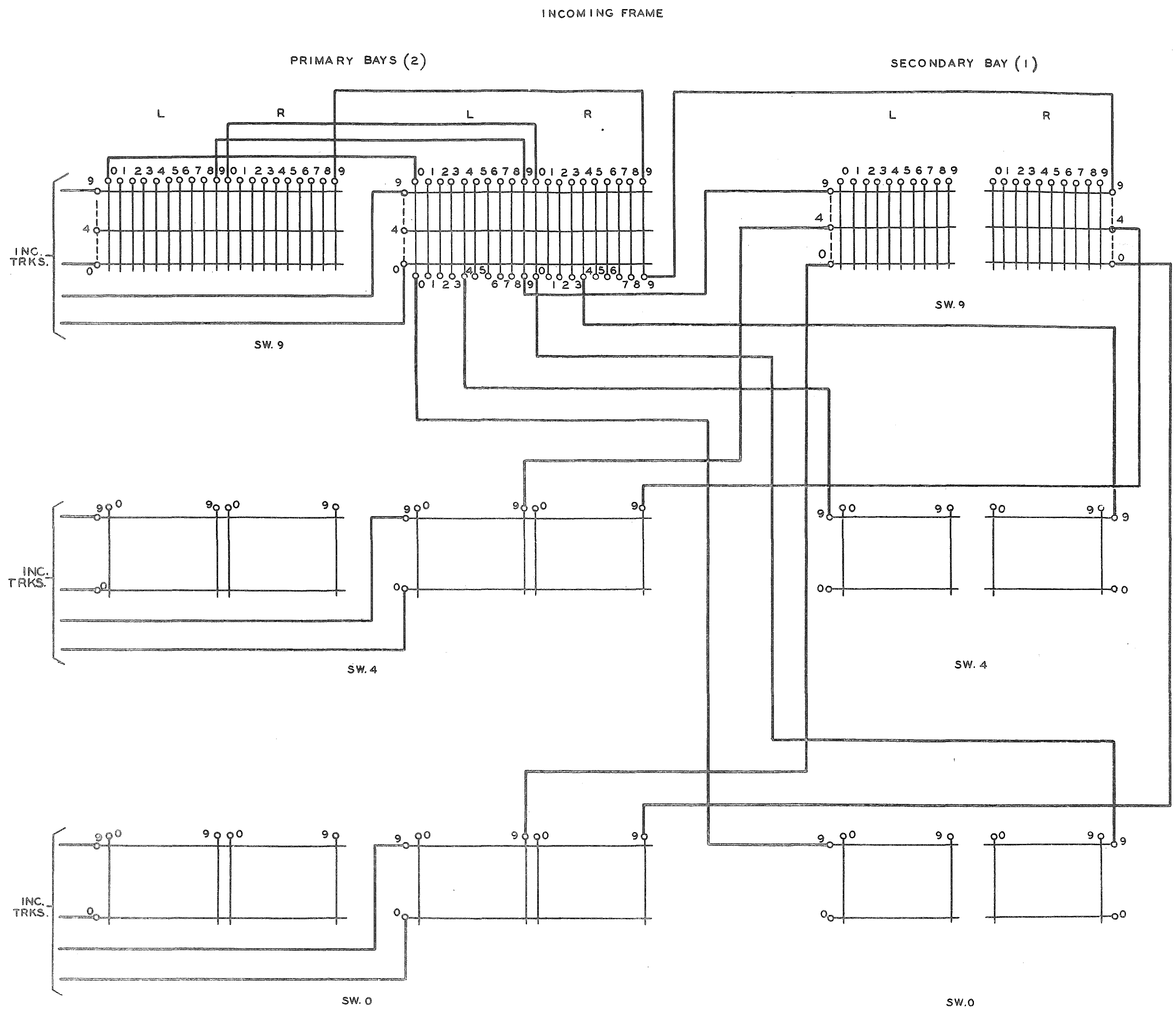


FIG. 20B

DISTRIBUTION OF OUTGOING LINKS.



NOTES:
NUMBER OF PRIMARY SWITCH = NUMBER OF SECONDARY SWITCH HORIZONTAL
NUMBER OF SECONDARY SWITCH NUMBER OF PRIMARY SWITCH VERTICAL.

FIG. 20A

DISTRIBUTION OF INCOMING LINKS.

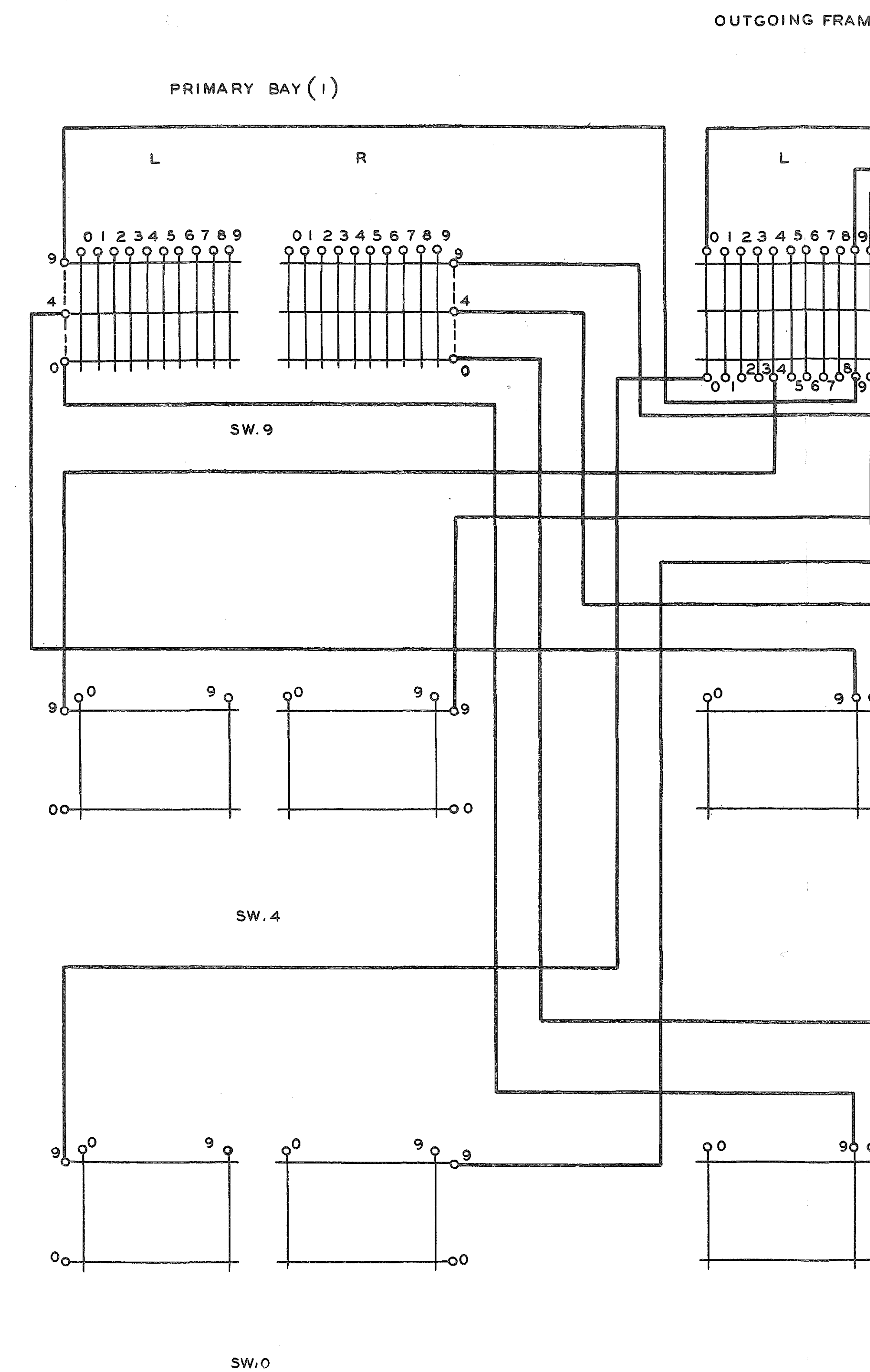


FIG. 20B

DISTRIBUTION OF OUTGO

BELL TELEPHONE LABORATORIES, INC.
PRINTED IN U.S.A.

NOTES:

1. THERE ARE TWO GROUPS OF 60 JUNCTORS FROM EACH INC. FRAME TO EACH OUT. FRAME. 20 OF THESE ARE CABLED DIRECTLY TO THE OUTGOING FRAMES AND 40 ARE CABLED TO THE JUNCTOR GROUPING FRAME WHERE THEY ARE CROSS-CONNECTED TO THE CABLES FROM THE OUTGOING FRAMES.
2. VERTICALS ON THE INCOMING AND OUTGOING FRAMES SHOWN WITH LIGHT LINES ARE NOT USED AND ARE CABLED TO THE JUNCTOR DISTRIBUTING FRAME AS SPARES.

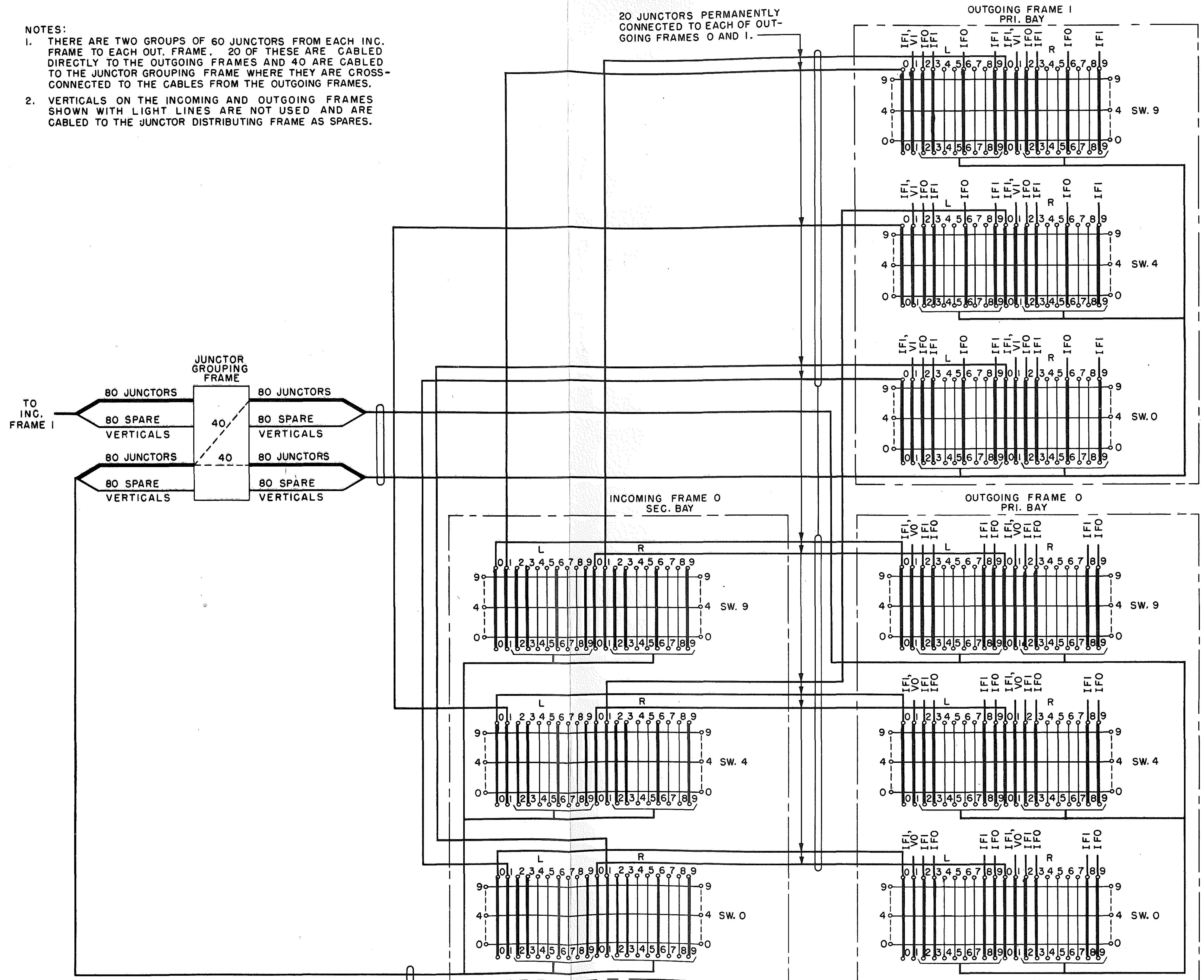


FIG. 23

JUNCTOR DISTRIBUTION-INTERTOLL OR COMBINED TRAIN OFFICE WITH TWO INCOMING AND TWO OUTGOING FRAMES
(INITIAL INSTALLATION) (ULTIMATE SIZE OFFICE 10 IF - 10 OF)

JUNCTOR DISTRIBUTION INTERTOLL OR COMBINED TRAIN 10 INC. GROUPS-20 OUT. FRAMES (ULTIMATE SIZE)						
NO. OF JUNCTORS	INC. GROUP	OUT. VERT.	INC. GROUP VERT.	OUT. FR.	INC. GROUP SEC. SW.	OUT. FR. 1/2 PRI. SW.
10	0	0	0	0	REG. 0-9	0L-9L
10	0	0	0	0	EXT. 0-9	0R-9R
10	0	0	1	2	REG. 0-9	0L-9L
10	0	0	1	2	EXT. 0-9	0R-9R
10	0	0	2	4	REG. 0-9	0L-9L
10	0	0	2	4	EXT. 0-9	0R-9R
60	0	0	3 TO 8	EVEN 6 TO 16	REG. 0-9	0L-9L
60	0	0	3 TO 8	EVEN 6 TO 16	EXT. 0-9	0R-9R
10	0	0	9	18	REG. 0-9	0L-9L
10	0	0	9	18	EXT. 0-9	0R-9R
10	0	0	10	1	REG. 0-9	0L-9L
10	0	0	10	1	EXT. 0-9	0R-9R
10	0	0	11	3	REG. 0-9	0L-9L
10	0	0	11	3	EXT. 0-9	0R-9R
70	0	0	12 TO 18	ODD 5 TO 17	REG. 0-9	0L-9L
70	0	0	12 TO 18	ODD 5 TO 17	EXT. 0-9	0R-9R
10	0	0	19	19	REG. 0-9	0L-9L
10	0	0	19	19	EXT. 0-9	0R-9R
TOTAL 400						
10	7	7	0	0	REG 0-9	0L-9L
10	7	7	0	0	EXT. 0-9	0R-9R
10	7	7	1	2	REG. 0-9	0L-9L
10	7	7	1	2	EXT. 0-9	0R-9R
80	7	7	2 TO 9	EVEN 2 TO 18	REG. 0-9	0L-9L
80	7	7	2 TO 9	EVEN 2 TO 18	EXT. 0-9	0R-9R
10	7	7	10	1	REG 0-9	0L-9L
10	7	7	10	1	EXT. 0-9	0R-9R
10	7	7	11	3	REG. 0-9	0L-9L
10	7	7	11	3	EXT. 0-9	0R-9R
80	7	7	12 TO 19	ODD 5 TO 19	REG. 0-9	0L-9L
80	7	7	12 TO 19	ODD 5 TO 19	EXT. 0-9	0R-9R
TOTAL 400						

NOTES:

(a) INC. GROUP REG. SEC. BAY SW. NO. = OUT. FRAME PRI. BAY LEFT HALF SW. NO.

(b) INC. GROUP EXT. SEC. BAY SW. NO. = OUT. FRAME PRI. BAY RIGHT HALF SW. NO.

(c) INC. GROUP NO. = OUT. FRAME VERT. NO.

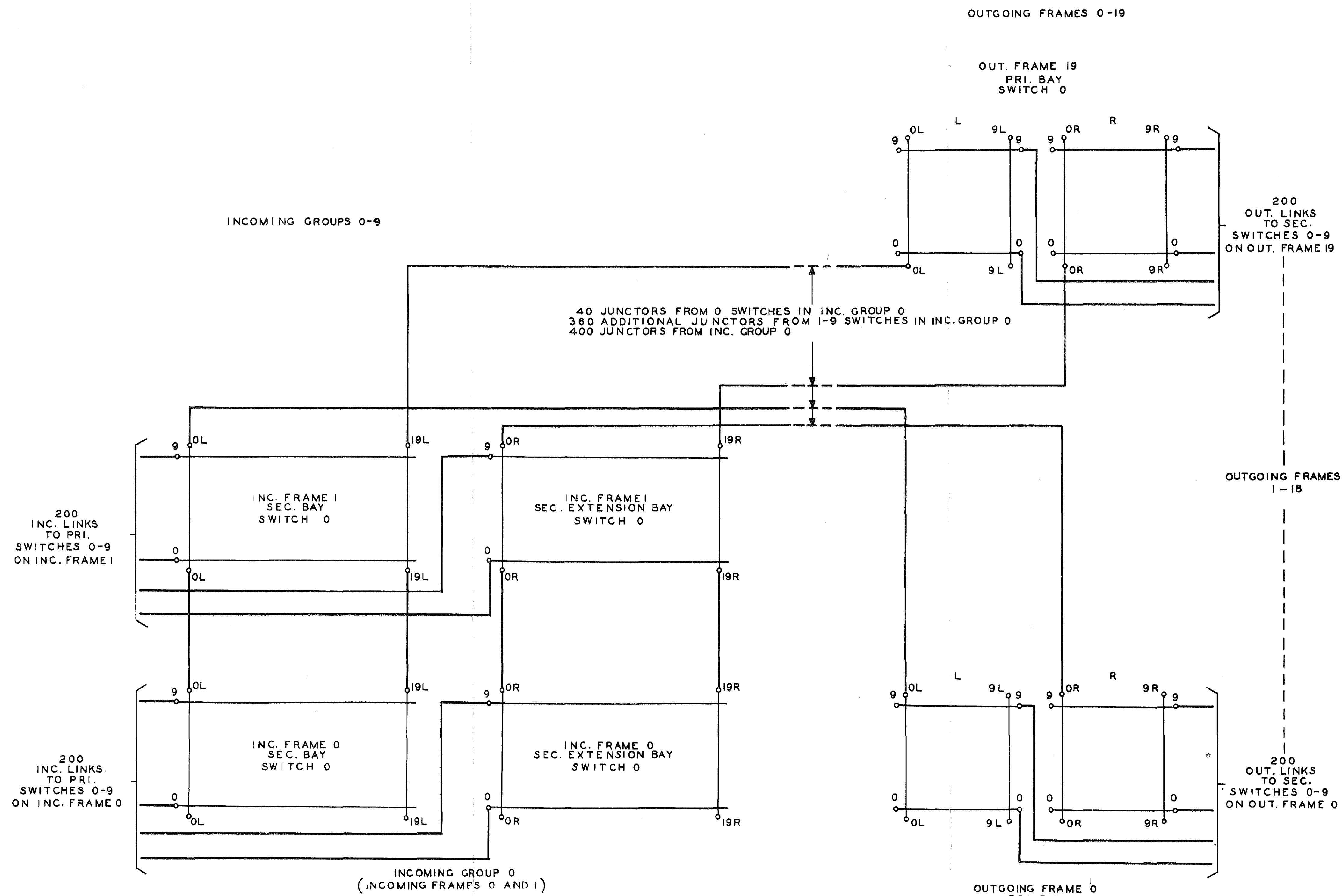


FIG. 24
PAIRING OF INCOMING FRAMES TO FORM GROUPS OF TWO WHICH SHARE 400 JUNCTORS (ULTIMATE SIZE OFFICE 10IG - 20OF)

JUNCTOR DISTRIBUTION INTERTOLL OR COMBINED TRAIN 20 INC. GROUPS - 20 OUT. GROUPS (ULTIMATE SIZE)						
NO. OF JUNCTORS	INC. GROUP	OUT. GROUP VERT.	INC. GROUP VERT.	OUT. GROUP	INC. GROUP SEC. SW.	OUT. GROUP PRI. SW.
10	0	0	0	0	REG. 0-9	EXT. 0-9
10	0	0	0	0	EXT. 0-9	REG. 0-9
10	0	0	1	1	REG. 0-9	EXT. 0-9
10	0	0	1	1	EXT. 0-9	REG. 0-9
10	0	0	2	2	REG. 0-9	EXT. 0-9
10	0	0	2	2	EXT. 0-9	REG. 0-9
170	0	0	3 TO 19	3 TO 19	REG. 0-9	EXT. 0-9
170	0	0	3 TO 19	3 TO 19	EXT. 0-9	REG. 0-9
TOTAL 400						
10	7	7	0	0	REG. 0-9	EXT. 0-9
10	7	7	0	0	EXT. 0-9	REG. 0-9
10	7	7	1	1	REG. 0-9	EXT. 0-9
10	7	7	1	1	EXT. 0-9	REG. 0-9
10	7	7	2	2	REG. 0-9	EXT. 0-9
10	7	7	2	2	EXT. 0-9	REG. 0-9
170	7	7	3 TO 19	3 TO 19	REG. 0-9	EXT. 0-9
170	7	7	3 TO 19	3 TO 19	EXT. 0-9	REG. 0-9
TOTAL 400						

NOTES:

(a) INC. GROUP REG. SEC. BAY SW. NO.= OUT. GROUP EXT. PRI. BAY SW. NO.

(b) INC. GROUP EXT. SEC. BAY SW. NO.=OUT. GROUP REG. PRI. BAY SW. NO.

(c) INC. GROUP NO.= OUT. GROUP VERT. NO.

(d) OUT. GROUP NO.=INC. GROUP VERT. NO.

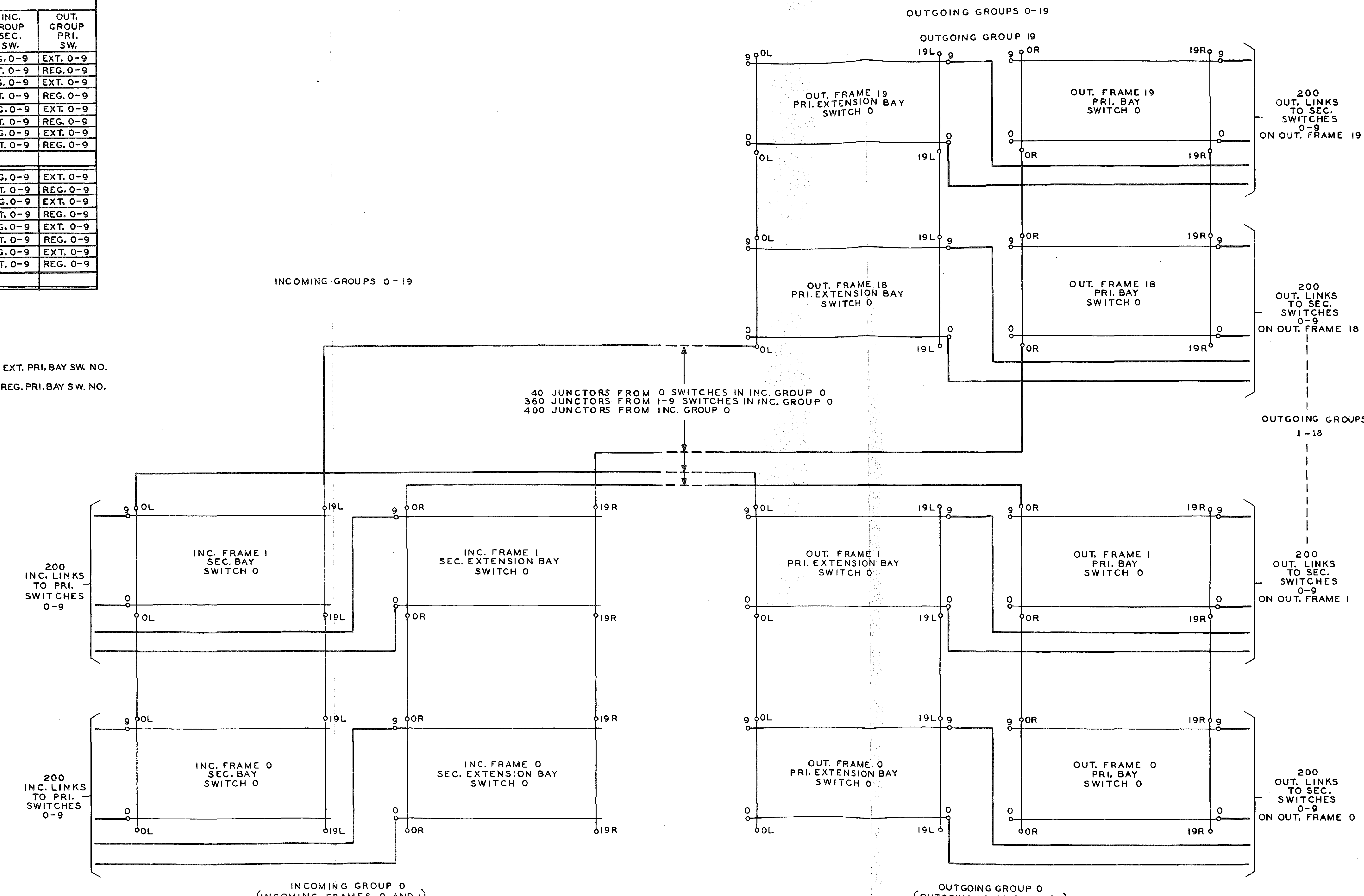


FIG. 25

PAIRING OF INCOMING FRAMES AND OF OUTGOING FRAMES TO FORM GROUPS OF TWO WHICH SHARE 400 JUNCTORS (ULTIMATE SIZE OFFICE 20IG-20 OG)

**JUNCTOR DISTRIBUTION
INTERTOLL OR COMBINED TRAIN
20 INC. GROUPS - 20 OUT. GROUPS
(ULTIMATE SIZE)**

NO. OF JUNCTORS	INC. GROUP	OUT. GROUP VERT.	INC. GROUP VERT.	OUT. GROUP	INC. GROUP SEC. SW.	OUT. GROUP PRI. SW.
10	0	0	0	0	REG. 0-9	EXT. 0-9
10	0	0	0	0	EXT. 0-9	REG. 0-9
10	0	0	1	1	REG. 0-9	EXT. 0-9
10	0	0	1	1	EXT. 0-9	REG. 0-9
10	0	0	2	2	REG. 0-9	EXT. 0-9
10	0	0	2	2	EXT. 0-9	REG. 0-9
170	0	0	3 TO 19	3 TO 19	REG. 0-9	EXT. 0-9
170	0	0	3 TO 19	3 TO 19	EXT. 0-9	REG. 0-9
TOTAL 400						
10	7	7	0	0	REG. 0-9	EXT. 0-9
10	7	7	0	0	EXT. 0-9	REG. 0-9
10	7	7	1	1	REG. 0-9	EXT. 0-9
10	7	7	1	1	EXT. 0-9	REG. 0-9
10	7	7	2	2	REG. 0-9	EXT. 0-9
10	7	7	2	2	EXT. 0-9	REG. 0-9
170	7	7	3 TO 19	3 TO 19	REG. 0-9	EXT. 0-9
170	7	7	3 TO 19	3 TO 19	EXT. 0-9	REG. 0-9
TOTAL 400						

NOTES:

(a) INC. GROUP REG. SEC. BAY SW. NO.= OUT. GROUP EXT. PRI. BAY SW. NO.
(b) INC. GROUP EXT. SEC. BAY SW. NO.=OUT. GROUP REG. PRI. BAY SW. NO.
(c) INC. GROUP NO.= OUT. GROUP VERT. NO.
(d) OUT. GROUP NO.=INC. GROUP VERT. NO.

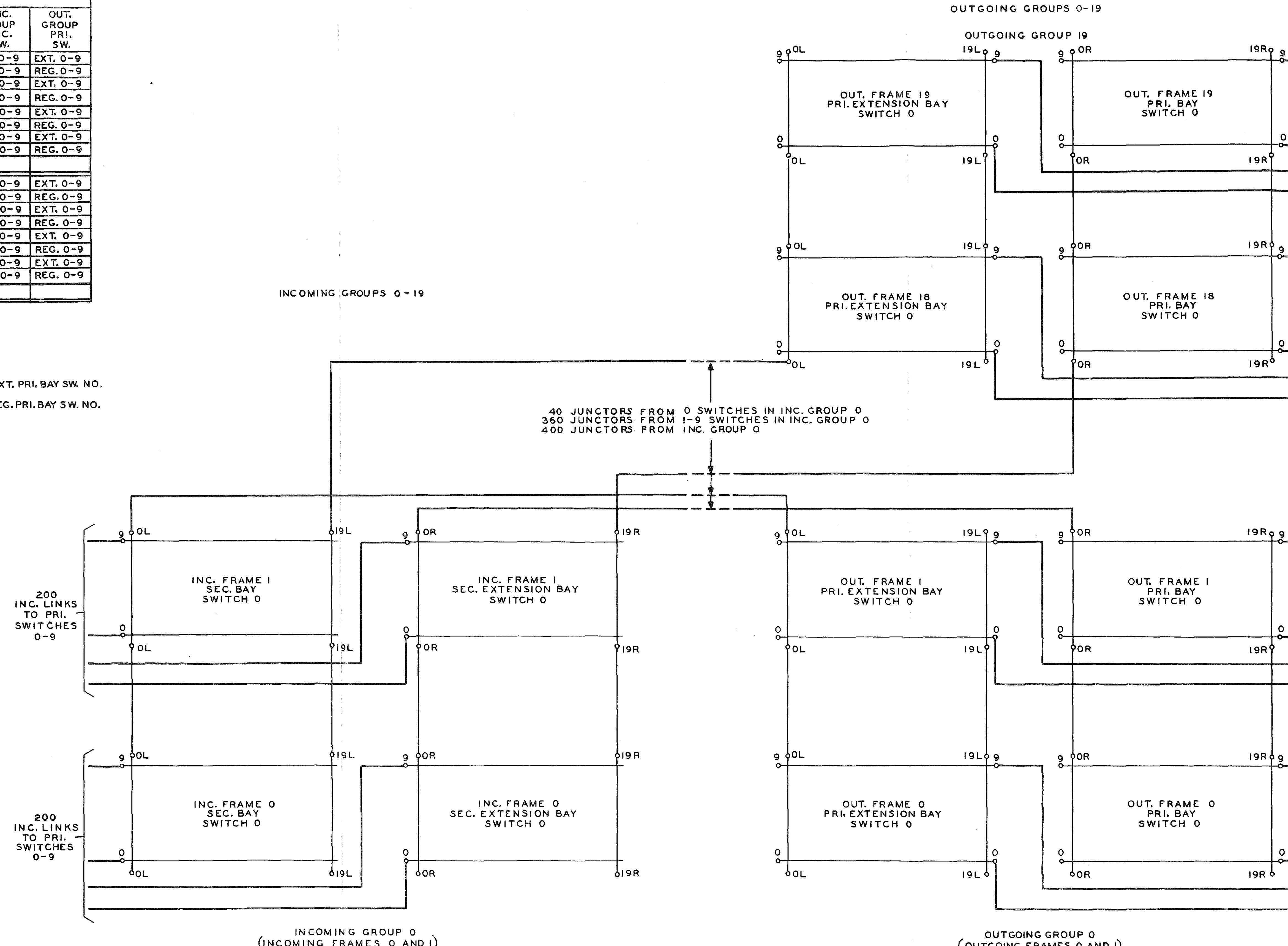
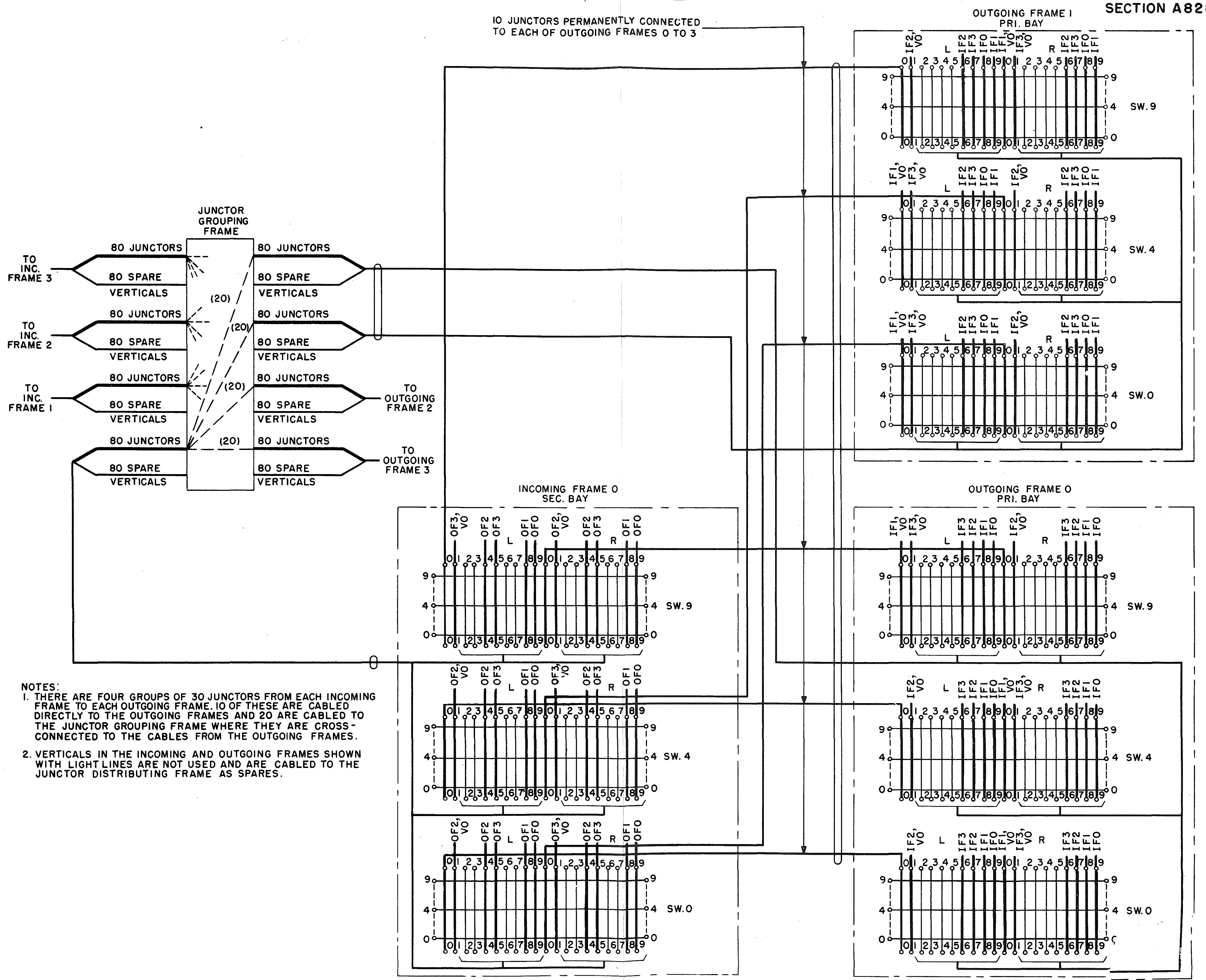


FIG. 25
PAIRING OF INCOMING FRAMES AND OF OUTGOING FRAMES
TO FORM GROUPS OF TWO WHICH SHARE 400 JUNCTORS
(ULTIMATE SIZE OFFICE 20IG-20 OG)



NOTES:

1. THERE ARE FOUR GROUPS OF 30 JUNCTORS FROM EACH INCOMING FRAME TO EACH OUTGOING FRAME. 10 OF THESE ARE CABLED DIRECTLY TO THE OUTGOING FRAMES AND 20 ARE CABLED TO THE JUNCTOR GROUPING FRAME WHERE THEY ARE CROSS-CONNECTED TO THE CABLES FROM THE OUTGOING FRAMES.
2. VERTICALS IN THE INCOMING AND OUTGOING FRAMES SHOWN WITH LIGHT LINES ARE NOT USED AND ARE CABLED TO THE JUNCTOR DISTRIBUTING FRAME AS SPARES.

FIG. 26

JUNCTOR DISTRIBUTION - TOLL COMPLETING TRAIN OFFICE WITH FOUR INCOMING AND FOUR OUTGOING FRAMES (INITIAL INSTALLATION) (ULTIMATE SIZE OFFICE 20IF 20OF)

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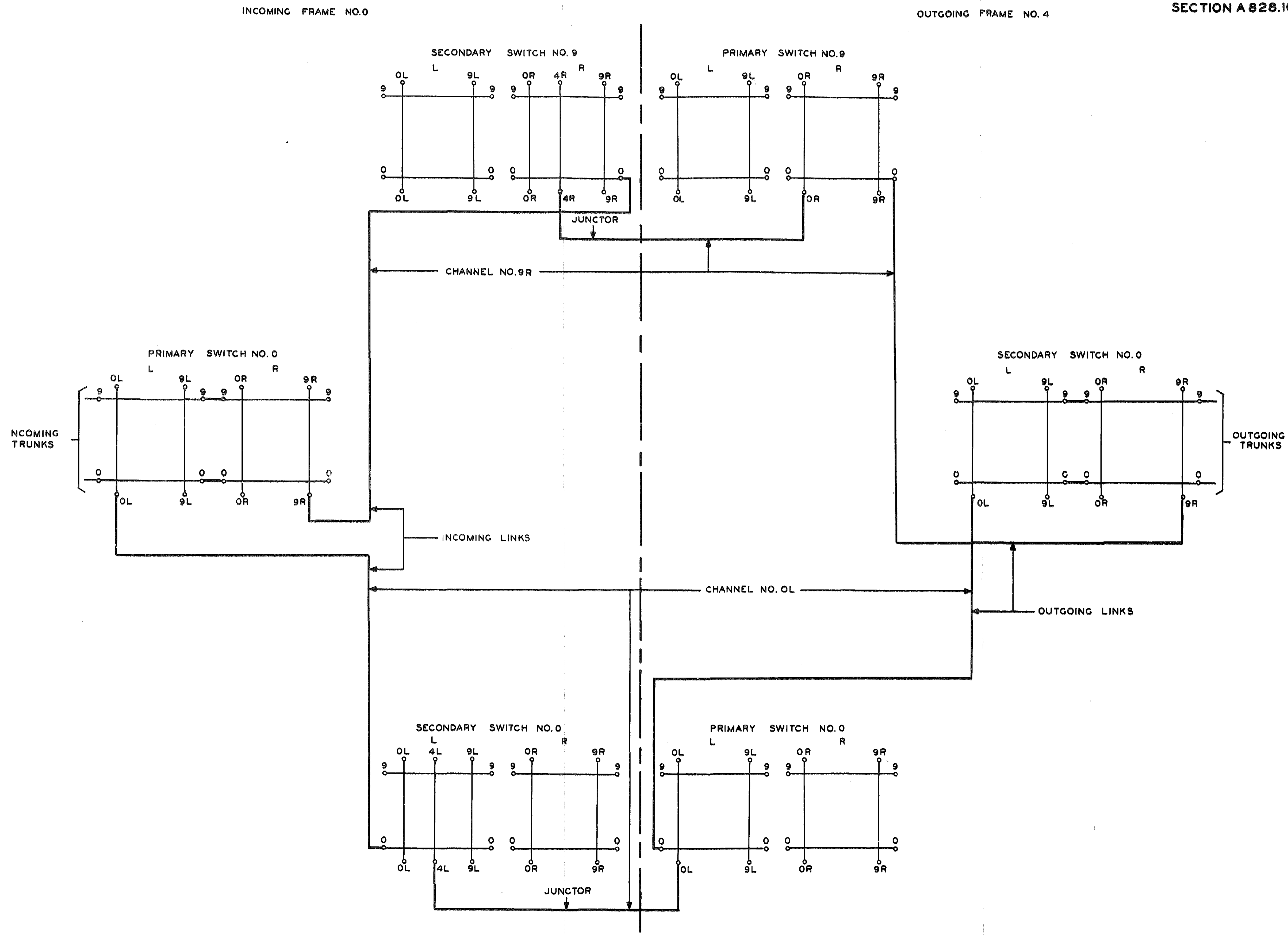

FIG. 27
CHANNELS

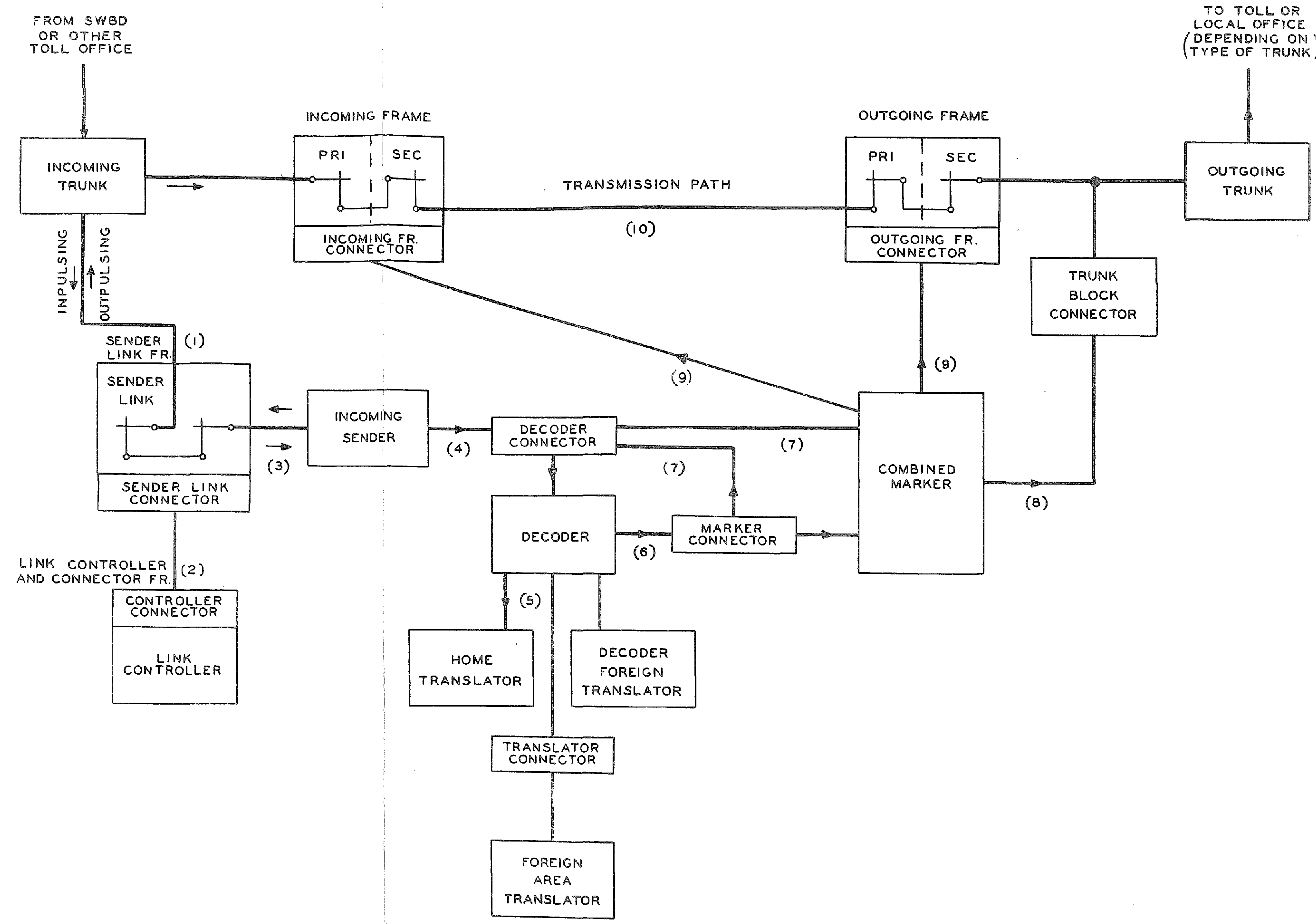

FIG. 29
CALL THROUGH A COMBINED TRAIN OFFICE

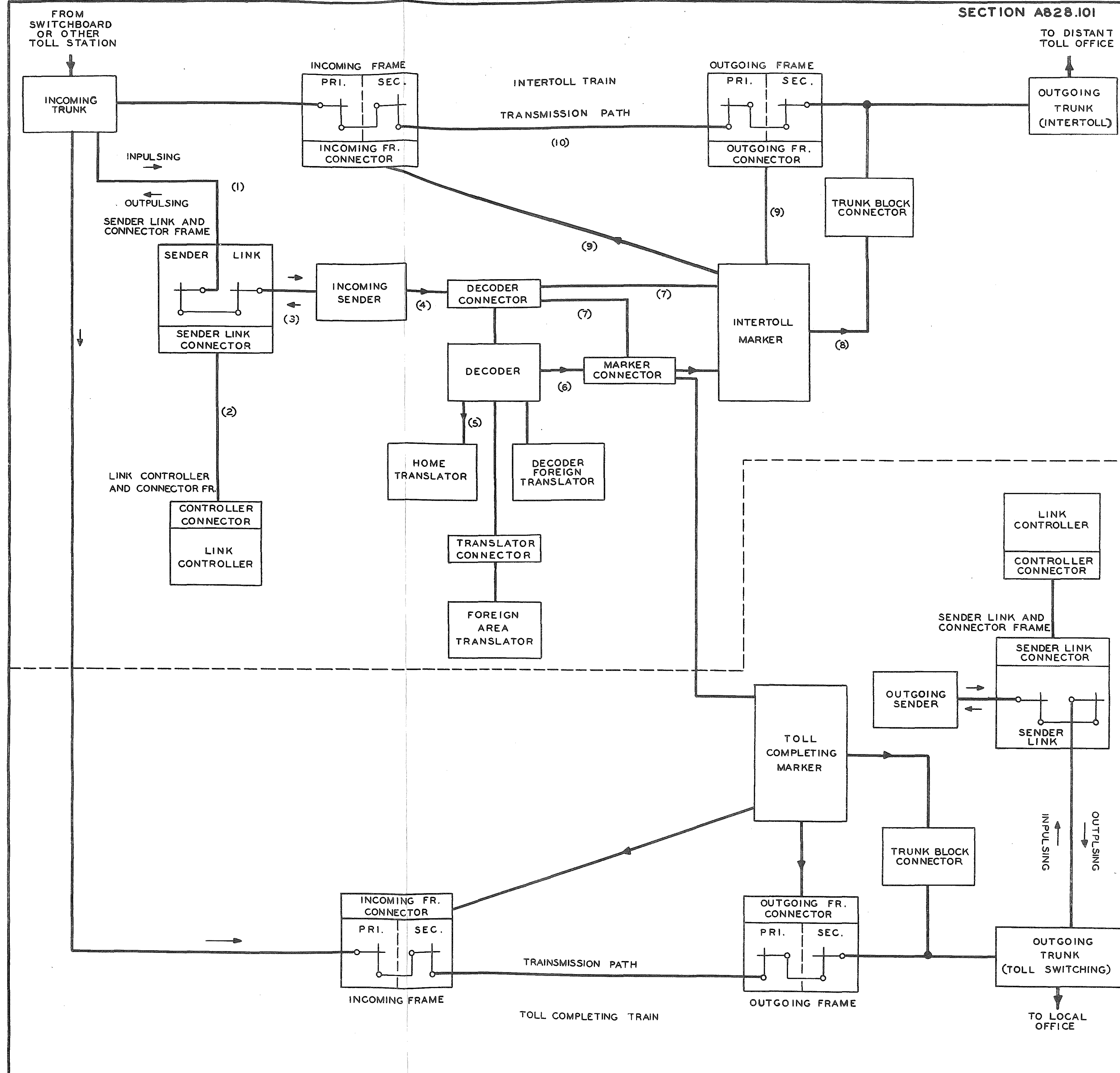

FIG. 30
CALL THROUGH A SEPARATE TRAIN OFFICE.

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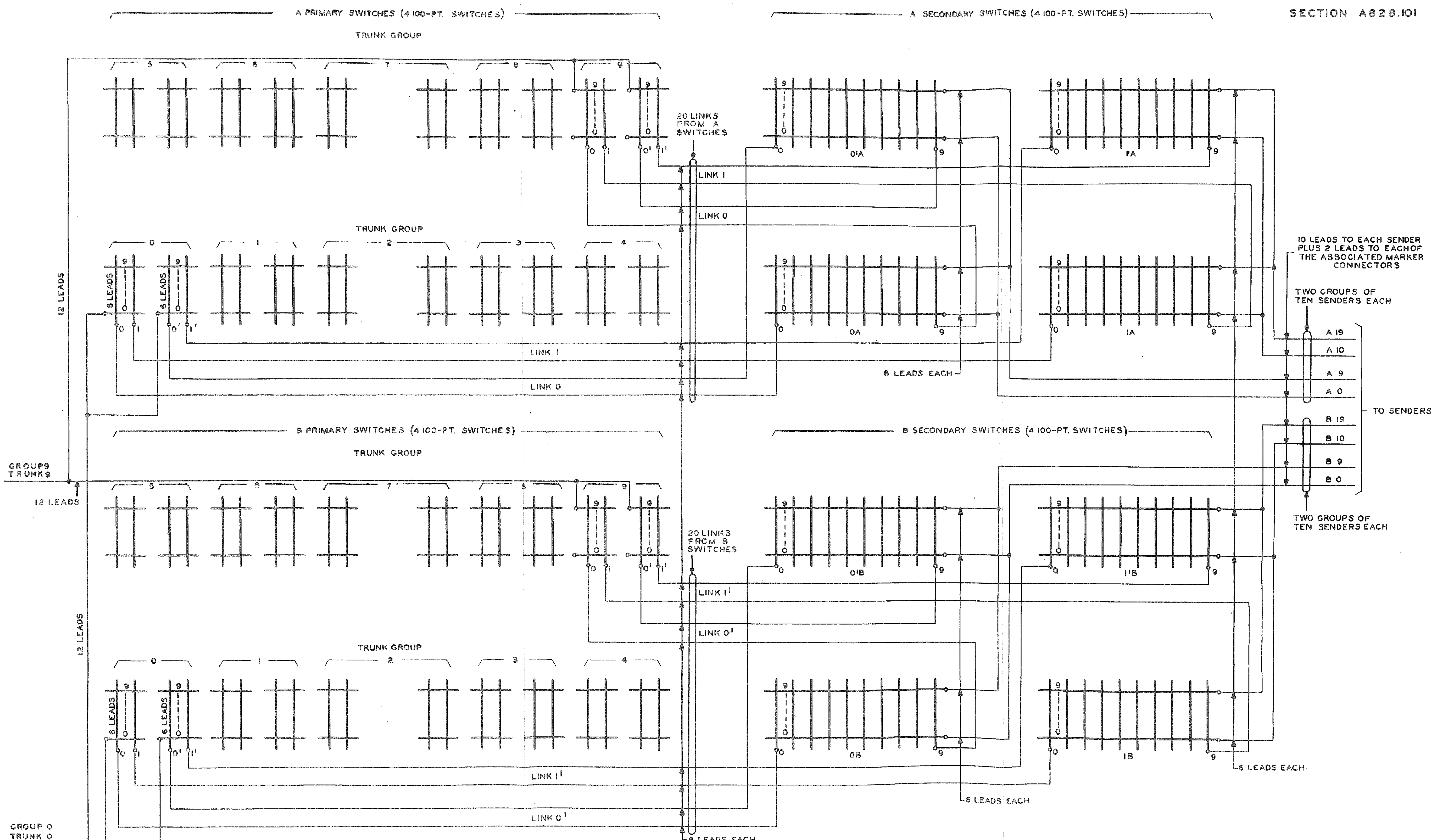

FIG. 40
SENDER LINK FRAME – SENDER LINK SPREAD

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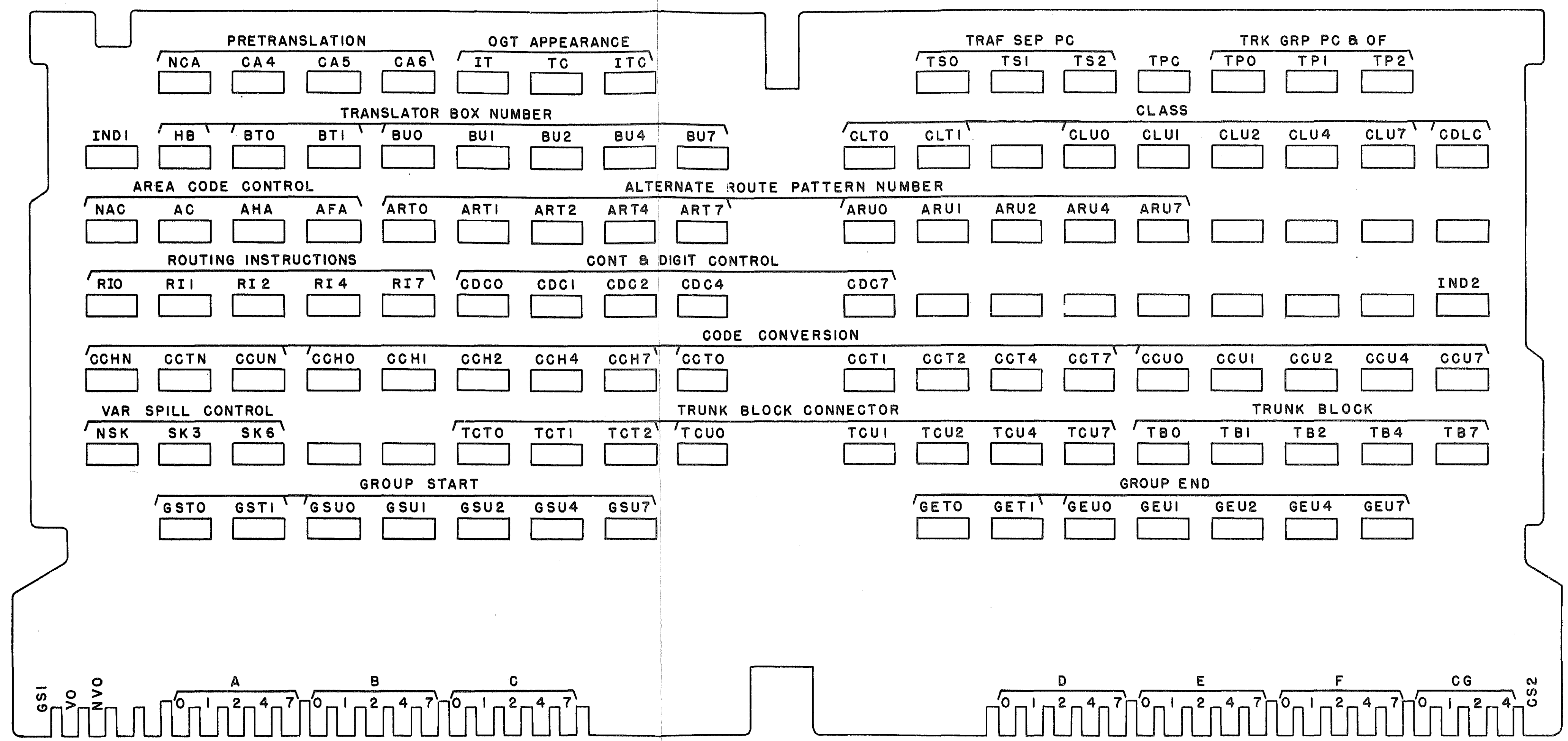


FIG. 46
TRANSLATOR CARD

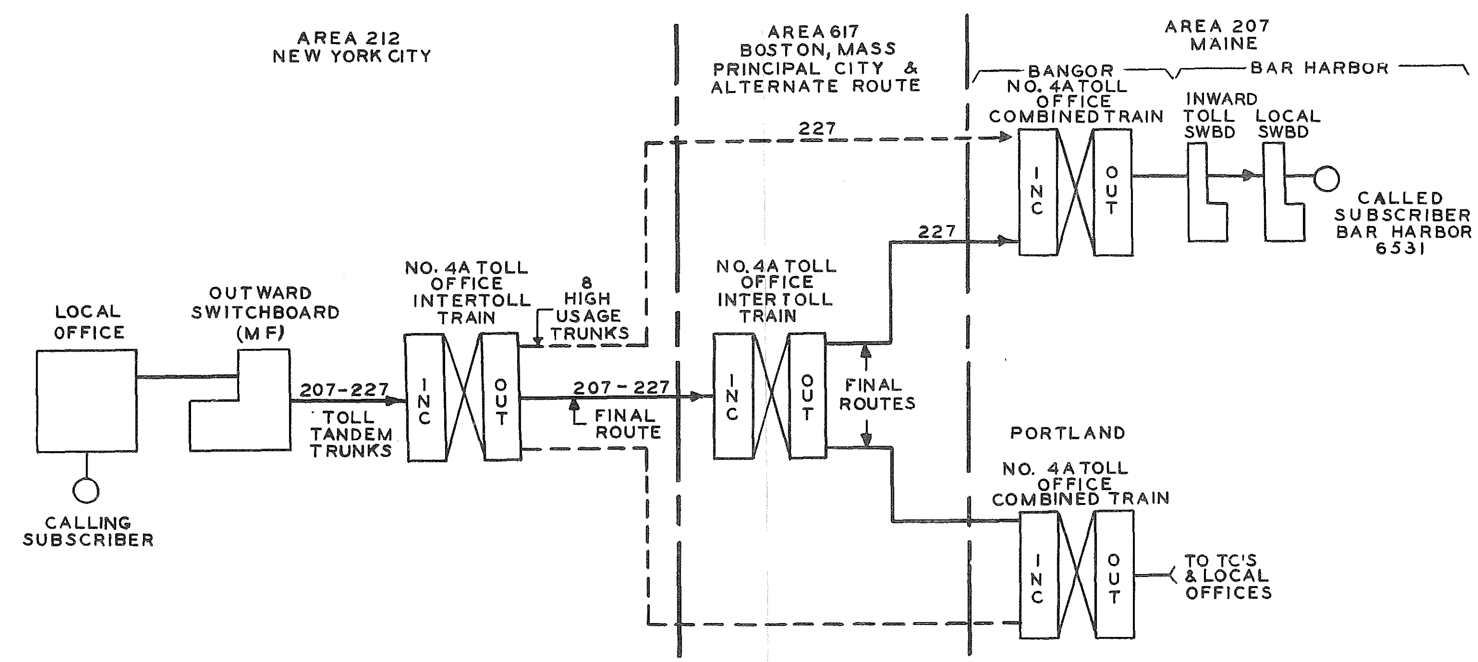


FIG. 67

(1) CALL ILLUSTRATING SIX-DIGIT TRANSLATION
TWO TRUNK GROUPS TO AN AREA

(2) CALL ILLUSTRATING AUTOMATIC ALTERNATE ROUTING

(3) CALL ILLUSTRATING VACANT CODE ROUTING

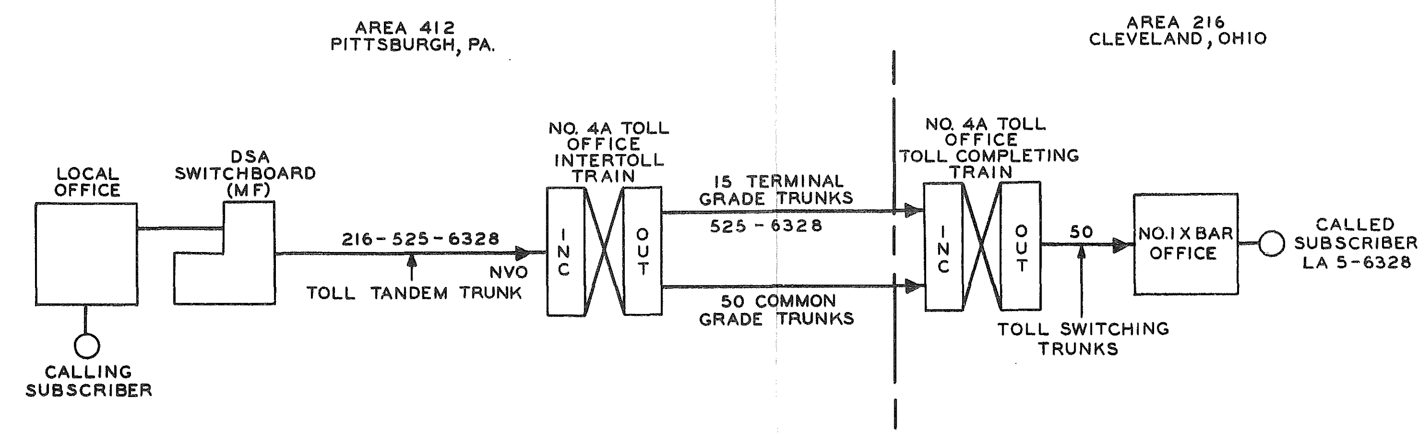


FIG. 68

CALL ILLUSTRATING SIX-DIGIT TRANSLATION
TERMINAL AND COMMON GRADE TRUNKS

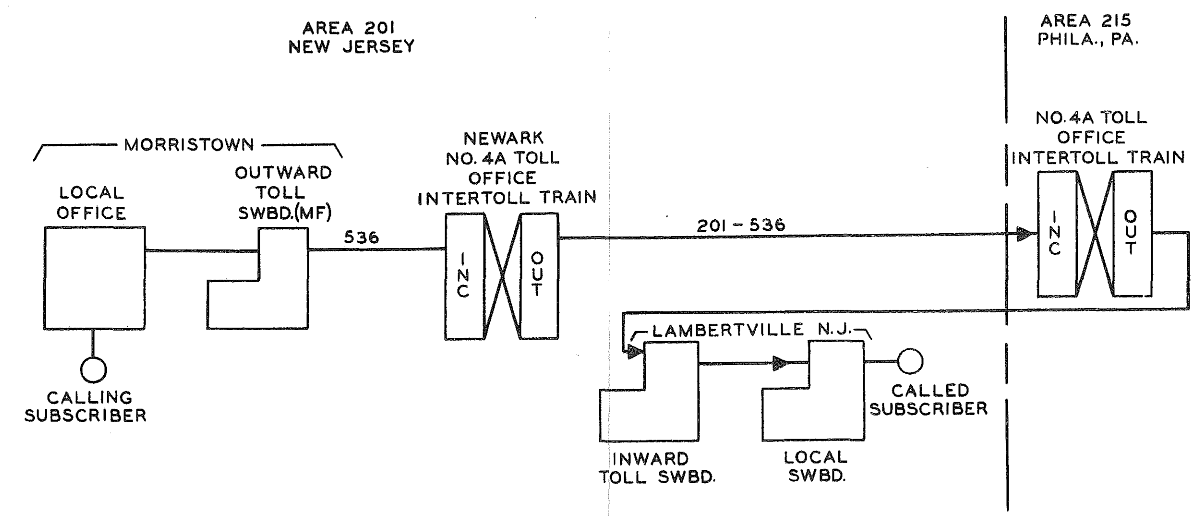
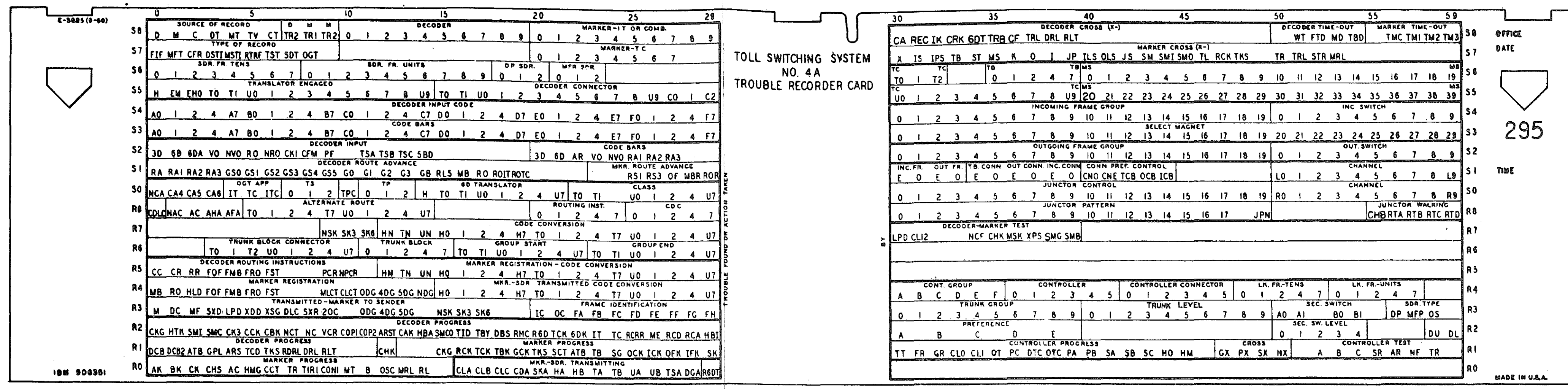
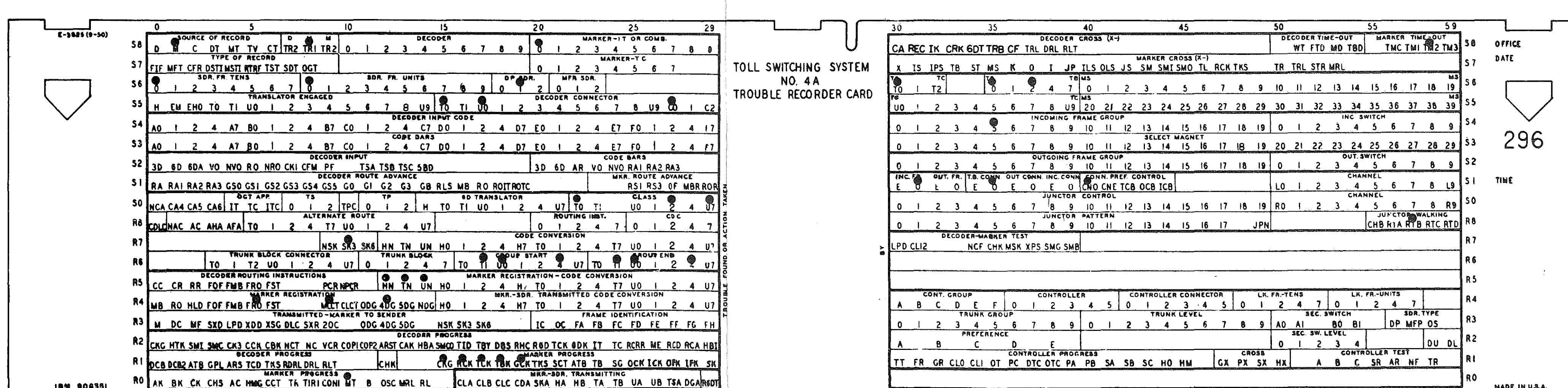


FIG. 69

CALL ILLUSTRATING THE PREFIXING OF
AN AREA CODE



CARD BLANK



PUNCHED CARD

FIG. 71

TROUBLE RECORD CARDS

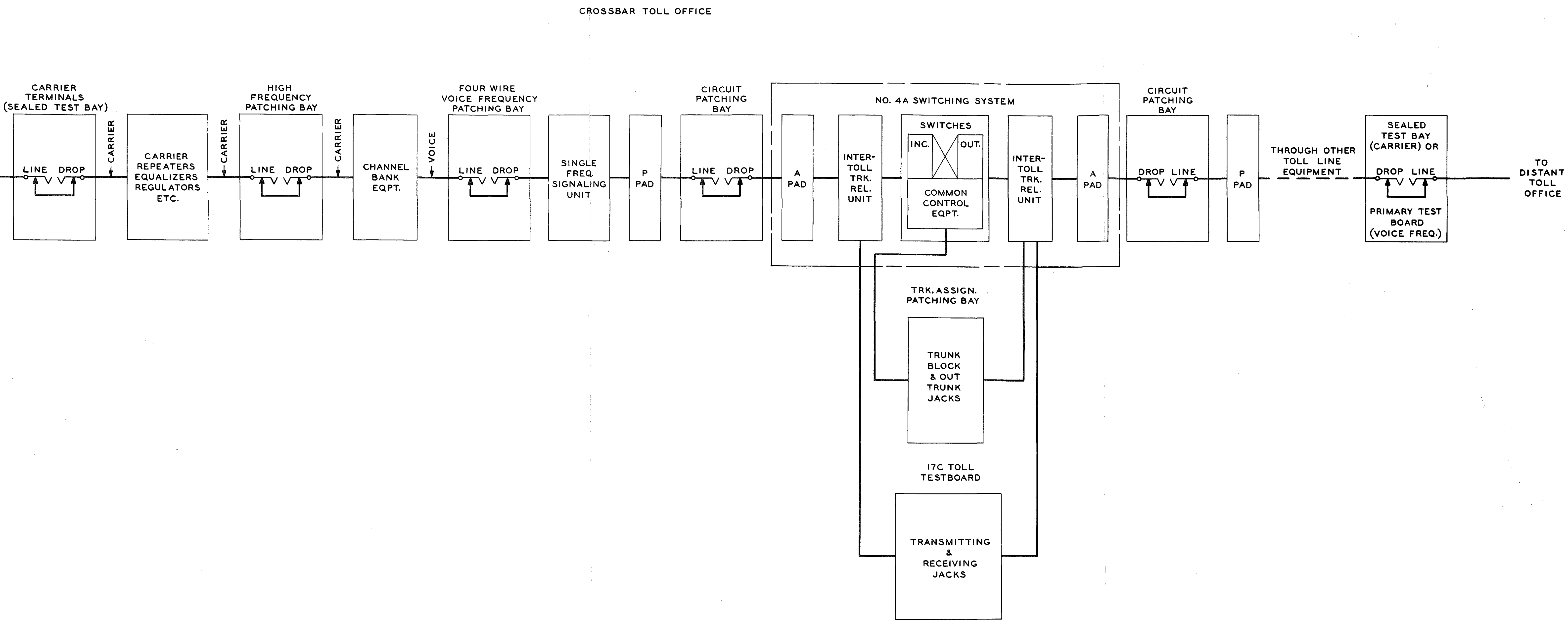


FIG. 77

DIAGRAM SHOWING TYPICAL INTERTOLL CONNECTION THROUGH A CROSSBAR TOLL OFFICE

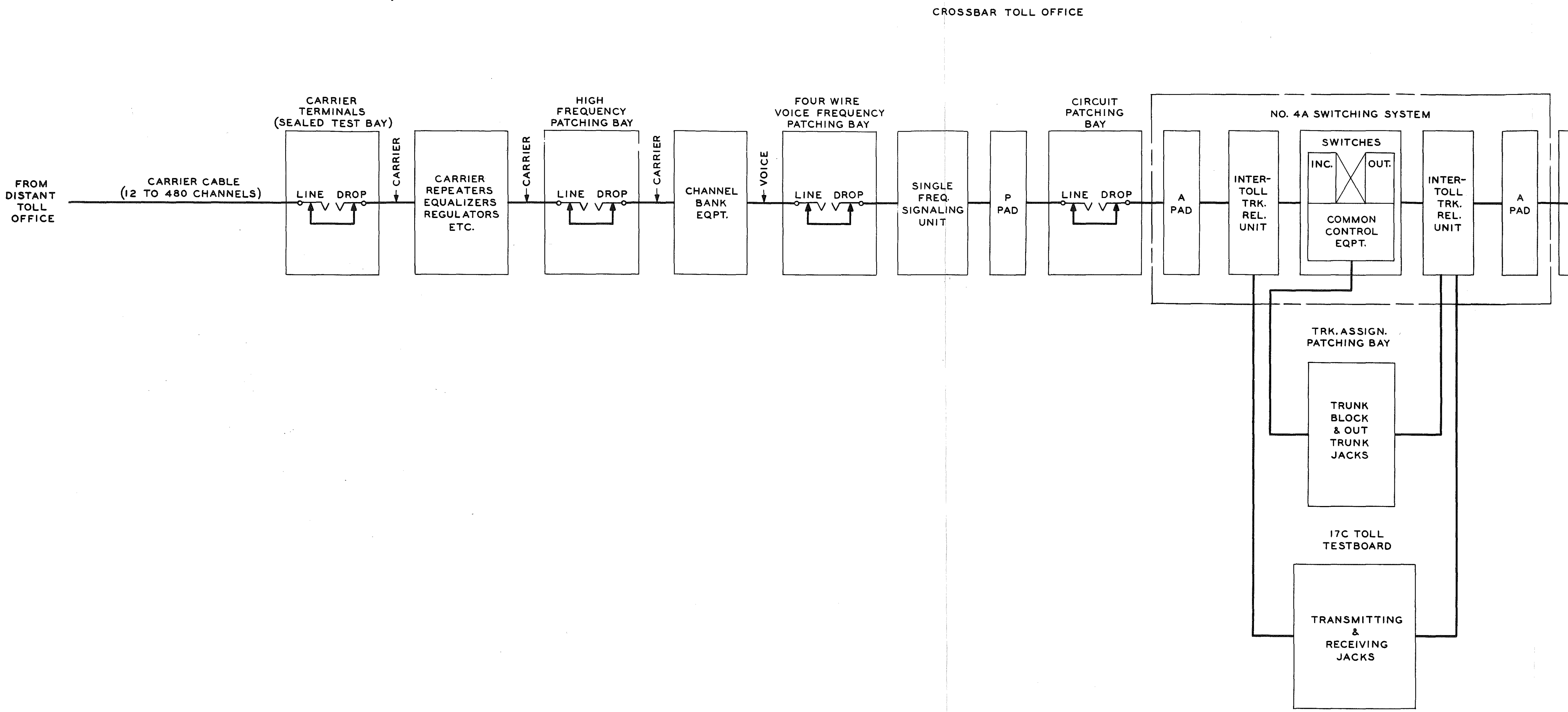


FIG. 77

DIAGRAM SHOWING TYPICAL INTERTOLL CONNECTION THROUGH A CROSSBAR TOLL OFFICE

BELL TELEPHONE LABORATORIES, INC.

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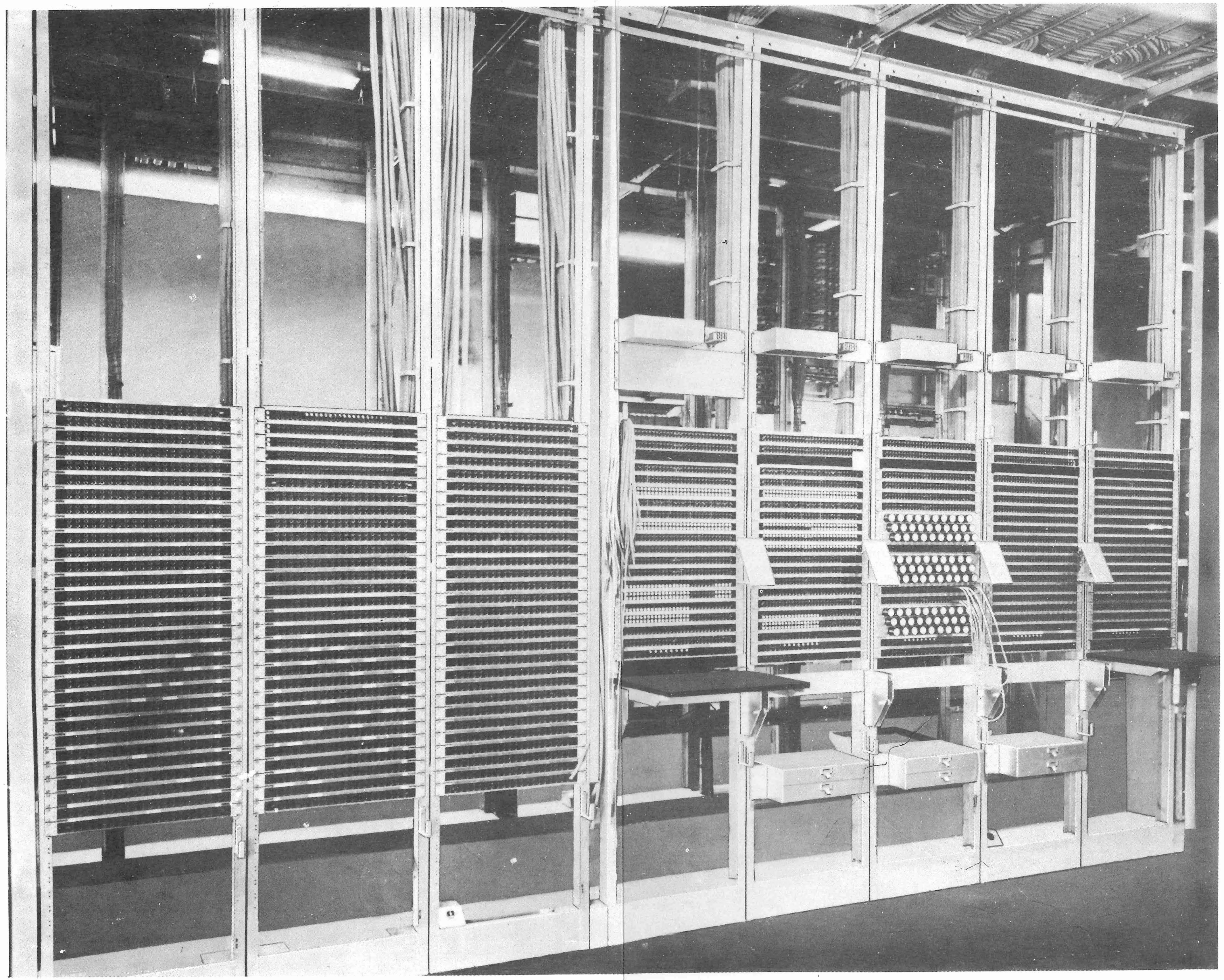

FIG. 78 ASSIGNMENT PATCHING BAY AND CIRCUIT PATCHING BAY