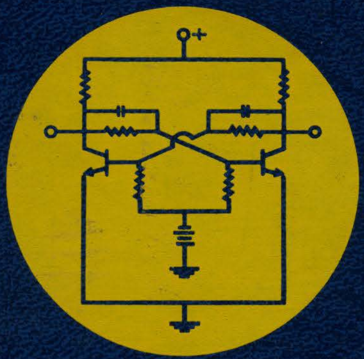
TELEPHONE COMMUNICATION SYSTEMS

VOLUME II
CROSSBAR SYSTEMS



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PREFACE

Connecting any two phones among the millions of subscribers is accomplished by telephone switching systems. The process, although not simple, is normally taken for granted in our everyday use of telephone services. This is indeed a compliment to the Bell System people who have developed, engineered, and maintained the many types of telephone systems. The switching equipment in the Central office is considered by many to be the heart of the telephone highway, for without it the telephone never would have progressed to the highly developed and integrated entity it is today.

Although the switching equipments may be considered the "heart," the other parts of the telephone network are equally important. For without the connecting wires and cables, the subscribers' equipment and the power plant, there could be no universal telephone network and no Direct Distance Dialing.

Switching is a highly dynamic field. From the first crude switching arrangements developed by the Holmes Electric Company in Boston in 1877 to the highly sophisticated No. 1 ESS system developed by the Bell System Laboratories in the early 1960's, the telephone switching system has indeed come a long way. What the future holds can only be speculated upon: on the horizon, we now see new developments, such as the use of satellites, lasers, and holography in communications.

Each subject covered in this text could be developed much more extensively; however, our objective is not to print a comprehensive treatise on telephony, but rather to treat each subject briefly presenting a general technical explanation of its operation and function.

This text has been prepared for Graduate Engineering Education courses presented at the Western Electric Corporate Education Center. Its contents are the result of over 12 years of development, starting from a group of handouts given to students and leading to the book we have today. Although much of the material and ideas were taken from various Bell System sources, a great deal of the book can be attributed to the members of the Graduate Engineering Education staff. Acting as writers, instructors, and editors, each diligently worked in assembling a well organized telephone communications text. Their collective efforts are sincerely appreciated, and are hereby gratefully acknowledged.

J. E. GARRETT
Manager, Graduate Engineering
and Information Systems Education

Corporate Education Center
Hopewell, New Jersey

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CHAPTER 6

PRINCIPLES OF CROSSBAR SWITCHING

6.1 INTRODUCTION

Crossbar systems were developed in the mid 1930's to counteract some of the disadvantages of the Panel System. The panel selector switches, which introduced a high degree of noise, were eliminated from the new systems as well as their associated power driven elements. Instead, virtually noise-free talking paths were developed by using a radically new type of switch called a crossbar switch and relays with precious metal contacts. The crossbar common control units made possible more efficient operation of line and trunk network connections, derived the maximum use of intraoffice and interoffice trunk circuits and eased the overflow traffic during busy hours into alternate routes. Furthermore, the crossbar system provided the additional advantages of shorter call completing times and reduced maintenance.

6.2 THE CROSSBAR SWITCH

The basic element of any crossbar system is the crossbar switch, through which all talking connections are made. The crossbar switch is essentially a relay mechanism consisting of ten horizontal paths and ten or 20 vertical paths, depending on what size switch is needed. Any horizontal path can be connected to any vertical path by means 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 20 vertical paths has 200 crosspoints and is called a 200-point switch. Figure 6-1 shows a partial perspective view of a crossbar switch.

Horizontal Paths: There are five selecting bars mounted horizontally across the face of each switch. Each selecting bar has flexible selecting fingers attached to it, one finger for each vertical path, and the bars can be rotated slightly to cause the select fingers to go either up or down.

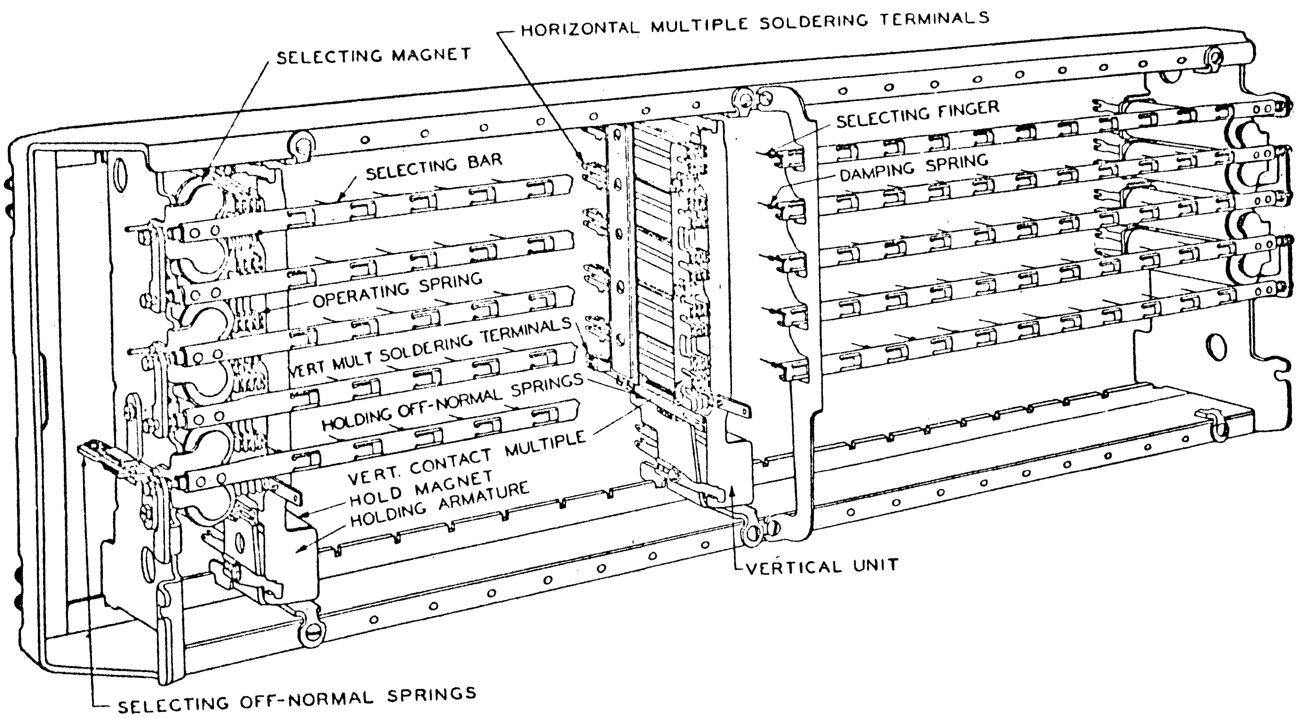


Figure 6-1 Partial Perspective View of a 200-Point Crossbar Switch - For 20 Vertical Units

Vertical Paths - Ten or 20 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.

3-Wire or 6-Wire - 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, 3-wire crossbar switch or a 200-point, 6-wire crossbar switch.

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 rotated and one of the two horizontal paths available to this bar is chosen. The selecting fingers now lie in front a group of contacts as shown in Figure 6-2.

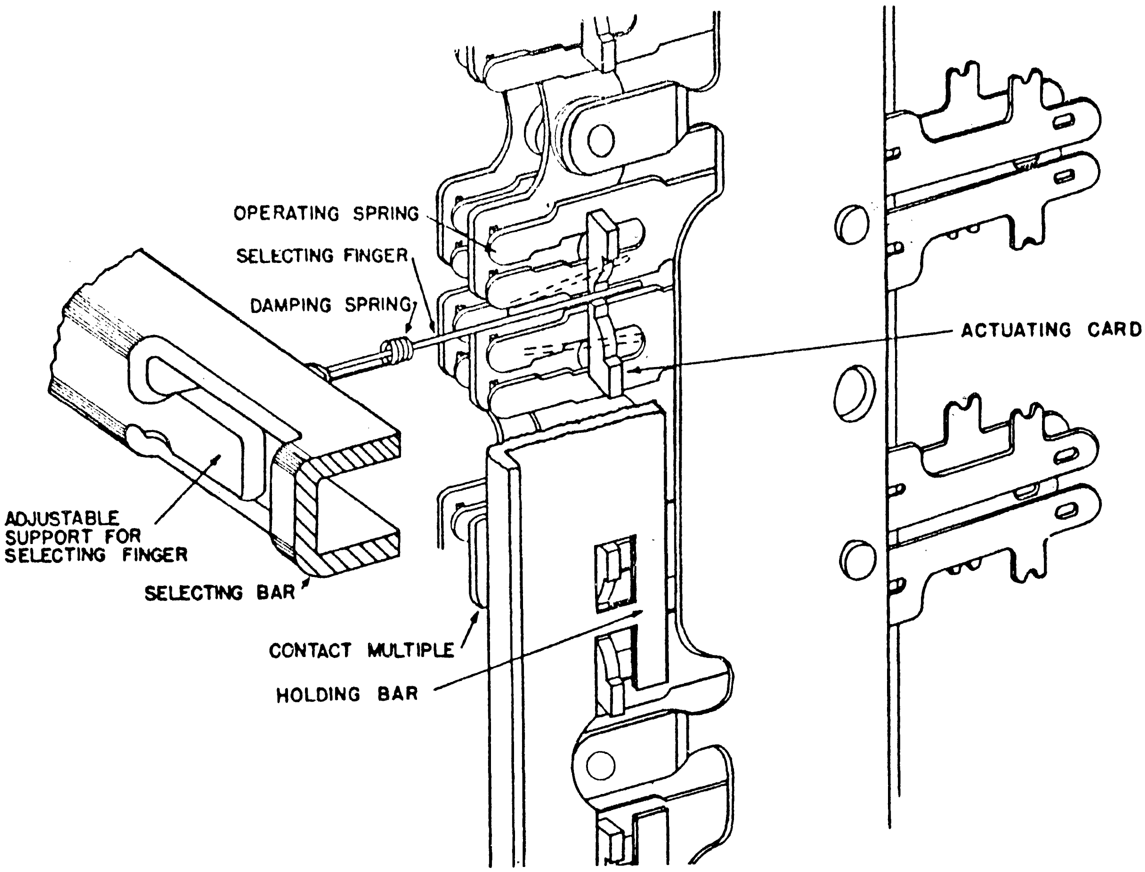


Figure 6-2 Crossbar Switch Selecting Mechanism

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 cross-point. The other groups of contacts on this vertical unit do not operate since there is no selecting finger between them and the holding bar.

After the operation of the hold magnet, the select magnet releases returning the horizontal bar and all of the selecting fingers back to normal, except those actively held by operated hold magnets. 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. Since the selecting finger tends to oscillate upon being released, damping cones are provided on the hold magnet armature to act in conjunction with the damping springs to minimize these oscillations.

Only one selecting magnet on a switch may be operated at one time if the closing of more than one crosspoint on a vertical unit, with the resulting double connection, is to be avoided. More than one connection throughout a switch may exist at the same time without interference after the crosspoints for each have been closed, but those crosspoints must each be closed one at a time.

The handling of one connection at a time in a switch, later extended to handling one call at a time in a frame of switches, is a fundamental operating principle of all crossbar systems. Thus double connections are avoided and the time required by a control circuit to establish each connection is reduced to a minimum.

6.3 NETWORKS

Groups of interconnected and interrelated crossbar switches, structured to form a system of metallic paths used for talking and for signals such as tones and ringing, comprise a switching network. Networks and the paths of a network are selected and controlled by relay logic units. Collectively, these relay logic units in crossbar systems are known as the "markers".

In developing a switching network using crossbar switches it was possible to vary the size of each group of subscribers and trunks and still satisfy the requirement that a telephone switching network have multiple access from each subscriber to any other subscriber or trunk.

Depicted in Figure 6-3 is a typical two stage grid network. Each switch block in both stages may be considered to have ten inputs and ten outputs. Within each block the switches can connect any input to any output. The switch units within the blocks may be either forward or backward-facing without affecting the validity of the network as a connecting means. The ten outputs of each input switch block fan out equally to the ten output switch blocks to give a total of 100 links spread uniformly between inputs and outputs. However, if each group (group size assumed to be ten) is spread equally over the ten output blocks, each individual output of a group is accessible to a separate link from a particular input group. Thus, any input can reach an output group via ten links, but a particular link and a particular output must be matched for a successful connection. This type of network then provides adequate access into an output group. Since the whole switch structure represents a coordinate grid with each intersection of horizontal and vertical forming a crosspoint with no directional motion, either side can be considered as the input.

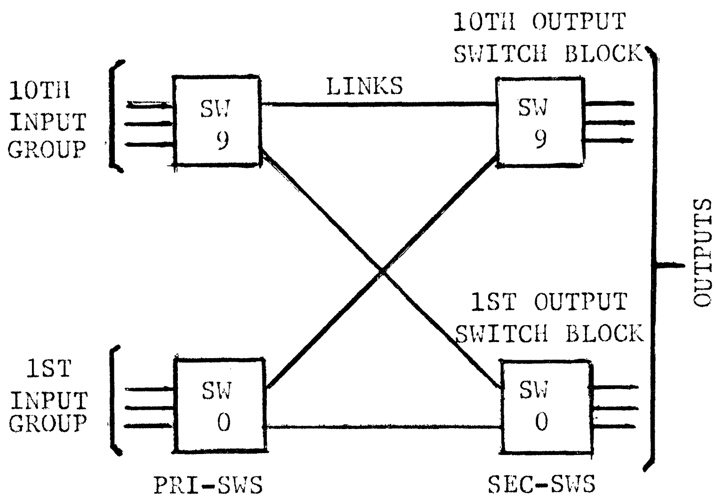


Figure 6-3 Two-Stage Grid Network

The input switches of the grid are usually designated as primary switches, and the output switches as secondary switches. The basic requirement is that each primary switch have access via at least one link to each secondary switch group. The link spread between switch groups is almost invariably laid out in an orderly fashion for ease of control and administration. For example, in Figure 6-3 note how the 0 outputs of all primary switch groups connect to the 0 secondary switch group, the 1 outputs connect to the 1 secondary switch group, and so forth. In allocating secondary terminations of links, the output terminal number on the primary switch designates the secondary switch number, and the primary switch number designates the secondary switch terminal. This is characteristic of primary-secondary grids.

With crossbar switches, a convenient size for the grid is ten switches high, both primary and secondary. There are usually ten or twenty link groups per switch, although in the latter case the links are usually considered as two groups of ten per switch. There are occasional situations in which the link spread is different from that described, but these are special cases.

When it is recognized that a two-stage grid wired as in Figure 6-3 is satisfactory for connecting any input to one of a group of outputs, it is not difficult to extend the grid to provide for connection to a particular output. It is only necessary to add a third stage, the links which will duplicate the link spread between the first two stages. This is shown symbolically in Figure 6-4 where each stage is assumed to be ten switch blocks high. Examination of this network will show that any network input can be connected to any network output over ten matching pairs of paths, usually called channels. To determine the set of ten paths which can be used, it is only necessary to know the input and output switch blocks involved. The identifying number of both links in a matching pair are the same when the numbers are assigned according to the position of the link on the switch blocks of the primary and tertiary stages.

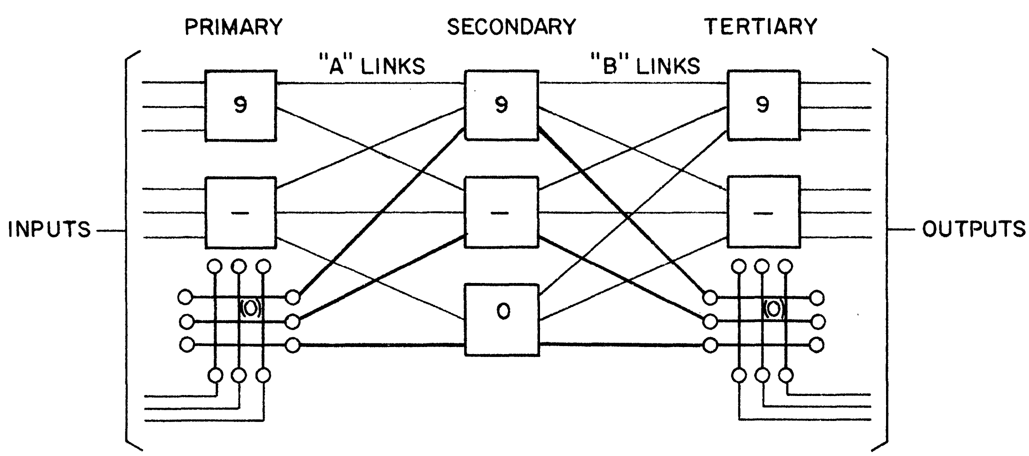


Figure 6-4 Three-Stage Switching Network

For a call between an input on primary switch block 0 and an output on tertiary switch block 0, the links which can form permissible channels are shown in heavy lines on Figure 6-4. If the input were on primary switch block 1 while the output remained unchanged, a new set of "A" links are required to match with the original set of "B" links. Since the links that make up the matching channels are available to more inputs and outputs than there are links, blocking on a particular call can occur. Since a channel can be made busy by either link in a matching pair, idle "A" and "B" links may, and frequently will, exist in the busy channel group. The hazard of blocking is reduced if the control means always assigns channels in a definite order instead of at random.

The three-stage grid is not generally suitable as an overall network because of the relatively limited number of paths it provides. However, it is useful for small switching systems. In the larger switching systems, the interconnecting paths are most frequently made up of a network of two stages of primary-secondary grids, which is, in effect, a four stage grid. A typical arrangement of these grids is shown in Figure 6-5. The fourth stage, which is actually the primary stage of the output grids, results from splitting the secondary switches on Figure 6-4. The interconnections between grids (called junctors) are not necessarily distributed in the same manner that links are within a grid. It is merely required that at least one junctor per secondary switch of each input grid connect to one primary switch of each output grid. The junctors are wired between switches of corresponding number on the opposing grids. This provides, as a minimum, one junctor to match with any pair of originating and terminating links. If the junctors are numbered in accordance with the number of the switch on which they originate or terminate, the result is a simple system of coordinating links and junctors into channels. For example, if in Figure 6-5 an input on input grid 0, primary switch 0 requires connection to an output on output grid 1 secondary switch 1, ten channels are available utilizing a particular "A" link group, a particular "B" link or junctor group, and a particular "C" link group. From input to output there exists matched A, B and C links designed to provide a pattern of fixed wired paths or channels. With this wiring scheme, previous calls equal in number to the size of the link or junctor group can block a call to an idle output, since the use of any single element in a channel makes the whole channel busy.

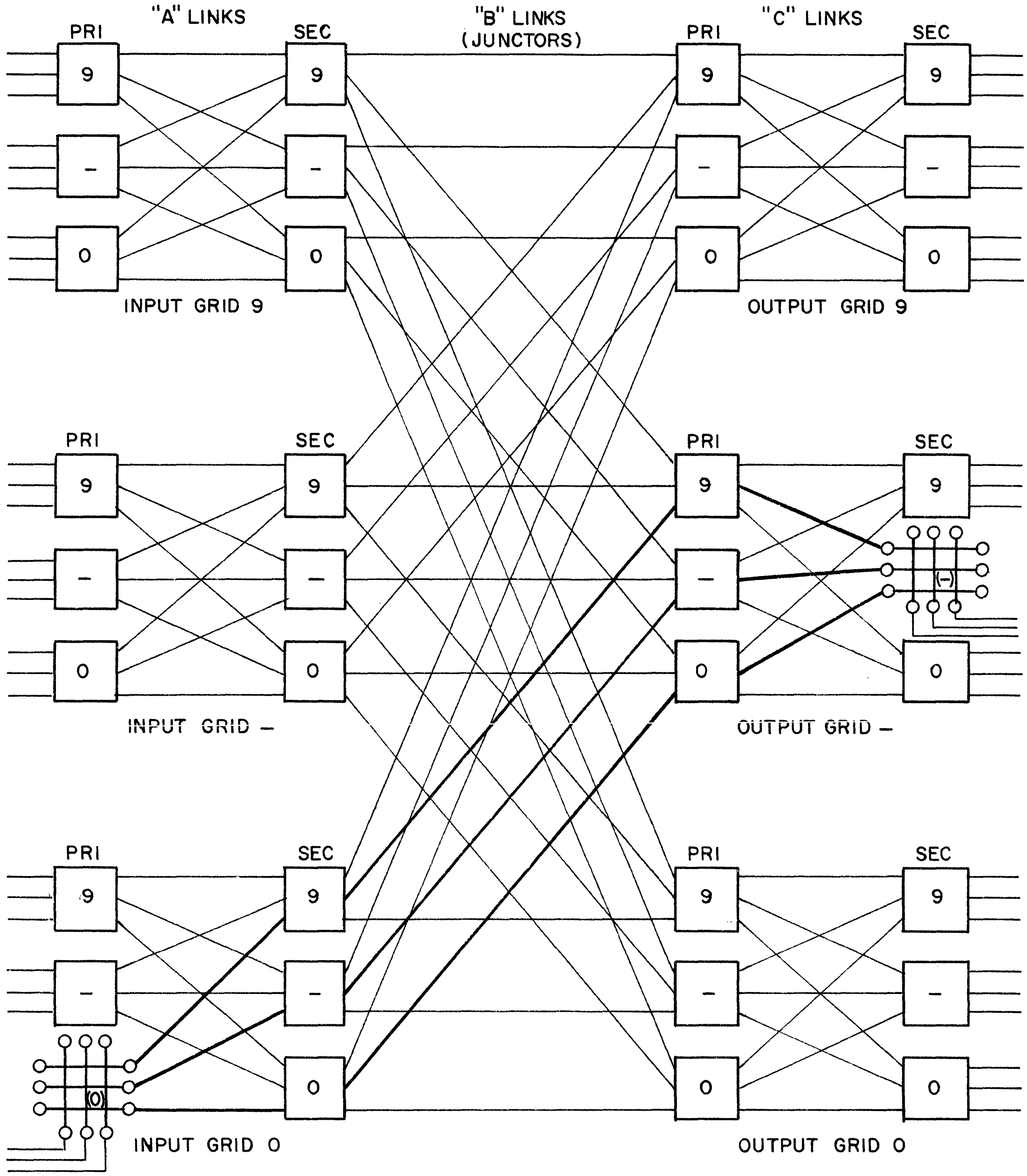


Figure 6-5 A Four-Stage Switching Network

6.4 NETWORK SWITCHING CONTROL

In applying the principle of the grid network to a telephone switching system we can see by inspection of Figure 6-5 that the selection of a path or channel through the grid, or switching network using crossbar switches, requires knowledge of both input and output assignments. The selection of a channel in a crossbar system is commonly called a marking function. Following this line of reasoning the marking function cannot be performed until the digit information of the telephone number has been received either in whole or part, depending upon the particular control arrangement used. It can also be reasoned that since the group of outgoing trunks to a particular destination is distributed over the secondary switches of the output group, some means is required for associating a code number and a number of widely distributed outgoing trunk locations. Besides this association there must be some means of testing these widely distributed locations and making logical decisions regarding availability and selection. It is not only possible but very probable that the digit information dialed by the subscriber is received at the central office before the marking function is completed. Therefore, in order to transmit the digit information to the next office some means of storing and regenerating digits is required.

Some of the major functions that must be accomplished by the control circuits of a marker system are:

a. Registration: Counting and storage of the digits dialed by the customer.

b. Translation: Conversion of code numbers into equipment locations such as office code into outgoing trunk locations, of the subscriber's number into his particular equipment location.

c. Testing and Selection: Making busy tests of possible outgoing trunks or paths through the switching network and then selecting one to be used on each call.

d. Outpulsing: Generation of pulses to match the stored digit information and of the proper type to be used by the next switching office.

e. Connection: Means of temporarily interconnecting various circuits for controlling circuit action or passage of information.

f. Various other logical decisions regarding items such as identification of calling subscribers, authorized or unauthorized calls, quantity of digits to be outpulsed, type of pulsing required and alternate action to be taken due to busy or trouble conditions.

The circuits for accomplishing the above functions are physically separated into common groups of frames or units. There is a great variation of operating time between the various functions as well as variations of circuit size for each function.

6.5 GENERALIZATION OF THE MARKER SYSTEM

Figure 6-6 shows a schematic representation of an interconnecting network and its associated common control or marker. For the moment, the central office network will be considered as being split into separate originating and terminating halves, and the network of Figure 6-6 may represent either half. If it is the originating half, the inputs are subscriber lines and the outputs are trunk groups. If it is the terminating half, the inputs are incoming trunks and the outputs are subscriber lines. If a tandem[1] operation is considered, Figure 6-6 may represent the entire office and both inputs and outputs are trunks. In any case, associated with the inputs are registers which receive the call information and which have access to the marker. Access from the inputs to the register can be achieved in a variety of ways, either through separate connectors or through the main interconnecting network.

On an originating call, the register must receive information from the subscriber before it can utilize the services of the marker. In the general case the office code is sufficient to identify the required outgoing trunk group, and as soon as it has been received, the register can request the marker to set up the connection between the subscriber's line and an outgoing trunk. When access is established between the register and marker, the register transfers the office code together with information of the location of the calling input, to the marker. Since this latter information

[1] Tandem Central Offices are used primarily as intermediate switching points between other central offices.

is used for control purposes, the register establishes means of determining the calling input location for use by the marker.

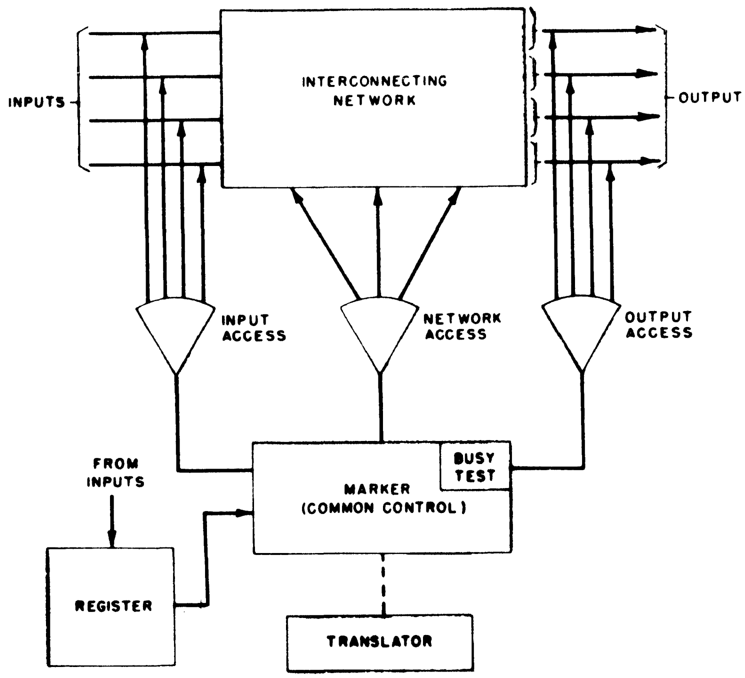


Figure 6-6 Generalization of Marker System

It is highly desirable not to have a fixed relationship between office code and trunk location on the switches. Furthermore, the nature of grid networks almost necessarily precludes such a relationship. Therefore, when the marker receives the office code from the register, it determines by <u>translation</u> how to gain access to the trunk group, plus any other pertinent information such as the type of trunk, pulsing required, customer charges, etc. Since it is neither practical nor desirable to establish a method of automatically hunting over adjacent terminals by the crossbar switches themselves, the individual trunks of a group can be dispersed over the whole network with considerable freedom. This, however, requires that the trunk busy test function be concentrated in the marker and that access be provided from the marker to the test leads of the trunk group. Successive individual tests of the trunks take too much time, consequently, the test leads are grouped for simultaneous testing.

There are several ways in which the marker can determine the location of a particular trunk. On Figure 6-6, a generalized access to the output groups is shown. This access may include control paths in addition to the testing paths. At the same time that the marker is locating and connecting to the output terminal of the network, it connects to the particular input terminal being served, through the input access paths.

As a result of these two actions the marker has control of the terminal points that must be connected together. The marker examines the individual network links which match to form a channel and connects together an idle set. It is desirable to examine all links simultaneously, rather than on a progressive basis, in order to save time. Within the marker, the link testing paths, are grouped to associate the "A", "B" and "C" links into matching sets so that the channel matching circuit of the marker can determine in which channels all links are idle. One is selected and the channel control circuit transmits the control signals over the access paths to establish the connection.

On Figure 6-6 only one marker is shown. This is obviously the most efficient means of control, concentrating as it does all test and control features into a single equipment unit. With relay type control circuits, the traffic volume of an average office requires the use of several markers.

As soon as more than one marker is introduced into a system, the problems multiply rapidly. Since it must be possible to place a call from any input switch to any output switch, access must be provided from each marker to every grid in the network. Each access path consists of a large number of leads which are necessary to test and establish paths on a single switch, although only a small fraction are utilized on a particular call. A simplified block schematic indicating how the access problem grows with several grids and markers is shown in Figure 6-7. When so many leads are involved, the only practicable method of handling access is to use multicontact relay connectors. The connectors can be designed so that control signals cause selection of the individual groups of frame leads applicable to a particular call. A limited number of leads then pass from markers to the connectors on the grids and the fanning out of the leads takes place within the grid frame. Furthermore, much of the connector equipment can be used in common by all control circuits.

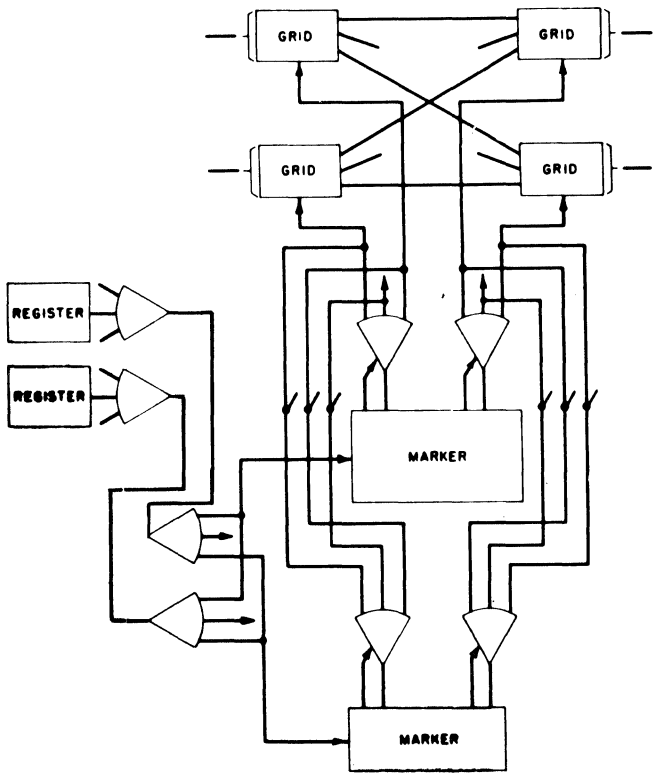


Figure 6-7 Several Markers Applied to a Network of Grids

It is inherent in most common control systems that only one control unit can work into an individual frame at a time. Otherwise there is mutual interference that may permit double connections or mutilated calls. This requires an elaborate system of lockouts in the connectors to provide exclusive access. A result of this is that the markers may block each other in the handling of calls and are subject to delays while waiting for frames to become idle. This, of course, reduces the efficiency of use of the control units. In designing systems care must be taken that such blocking cannot cause complete exclusion between control circuits. For example, if two markers simultaneously require access to the same input and output frames and each is able to seize one of the two frames, an impasse exists. This difficulty can be obviated by designing the circuits so that the grid frames must be seized in a definite order (output before input, for example). Preference assignments for each frame will also help to eliminate attempts of double seizure.

These considerations, in addition to the fact that marker units are very complex and expensive, make clear the necessity of keeping the holding time per call very low. A small holding time reduces the required number of markers, with their associated access, and increases their efficiency of use. Marker holding time is to a large extent dependent upon the actuating time of the switches making up the interconnecting network. For this reason common control of the type discussed here is only economical when a high-speed switch mechanism is available. The necessity for speed has also imposed the use of fast-acting circuit elements in the control circuits themselves. The present result of this is that common control circuits are almost invariably all-relay devices with some utilization of electron tubes. This has a definite effect upon the complexity of control circuits since many circuit functions that are performed very simply, although slowly, by a multiterminal switch require intricate arrangements of many relays for equivalent action.

An important aspect of marker systems is that the control circuits themselves must incorporate intricate checking features to insure that they are functioning properly. When a trouble condition, serious enough to block a call is encountered by a marker, additional efforts must be made to take care of the call or it will be left hanging in the air, so to speak. Such efforts are, however, facilitated by the nature of common control which is capable of making subsequent attempts to complete a call via second trial features. In theory it is possible to make an unlimited number of additional trials to complete a call. However, each trial requires extra marker usage which reduces the availability of markers to other calls. In practice, therefore, additional trials may be restricted to two.

After the marker has picked a trunk or a called line, it may discover a channel busy condition. If there are alternate channels available, they will be tested as a second attempt. On originating calls to outgoing trunk groups, the next recourse is to choose a new trunk in the same group which will usually make available a new set of channels. When a marker encounters an all-trunks or all-channels busy condition, it also must take some alternative action. Common control is ideally suited for utilizing alternate routes, since it tests trunks early in the control-circuit cycle before paths are set up. Hence, such systems permit optimum use of direct and tandem trunking facilities. When the control unit determines that all trunks in a particular direct group are busy, it can, with very little additional holding time, request the translator for directions to an alternate (tandem) trunk group. The control circuit then handles the call in the same fashion as though it were the original attempt. If there are additional tandem routes available, the alternate routine process can be continued as far as necessary. If all usable trunk groups are busy, the final route, in effect, is to a tone source or recorded announcement which can return a trunks busy or overflow signal to the subscriber. On terminating calls to a subscriber line, if the line is busy, a line busy signal is transmitted back to the originator.

The marker translators must provide full flexibility in furnishing information appropriate to each office code. At the present time the equipment usually consists of relay circuits plus changeable cross-connection fields on which the information for each code can be wired. Changes are relatively simple to make and the number of translator units is small. Some toll switching systems use punched cards which interrupt light beams in various patterns to provide translation information and some use electronic translators which utilize stored program control.

The information furnished by the office code translator includes the location of the trunk group for immediate use in establishing the originating connection, alternate routing directions, the type of pulsing and the number of digits to be pulsed to the terminating office. The necessary signaling information must be transferred to an outpulsing circuit. The latter circuit can be incorporated in the originating register or provided as a separate unit.

The outpulsing function is, of course, always necessary for communication with other offices and, in some systems, with the terminating end of the same office. The outpulsing function may be furnished as part of the register unit or may be furnished as separate units. If the register calls in a marker after the office code has been received, but before the rest of the called number is received, the register and outpulsing functions may be combined as shown in Figure 6-8A. This arrangement allows the outpulsing to start before registration of all digits is completed. If the register does not call in the marker until all digits are received, then separate register and outpulsing units are required as shown in Figure 6-8B.

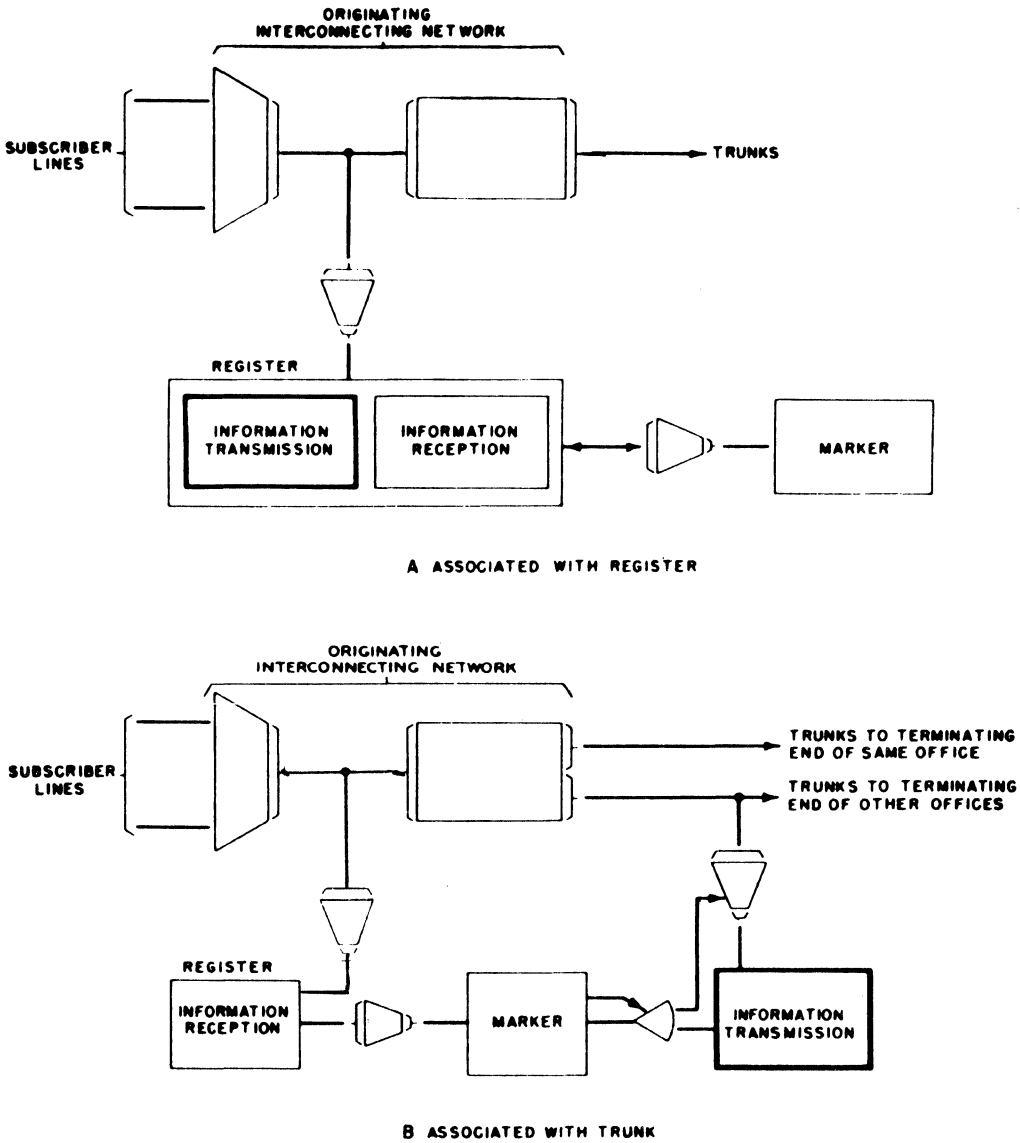


Figure 6-8 Location of Outpulsing Functions in Marker Systems

6.6 DIRECTORY NUMBER TO LINE NUMBER TRANSLATION

With grid type networks, line number to switch location translation, similar to office code translation, is almost invariably necessary. This comes about, not only because it is difficult to set up a logical relationship between line directory number and switch location with grid networks, but because the inherent advantages of flexibility. Therefore, line translators must be provided which enable the control circuit to determine the line location from the directory number. This implies that the overall control of terminating calls is similar to that for originating calls. The principle difference derives from the translation technique.

The considerations applying to line number translation are quite different from those obtaining for office code translation. The difference is primarily a matter of magnitude since line numbers in one central office may run up to 10,000 while office codes are well under 1,000. The resulting size and cost of the line translator is such, with present techniques, that it is uneconomical to provide one per marker. The alternative is to furnish common translators with access from all markers. Advantage can be taken of the probability that simultaneous calls will be to lines well distributed throughout the line number series. This permits breaking up one large translator into several parts, each containing the information pertinent to a grouped fraction of the lines. Each marker must have access to all subdivisions of the translator; the access must be exclusive to prevent mutual interference. This is the plan followed in present-day marker systems where the translator is known as the number group.

A sketch of this translation arrangement is shown in Figure 6-9. For convenience, each translator subdivision is shown as comprising 1,000 lines, although this number may vary from system to system depending upon traffic considerations and the particular translation method employed. It is also necessary to employ with the marker some form of pretranslation to determine the particular translator subdivision to use.

In addition to called line location and Private Branch Exchange hunting directions, the translator must also furnish information on the type of ringing required. This is later used to set up the trunk circuits to send out the correct ringing signals to the called subscriber.

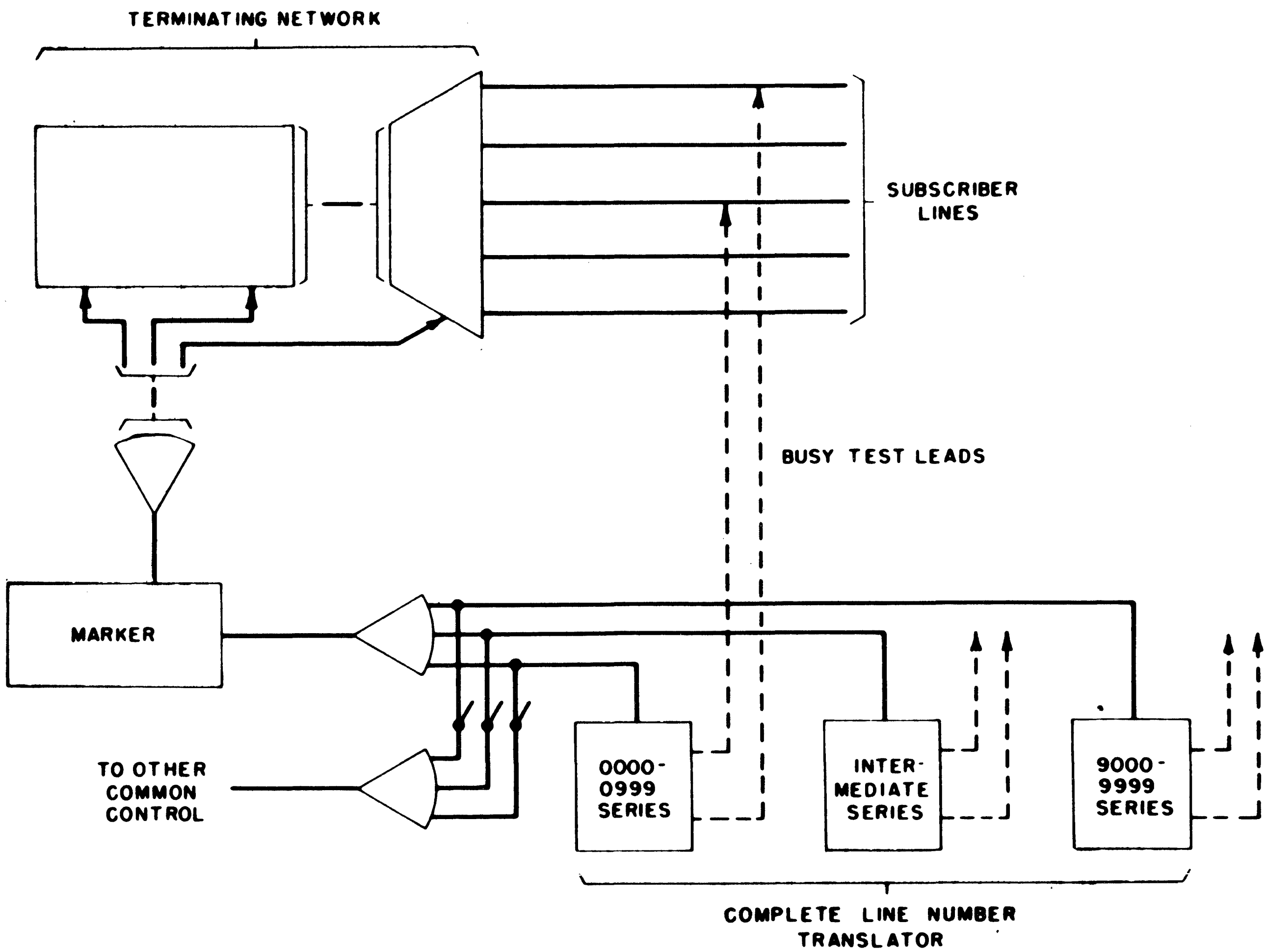


Figure 6-9 Number Translator in Marker Systems

6.7 PULSING LANGUAGES

Crossbar systems are designed to interpret the various types of pulsing used in other systems. Senders, for example, receive digits in the language of the calling central office and outpulse digits in a different language as required by the receiving central office. Some of the major pulsing techniques are Touch-Tone, Dial Pulsing (DP), Multifrequency (MF), Revertive Pulsing (RP), Panel Call Indicator (PCI), DC Key Pulsing (DC-KP), and Frequency Shift Pulse (FSP).

A. Dial Pulsing (DP)

The dial pulse is an interrupted DC signal of 10 or 20 PPS. It is the pulsing method most familar to the average person since it is the method used for dialing on all present subscribers' lines. It is also used extensively by operators, as well subscribers, for dialing over trunks which terminate in a step-by-step system. Dial pulsing is accomplished by a dial which controls a normally closed contact directly in the line circuit. This contact remains closed as the dial is pulled around to the digit desired; but as the dial is released, the contact is opened and closed a number of times corresponding to the digit. When the digit 1 is dialed, the contact is opened and closed only once; when the digit zero is dialed, the contact is opened and closed ten times.

B. Multifrequency Pulsing (MF)

MF is an AC signal consisting of a combination of 2 out of 6 single frequency tones in the audible range. The frequencies are 700, 900, 1100, 1300, and 1500 CPS. These are coded as 0, 1, 2, 4 and 7. Thus,to transmit the digit 1, we send a "0" and "1" (the 700 and 900 signals).To transmit the digit 9 we send a "2" and a "7" (the 1100 and 1500 signals).

Up to the recent introduction of the new FSP signaling technique, MF was the only AC signaling method available. Due to the obvious transmission advantages of an AC signal, MF is used in all toll operator dialing and intertoll trunks that terminate in a No. 5 Crossbar, Crossbar, TDM, or ESS offices.

C. Touch Tone

Touch Tone is an AC signal similar to MF except that it uses 7 audible tones of uneven frequencies so that accidental triggering by the human voice on background noise is minimized. This precaution was necessary because the Touch Tone signal is originated by the subscriber in his Touch Tone set while MF is originated only by trained operators on intertoll trunks. The frequencies used in Touch Tone are 697, 770, 852, 941, 1209, 1336, and 1477 CPS.

D. Revertive Pulsing (RP)

The revertive pulse is a DC interrupted signal of 30 PPS. This pulsing technique is used only in the panel switching system.

The dial pulses from the subscriber's dial release and reoperate a line relay in the sender. This in turn operates a series of pulsing relays for each digit dialed. The information from these pulsing relays is recorded in the operation of one or more of a set of register relays for each digit.

When the incoming selector at the terminating end is seized, the elevator is started upward, and as it travels, it sends series of pulses back to the sender, which counts the pulses and stops the elevator when the proper position is reached. This is called revertive pulsing, because the pulses are transmitted back from the controlled end of the circuit to the controlling end.

E. Panel Call Indicator Pulsing (PCI)

PCI is a pulse train of 4 pulses per digit. The 4 pulses represent the 4 digits, "1", "2", "4" and "5" respectively. Thus, a positive value on the first pulse and nothing on the other 3 represents the number 1, a positive value on the second and fourth pulse represents the number 5. In actual practice the pulses are more complicated with light or heavy negative pulses indicating the presence or absence of a signal on some pulses, instead of the mere presence or absence of a positive pulse.

PCI is used on all calls routed through an electromechanical office and terminating in a manual office. The PCI signal activates a display panel in front of the manual switchboard operator and lights lamps corresponding to the dialed number. The operator then connects the incoming call to the indicated number with her cord. The method used to transmit these numbers was first developed for the panel system and is therefore called the panel call-indicator-PCI-system. The primary reason for developing a new system was to speed up the time required to transmit the number, since the operator must wait during the entire transmitting period for the display on the call indicator. Numbers are transmitted by PCI pulsing at a rate of approximately 3 digits per second, which is almost twice as fast as with revertive pulsing.

F. DC Key Pulsing (DC-KP)

DC-KP is a single DC pulse per digit sent over the Tip lead, Ring lead or both. (In some cases a 3 wire positive pulse only system is utilized and the pulses may be on either or all of the 3 wires.) The pulse has 4 possible forms; high positive, low positive, high negative and low negative. The form of the pulse and the lead it is on is used for coding the digits.

DC-KP is used on calls originating in a manual office and terminating in a PANEL or No. 1 Crossbar office. The pulse is generated by an operator's 10-button keyset. This keyset is used by the manual operator to complete calls originating in her own office to the dial network. The operator plugs in the calling subscriber into a OGT dial trunk jack and keys the desired number on her DC-KP set. Actually she could have done the same thing with a simple dial, however, the DC-KP is much faster. The speed advantage of the DC-KP signal over DP was the reason for its development.

G. Frequency Shift Pulse

Frequency Shift Pulse represents an innovation in signaling. An electromechanical unit temporarily stores the binary digits to be transmitted and places mark or space signals on two sets of six leads going to a binary encoder. Continuous transmission is achieved by placing one digit (6 bits) on one of two sets of 6 leads and at the same time placing the next digit condition on the other set of 6 leads. At the terminal end these modulated frequencies are converted to signals on the two sets of leads to operate relays representing digits. FSP employs electronic computer techniques to transmit 200 bits per second over narrow band transmission facilities. The transmission consists of a synchronizing bit called a key pulse start signal followed by 6 bits representing a digit. The bits are 5 milliseconds in duration. A mark or space condition is set for each bit position and each digit is given a code of two mark and four space bits. The bits are arbitrarily designated 0, 1, 2, 4, 7 and 10. The coding is similar to that for multifrequency where two frequencies represent the digit, except for 0 which uses 4 and 7. The 10 bit is used for the key pulse start and finish signal. Digits are transmitted by modulating 1170CPS ± 100CPS; 1070 CPS represents a mark and 1270 CPS represents a space.

CHAPTER 7

NO. 1 CROSSBAR AND CROSSBAR TANDEM SYSTEMS

7.1 NO. 1 CROSSBAR SYSTEM

A. GENERAL

The No. 1 Crossbar System was developed in the mid-1930's to overcome some of the disadvantages of the Panel System. For instance, No. 1 Crossbar offered better transmission characteristics by using precious metal contacts in talking path connections; gave one appearance to each subscriber line on the frames for both originating and terminating traffic; and PBX hunting lines could be added without number changes. No. 1 Crossbar also made possible shorter call completing times and required less system maintenance.

Since it was expected that this system would be used largely in panel areas, revertive pulsing was employed for both incoming and outgoing traffic. The No. 1 Crossbar System is also a common control system; its originating and terminating equipment each has its own senders which function with the markers to complete subscribers' connections. A simplified view of the overall equipment arrangement is shown in Figure 7-1.

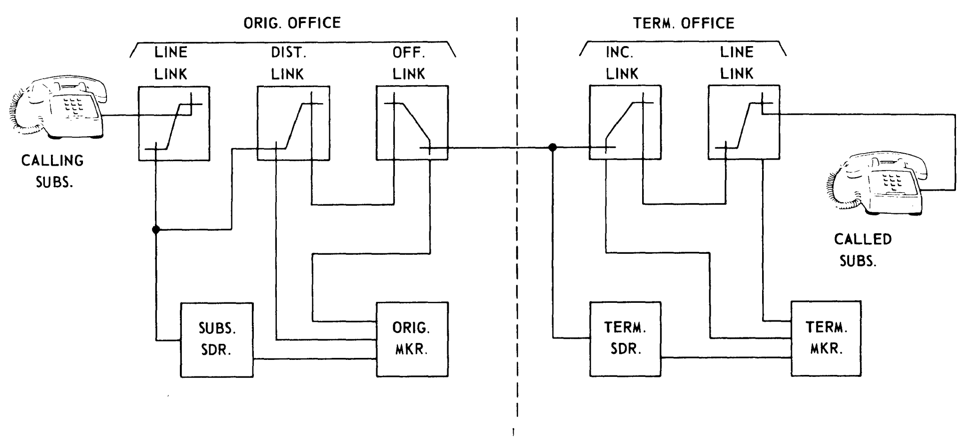


Figure 7-1 Simplified Block Diagram - No. 1 Crossbar System

From a traffic standpoint the major No. 1 Crossbar dial system frames may be divided into two general classes:

Originating Equipment	Terminating Equipment
Line Link Frame	Incoming Frame Group
District Frame Group	Incoming Trunk Frame
District Junctor Frame	Incoming Link Frame
District Link Frame	Incoming Link Extension Frame
Subscriber Sender Link	Terminating Sender link Frame
Office Link Frame	Terminating Sender Frame
Office Extension Frame	Terminating Marker Connector Frame
Subscriber Sender Frame	Terminating Marker Frame
Originating Marker Connector Frame	Number Group Connector Frame
Originating Marker Frame	Block Relay Frame
	Line Distributing Frame
	Line Choice Connector Frame
	Line Junctor Connector Frame
	Line Link Frame

Two distributing frames are also provided. The Main Distributing Frame (MDF) is used for cross-connecting the subscriber and trunk cable pairs to the crossbar frames. The Line Distributing Frame (LDF), provides a means of cross-connecting the line link frames to the terminating marker. This permits any directory number (vertical side LDF) to be assigned to any "line" circuit (Col. -Sw.-Vert. horizontal side LDF) as shown in Figure 7-2.

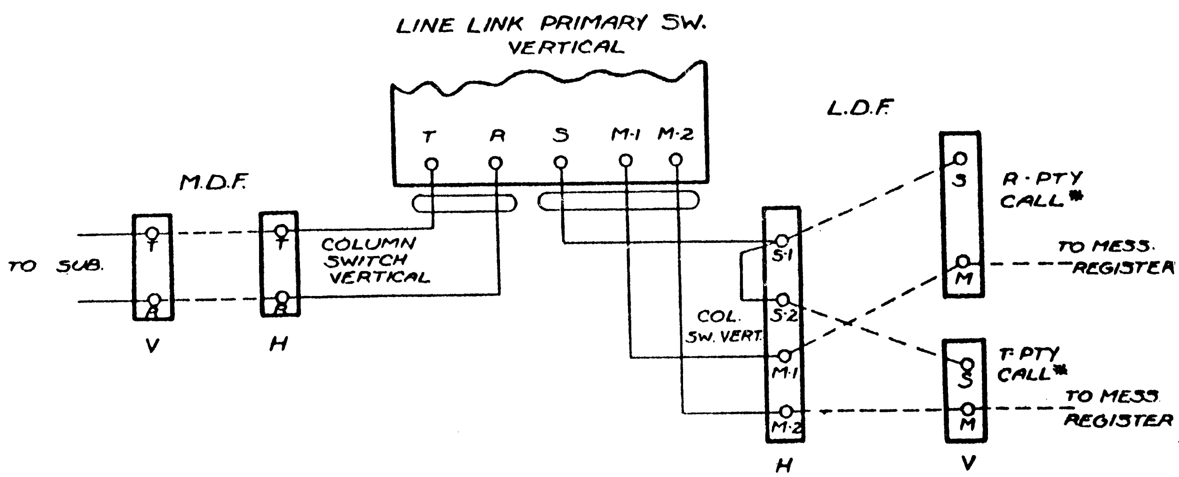


Figure 7-2 Distributing Frame Connections for No. 1 Crossbar Line Link Frames

The equipment required to complete a call and the path of a call through the No. 1 Crossbar System equipment frames is shown in Figure 7-3.

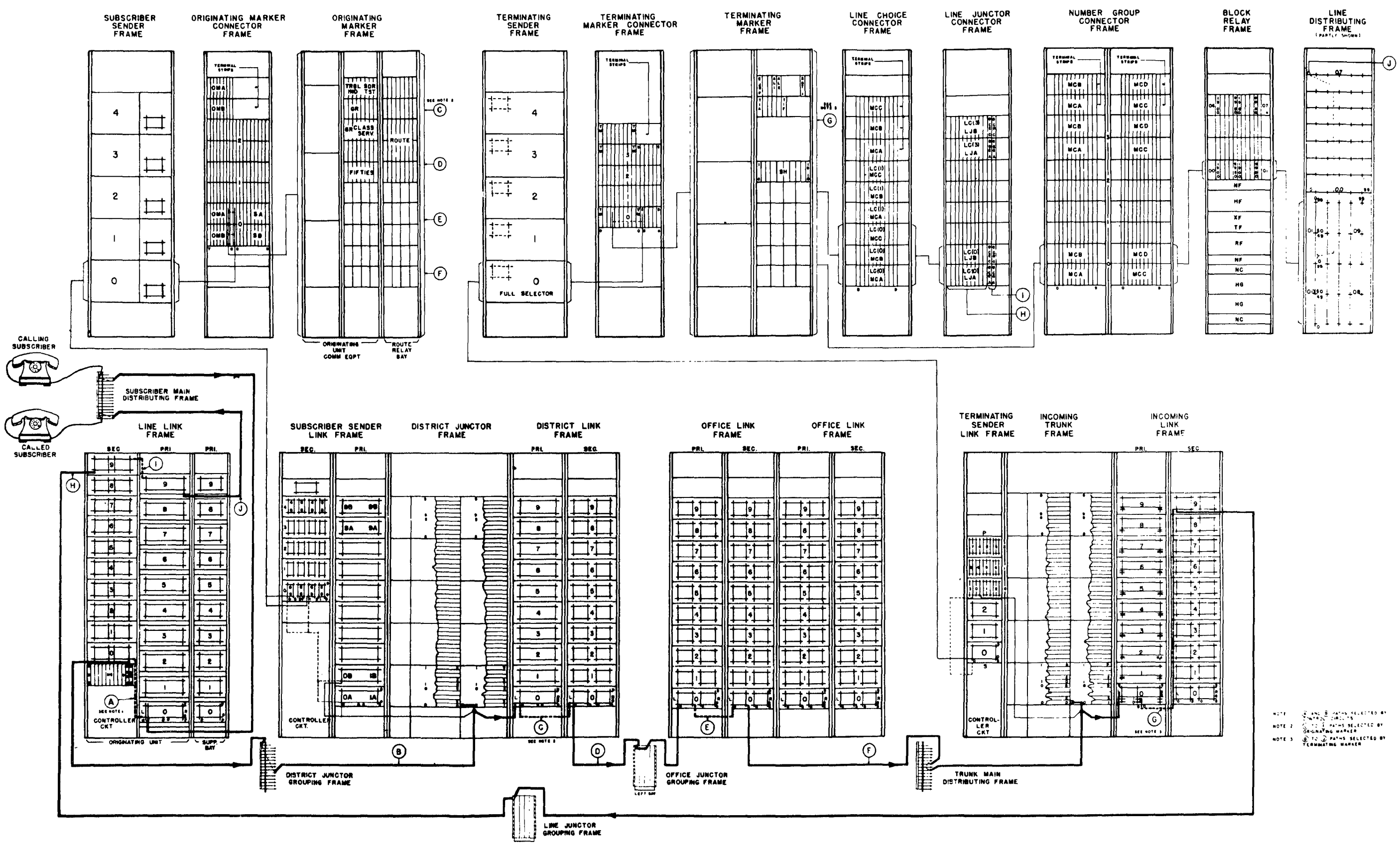


Figure 7-3 Major No. 1 Crossbar Frames

B. FRAME EQUIPMENT

1. Line Link

The line link frame is used for both originating and terminating calls. It connects the customers lines, which are assigned to verticals of the primary switches, with district junctors for outgoing calls and with line junctors for incoming calls. The assignment of lines to the line junctors for incoming calls. The assignment of lines to the line link frame is governed by load characteristics, calculated by the CCS per line for both in and out calls. CCS is an abbreviation for "Hundred Call-Second Per Hour" measurement of line load indicating the sum of the length of the time for each call on the line is one hour.

The crossbar customer's line is assigned to, and has exclusive use of a vertical of a primary crossbar switch. The primary switch has ten horizontal paths with which this vertical may connect. The ten paths handle all the traffic, both outward and inward for all the lines on a single switch. The first vertical on the first ten primary switches on each line link frame is used to obtain access to busy lines for test and verification purposes. These ten primary switches, plus the ten secondary switches are called the "basic unit." Since the traffic load for nineteen lines does not normally load the ten horizontal paths, or line links efficiently, additional switches for additional lines are added laterally to form what is known as a horizontal group shown in Figure 7-4.

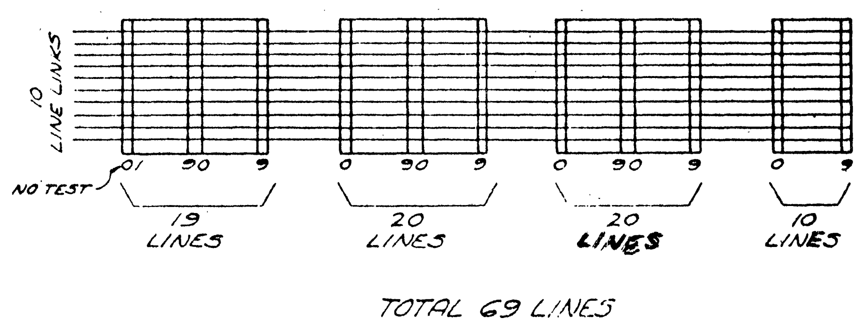


Figure 7-4 Maximum Horizontal Group

On service orders each line assignment will carry a location number for the line on the line link frame just as it does in the manual office (panel and jack), in the panel office (line group and terminal), and in the crossbar unit (column, switch, and vertical). For example, 0152 means column 01, switch 5 and vertical 2, illustrated in Figure 7-5.

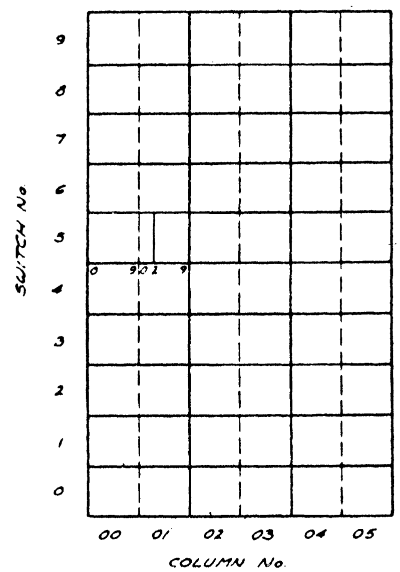


Figure 7-5 Service Order Number 0152.

Each line link frame has associated with it a "control circuit" whose function it is to recognize a calling line, choose an idle line link and assist in the selection of an idle district junctor and to operate the necessary selecting and holding magnets for connecting these paths together. On a terminating call it assists in setting up the call from the incoming trunk over a line junctor and line link to the called line.

Since a line link controller circuit may provide service to as many as 690 subscriber's lines, it is of the utmost importance that there is always a controller circuit available. As a service precaution, line link frames are arranged in pairs insofar as their controllers are concerned.

This arrangement is called a "home" and "mate" controller circuit operation. If a call is delayed in the "home" controller circuit, it will be transferred automatically to the "mate" controller circuit and handled on an "emergency" basis.

2. District Junctor

The district junctor frame is mounted in the center of the "District Frame Group," the subscriber sender link is on the left and the district link frame is on the right. The district junctor frame is used to mount the relay equipment which provides talking battery and supervision for the calling subscriber and controls the operation of the subscriber message register on calls dialed directly by the subscriber. Each frame will care for the 100 district junctors of the associated district link frame. The subscriber sender link frame provides access to office junctors. The district junctors are multipled to 2, 3, 4, 5, 6, or 7 line link frames as indicated by the traffic requirements. A diagram of connections to a district junctor is shown in Figure 7-6.

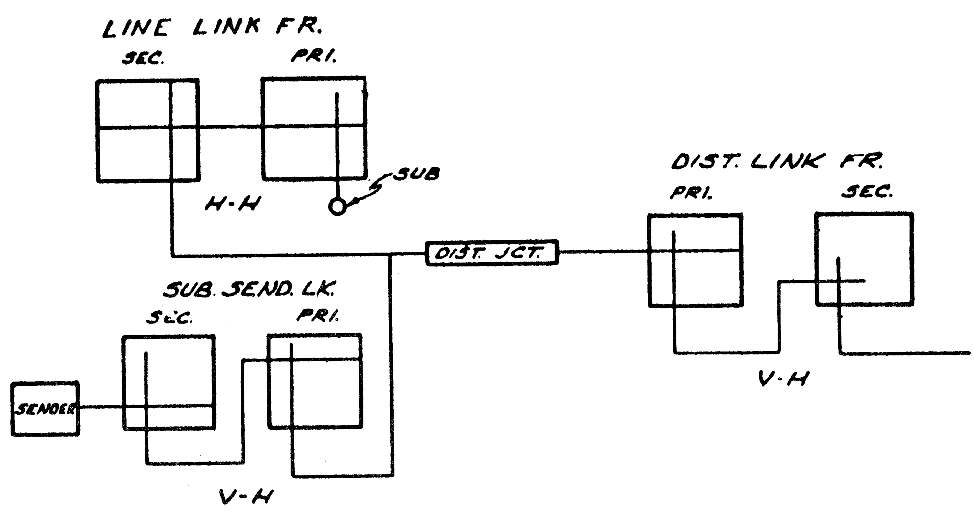


Figure 7-6 Connections Provided by a District Junctor.

The coin district junctors, in conjunction with a coin control circuit, collect or refund coins depending on whether or not the called party answers. Noncoin district junctor circuits can be arranged in conjunction with zone registration equipment to make additional charges for calls outside of the local charge zone or area.

3. District Link Frame

The district link frame also uses the primary - secondary arrangement of crossbar switches, each frame being equipped with ten 200 point primary switches and ten 200 point secondary switches.

The district junctors, which originate at the line link frames, terminate on the horizontals of the district link primary switches, ten junctors per switch. Further, the horizontals of the primary switches are continuous across each switch. Those on the secondary switches are cut (split) between the 10th and 11th verticals.

In addition to the primary and secondary switches, the district link frame is equipped with multicontact relays. The relays, located at the top of the district frame, are used by the originating marker to gain access to the links and junctors of the district link frames.

4. Subscriber Sender Link Frame

The subscriber senders are selected for each call by the subscriber sender link frame. This frame consists of primary and secondary switches whose function it is to connect an idle subscriber sender to the particular district junctor which has been selected for a given call. Since this frame must function before the subscriber begins to dial, and before the originating marker is connected, it is provided with a control circuit. The control circuit assists the line link control circuit in selecting the district junctor to be used on each outgoing call. It also determines which senders are available for use for each particular call.

An emergency control circuit is provided for use with any subscriber sender link frame. It can be connected to any one of the subscriber sender link frames by means of manually operated switches located directly above each regular controller cabinet.

Each subscriber sender link frame can handle a maximum of 100 district junctors and 10 sub-groups (10 senders each) or 100 originating senders.

5. Office Link Frame

Each office frame consists of a unit or bay of ten primary switches and ten secondary switches. All the switches are of the 200 point type.

Two hundred office junctors, originating on the secondary switch verticals of the district link frames, terminate on the vertical units of the office link frame primary switches. The two hundred links (left and right) originate on the office link frame primary switch horizontals and terminate on the secondary switch vertical units.

This arrangement makes it possible for any district junctor to obtain connection to as many as 4000 trunk locations (20 office frames with extensions times 200 trunks).

The outgoing trunks, which appear on the horizontals of the office link frame secondary switches are cabled to the main distributing frame. Here they can be cross-connected by jumpers to a local or underground trunk cable, to reach the various exchange areas.

Office frames are always used in pairs, and it is required that trunks to a given exchange be assigned to a pair of office link frames. This insures, that if a trouble condition occurs on one of the frames of the pair, a call to a given central office will be completed over a trunk available on the second office link frame.

6. Office Extension Frames

When the number of office frames exceeds ten and it is desirable to operate more than 200 trunks per pair of frames, extension frames must be provided. Extension frames consist of an additional group or bay of ten 200 point switches which are installed adjacent to the regular secondary switches of each office frame. The office link circuits are multipled giving each trunk location access to all the links.

7. Subscriber Sender

Each subscriber sender frame mounts five senders. The ten senders of two adjacent frames normally make up a subscriber sender group.

The subscriber senders of the crossbar system are similar to and perform much the same functions as those of the panel system, except that they do not control the setting up of the paths between the calling line and the outgoing trunk. On calls to panel and crossbar offices control of the incoming and final selections in the distant office will be on a revertive pulsing basis. In the case of a crossbar distant office, selections will require the use of full selector terminating senders. In panel distant offices the control remains with the originating sender for the entire operation. Calls to manual offices are handled on a call indicator or call announcer basis in the same manner as formerly handled by panel subscriber senders.

8. Originating Marker Connector

Each originating marker connector frame will accommodate three connectors which connect subscriber and keypulsing senders to origination markers.

Each connector circuit will serve a maximum of ten subscriber senders, or a maximum of eight subscriber and keypulsing senders combined. These may be connected to a minimum of two or a maximum of eight markers.

9. Originating Marker

The originating marker circuit receives information from the originating sender which it decodes and then returns information to the sender for controlling selections at the terminating end. The marker also selects a trunk to the desired office and establishes a path from the district junctor to the selected trunk as well as transmitting talking selection, charge or noncharge, and party information to the district junctor.

The originating markers are arranged for a maximum of 24 subscriber classes and one operator class of service per marker group. A maximum of eight markers per group may be provided. A group of markers may be associated with a maximum of 20 district frames.

The number of markers required for traffic is based on the originating office busy hour calls plus the keypulsing calls.

A few features and limitations of the originating markers follows:

a. The marker has a capacity for 802 possible codes including zero and permanent signal.

b. The maximum capacity of the originating marker when trunk groups are subdivided is as follows:

   30 trunk groups with 2 first choice subgroups - 1 route relay.

   3 trunk groups with 3 first choice subgroups - 2 route relays with common subgroups.

   3 trunk groups with 4 first choice subgroups - 2 route relays with common subgroups.

   3 trunk groups with 2, 3, 4, 6 or 12 first choice subgroups - 2 route relays.

   All trunk groups may or may not have a common subgroup in addition to above.

c. Each marker is equipped with a route relay bay arranged for 100 route relays (50 multi-contact relays). Supplementary bays may be added each of which will care for 100 additional route relays.

10. Incoming Frame Group

The first frames encountered in handling incoming calls are known as the incoming frame group. Similar to the district frame group, they employ three frames: a terminating sender link frame which is always installed to the left of an incoming trunk frame, and an incoming link frame which is mounted to the right of the incoming trunk frames.

11. Incoming Trunk Frame

The incoming trunk frame provides a location for the relay equipment associated with the incoming trunk circuit. Its functions are to ring the called party's bell, to recognize removal of receiver from switchhook by the called party, to furnish talking battery, and to maintain called party supervision during conversation. In addition, it returns overflow or line busy indications to the calling subscriber in case the call cannot be completed.

Each incoming trunk frame can handle 100 trunks, (5 groups of 20) of the full selector type. Larger size trunks (more relays per circuit) will occupy more space on the frame so these extra circuits are placed on the supplementary frame.

12. Incoming Link

The incoming link frame differs from the district link frame in that it is provided with a different type of primary switch equipped to connect 16 trunks instead of the usual 10.

As ten primary switches are provided, each incoming link frame can therefore connect to 160 incoming trunks. Since each incoming trunk frame can mount a maximum of only 100 trunks, the extra 60 trunks are located on an additional incoming trunk frame. This frame is known as an auxiliary incoming trunk frame, and mounts a maximum of 100 incoming trunk circuits, which will connect through the primary switches of several incoming link frames.

Each primary switch has twenty, ten left and ten right links, going to the secondary switches in a vertical to horizontal spread arrangement.

Multicontact relays located above the switches on the incoming link frame assist the terminating marker in the selection of the crosspoints on the primary and secondary switches of the incoming link frame.

13. Terminating Sender Link

The terminating sender link frame connects an idle terminating sender, of the proper type to an incoming trunk for the handling of an incoming call.

The terminating sender link frame is arranged to mount three 100 point 6 wire primary and three 100 point 6-wire secondary crossbar switches together with the associated control equipment.

The control circuits of a pair of link frames are arranged to work on a mate frame basis to care for emergencies.

14. Terminating Sender

The terminating sender receives information from the originating subscriber sender, from keypulse sender or from dialing trunks. This information is converted by the sender into the called number and passed to the terminating marker.

The terminating sender frame is arranged to mount five senders. The top three positions (2, 3 and 4) will mount full selector senders only while the bottom two positions (0 and 1) will mount either full selector or "B" senders.

15. Terminating Marker Connector

The terminating marker connector selects an idle terminating marker and connects the sender to the marker.

Each connector frame will care for four marker connector circuits, associated control and alarm relay equipment common to these circuits, together with a location at the top of the frame for a maximum of two "B" position finder units, required when the office unit is served by a local "B" switchboard.

One connector circuit will consist of from 7 to 15 multicontact relays. The number varies with the number of terminating markers and the number of senders associated with connector.

16. Terminating Marker

The terminating marker frame is used to register the called number it receives from the terminating sender and from the translation of that number, locate and test the called line, and control the selection and closure of a path from the incoming trunk through the incoming link and line frames to the called line.

The number of terminating markers provided in an office will vary from two to ten, depending on the total number of terminating busy hour calls the markers will be required to handle.

When a marker is seized by a sender, it must determine, from the number that has been dialed, the correct number group connector to operate, and also the correct 100 block and 20 block relays to operate in the number group. This process is known as decoding, because the decimal directory number received, must be translated in terms designating a number group, a 500 group relay, a 100 block relay, and a 20 block relay. The marker can be arranged to test twenty lines at one time.

17. Number Group Connector Circuit

The 10,000 numbers in a given office are divided into "number groups." A number group consists of a series of numbers into which all the terminating markers have access, but only one at a time. The size of a number group depends upon the amount of terminating traffic delivered to the numbers. Number groups will never be smaller than 100 numbers and are furnished in increments of 100 numbers up to a maximum of 2500 numbers.

The terminating marker obtains access to a particular number group through a number group connector circuit composed of equipment on a number group connector frame and block relay frame.

It is impractical to build a marker that is able to recognize ten thousand individual indications, and it is, therefore, arranged so that in conjunction with the number group connector and block relay frames it may locate and test the lines in blocks of twenty numbers each, selecting a block of twenty and ultimately the particular one of that block of twenty corresponding to the called number.

The possible 10,000 subscriber numbers of the office are arranged in blocks of twenty, and a 20 block relay (TB) is provided for each subgroup. There may be as many as 500 of these 20 block relays in an office, and, to simplify the selection of the desired one they are grouped into sets of five and operated through a 100 block relay (HB) also located on the block relay frame. Several of the 100 block relays are formed into a "number group" and by means of a number group connector can be temporarily connected to any one of the terminating markers.

18. Block Relays

The block relay frame, besides mounting the hundred and twenty block relays associated with 800 lines, is equipped with cross-connecting fields for passing additional line information to the marker.

One field, the "NF," is used to cross-connect the subscribers number to the line choice using one of the following punchings: (a) RF punching if the line is ring party, individual line, or the last line of a PBX hunting group (b) TF punchings if the line is a tip party of a party line; (C) HF punching if it is the first or an intermediate line of a PBX group; (d) JF punching to indicate "jump hunting;' (e) ANF punching for line overflow registrations.

The other cross-connecting field (NC) associated with each number is used for (a) quarter choice location and (b) horizontal group location for the called number.

Another cross-connection which is not associated with the block relay frame is required to give the marker complete information regarding the subscriber line. This is the NS lead which is run on the LDF. It cross-connects the subscriber's number to the column - Switch - Vertical.

19. Direct Distance Dial Service

In addition to certain modifications required in existing subscriber senders and originating markers, two new equipment elements are required for providing DDD facilities in No. 1 Crossbar offices. These are the auxiliary sender and the auxiliary sender link.

20. Auxiliary Sender

The auxiliary sender is a wire-spring relay unit and performs the following basic functions:

(a) Registers two dialed digits, thus supplementing the 8-digit capacity of the subscriber sender to enable the customer to dial 10-digit foreign area calls.

(b) Makes trunk test toward the distant office when dialing is completed, and when the remote incoming sender is attached, gives the subscriber sender an indication that it is ready to receive the digits registered in the subscriber sender.

(c) Receives the digit stored in the subscriber sender on a PCI basis in the order dialed and outpulses each digit, after it is received, on an MF basis to the distant office.

(d) Notifies the subscriber sender when outpulsing is completed so that both senders may release.

21. Auxiliary Sender Link

The auxiliary sender link provides the connecting path between any one of a maximum of 100 subscriber senders and their associated auxiliary senders. This frame may be partially equipped in individual units, each with capacity for ten subscriber senders and, when fully equipped, consists of ten auxiliary sender link units. An auxiliary sender link unit is made up of of 200-point, 6-wire crossbar switch with associated relays.

22. Subscriber Senders

Certain modifications have been made to existing subscriber senders in order to function properly with the auxiliary sender and auxiliary sender link.

Relays have been added to these senders to enable them to perform the following functions:

(a) Recognize calls which require an auxiliary sender either through the "0" or "1" in the second digit of the foreign numbering plan area code for 10-digit calls or on instructions from the originating marker for 7- or 8-digit calls.

(b) Passes on to the auxiliary sender, on instructions from the originating marker, the number of digits to be deleted, if any.

(c) Routes to overflow any 10-digit call for which an auxiliary sender is not connected in time to register the first pulse of the ninth digit.

(d) PCI pulse its eight digits in the order dialed into the auxiliary sender instead of sending the stations digit ahead of the thousands, as is presently done when eight digits are outpulsed PCI.

23. Originating Markers

The originating markers have been modified to inform the subscriber sender when an auxiliary sender is required on 7-digit calls. Also, the markers will pass to the auxiliary sender via the subscriber sender, the number of digits to be deleted.

SWITCHING A CALL THROUGH THE NO. 1 CROSSBAR SYSTEM

When a subscriber lifts the receiver, a line relay, associated with the line link frame primary switch vertical to which the line is connected, operates. The operation of the line relay notifies the line link controller that a call is being originated. The controller identifies the calling line by determining the horizontal group, vertical column, and vertical file in which the line is located. The progress of the call can be readily traced by following the heavy connecting lines shown in Figure 7-7.

The Line Link controller also connects itself to one of several sender link controllers with which the line link frame is associated. The two controllers function together to select an idle district junctor. The selection is made from one of the groups of ten district junctors which has an idle line link back to the calling line and an idle sender link to a sender sub-group which has an idle sender. District junctor groups having at least two idle junctors are preferred.

Coincident with the selection of a district junctor, the sender link controller is selecting an idle sender. This selection is made from subgroups having an idle sender link to the selected district junctors. Preference is given to those subgroups having two or more idle senders.

Following these selections, crosspoints are closed on the line link frame primary and secondary switches connecting the customer's line to a district junctor, and at the same time crosspoints are closed on the sender link primary and secondary switches to connect the district junctor to a sender. Over these paths the tip and ring of the customer's line are now connected to a subscriber's sender. The sender sends out dial tone, indicating that it is ready to receive dial pulses. Approximately 0.6 second is required to complete this connection.

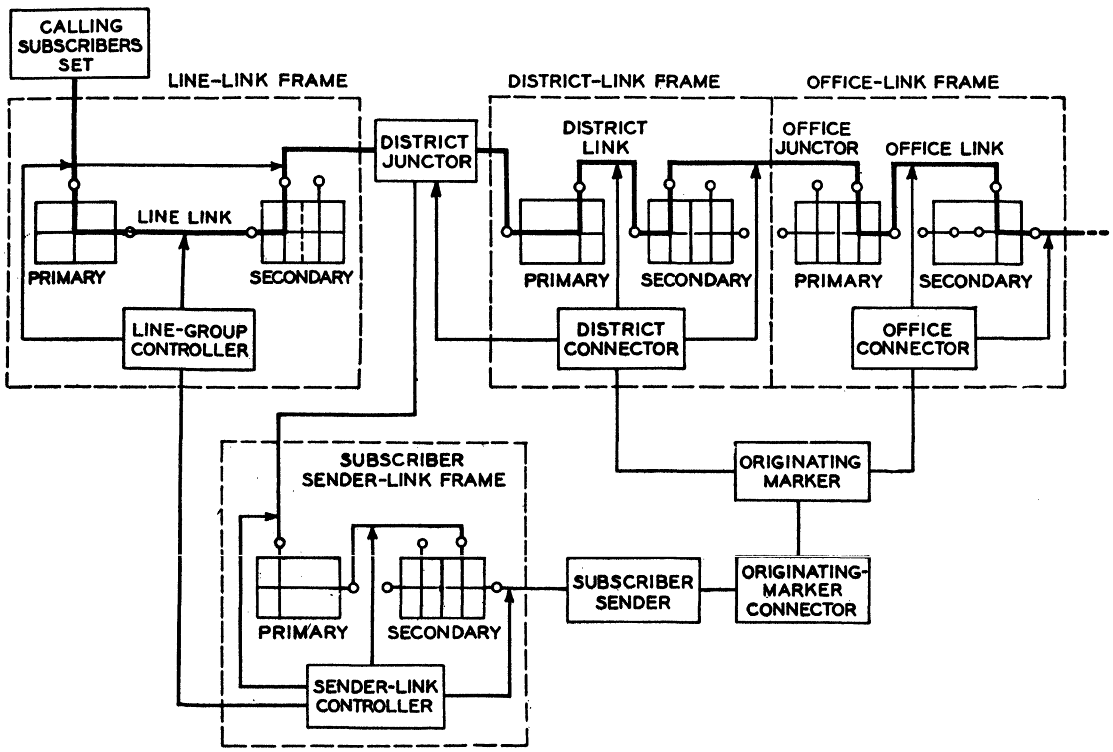


Figure 7-7 Originating Call in a No. 1 Crossbar Office

The sender also registers the number of the link frame involved, receiving this information from the sender controller.

The subscriber now dials the office code and directory number of the called subscriber. The sender counts the dial pulses and registers all digits dialed on the register switch.

As soon as the office code is registered, the sender signals the originating marker connector which connects the sender to an idle originating marker cutting through a large number of leads over which the sender and marker exchange information.

The marker receives from the sender the district frame number and the office code dialed. It decodes this information and sends back to the sender the information it needs to complete its part in handling the call.

From the route relay assigned to the office code the marker determines the pair of office frames on which the trunks to the desired office are located. The route relay also provides information as to the trunk level and the start and stop test points within that level. Through connector relays at the office frame, the marker gains access to the specified trunk locations, tests and selects an idle trunk.

The marker gains access to the office links that serve the selected trunk through connector relays at the office link frame. It also obtains access to the district link that serves the district junctor and office junctors leading to the office frame on which the selected trunk is located. Access to both the office links and office junctors is obtained through the district frame connector relays. From this combination of links and junctors the marker selects an idle district link which has access to an idle office junctor which in turn has access to an idle office link which appears before the selected trunk.

The marker now operates the select and hold magnets on the district and office link frames necessary to complete this channel from the district junctor to the selected trunk. This also provides a path from the subscriber sender to the trunk since the sender was cut through to the district junctor. The marker now has completed its functions and releases. The marker completes its function in approximately 0.5 second.

This outgoing trunk is connected to an incoming trunk in the terminating office shown in Figure 7-8.

The incoming trunk when signaled by the subscriber sender, will cause the terminating sender link controller to select an idle terminating sender and to connect it to the incoming trunk.

The two senders are now connected. The called number is transferred from the subscriber sender to the terminating sender where it is recorded on a register switch. With this information transferred the originating sender has completed its functions and releases.

The terminating sender now signals the terminating marker connector which connects an idle terminating marker to the sender cutting through the leads over which information is passed. The marker receives the called number and the incoming frame number from the sender.

The terminating marker translates this number as being in a block of 100 numbers and finally as being in one of five blocks of twenty lines in the selected block of 100 numbers. By means of cross-connections, the marker will then operate its number group connector relays in the proper number group, the proper hundreds block relay and through it the twenty block relay associated with twenty consecutively numbered lines, one of which is the called number.

The twenty block relay operates and cuts through to the marker a number of control leads which give the necessary information regarding the line and its location. The marker then tests the called line to determine whether it is busy or idle. If busy, the marker will set the incoming trunk so that the calling subscriber will receive busy tone. (The marker will then release immediately.)

If idle, the marker will determine from cross-connections on the block relay frame whether it is an individual or PBX line, whether tip or ring party ringing is required, in which line choice, on which one of the four line link frames of the choice and in which horizontal group of the line link frame the called line is located.

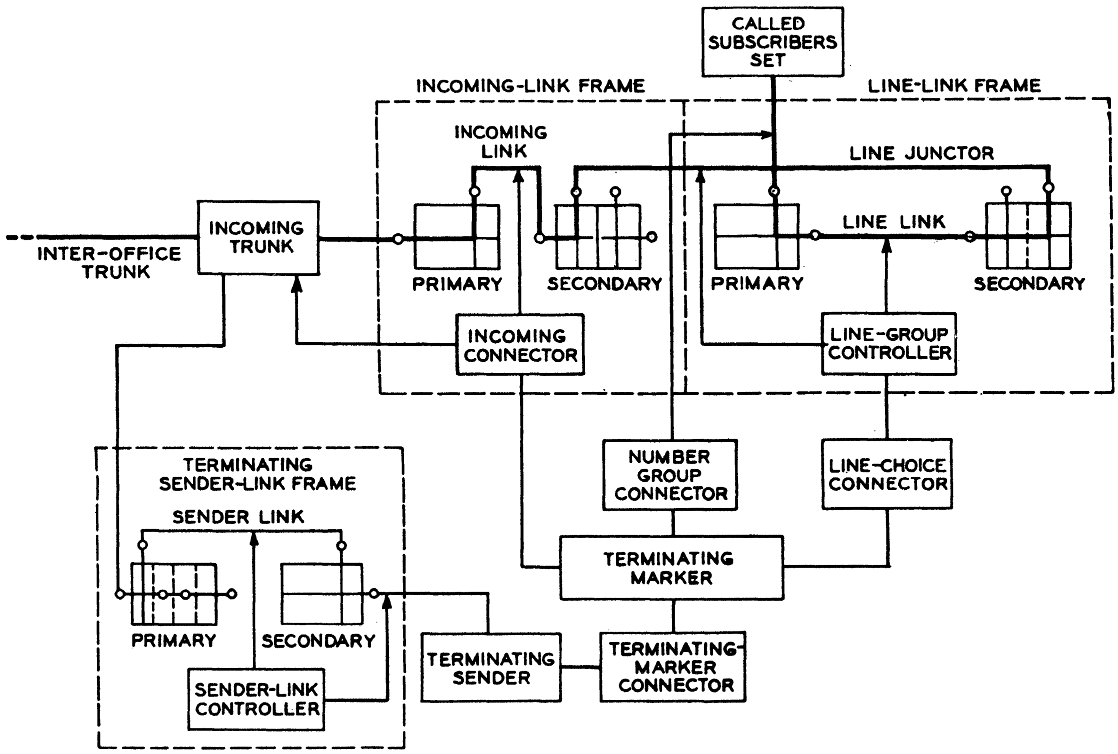


Figure 7-8 Terminating Call in a No. 1 Crossbar Office

From the line location information, the marker, by way of a line choice connector and line junctor connector, is able to test the line links that serve the horizontal group in which the called line is located. Knowing the incoming link frame to which it must connect, the marker tests the line junctors between this frame and the line link frame. At the incoming link frame, connector relays give the marker access to the links available to serve the incoming trunk. From this combination of links and junctors, the marker selects an idle incoming link with access to an idle line junctor which in turn has access to a line link serving the horizontal group in which the called line is located. The marker will then operate the primary and secondary select and hold magnets on the line link and incoming link frames necessary to close this path between the incoming trunks and the called subscriber.

The marker also sets the incoming trunk to apply proper ringing to the called line. The marker and terminating sender now release. This marker has completed its function in about 0.5 second.

The incoming trunk applies ringing current to the called line and, when the called party answers stops the ringing and signals the district junctor that the called party has answered, so that the correct charge may be made. The calling subscriber may now talk to the called subscriber, the district junctor applying talking battery to the calling subscriber, and the incoming trunk to the called subscriber. At the end of the conversation, the two parties will hang up, and all circuits will release.

A DIRECT DISTANCE DIALING (DDD) CALL SWITCHED THROUGH THE NO. 1 CROSSBAR SYSTEM

It is the function of the auxiliary sender to receive the 10-digit DDD calls or the 7- or 8-digit home area calls. Figure 7-9 illustrates the function of the auxiliary sender.

24. Ten-digit Call

A customer originating a call to a foreign area is connected to a subscriber sender in the usual manner and first dials the X 0/1 X foreign area code followed by the 7-digit directory number. The subscriber sender recognizes the "0" or "1" in the second digit as an indication that an auxiliary sender may be required to aid in the completion of the call. (Service codes in the X-1-1 series indicate only 3-digit calls which do not require use of the auxiliary sender.) After the third digit is dialed, the subscriber sender calls for an originating marker as at present. When one is connected, it decodes the foreign area code in the same manner as a local office ABX code, completes a path to the outgoing CAMA tandem trunk, transmits to the subscriber sender the usual selection information, and releases.

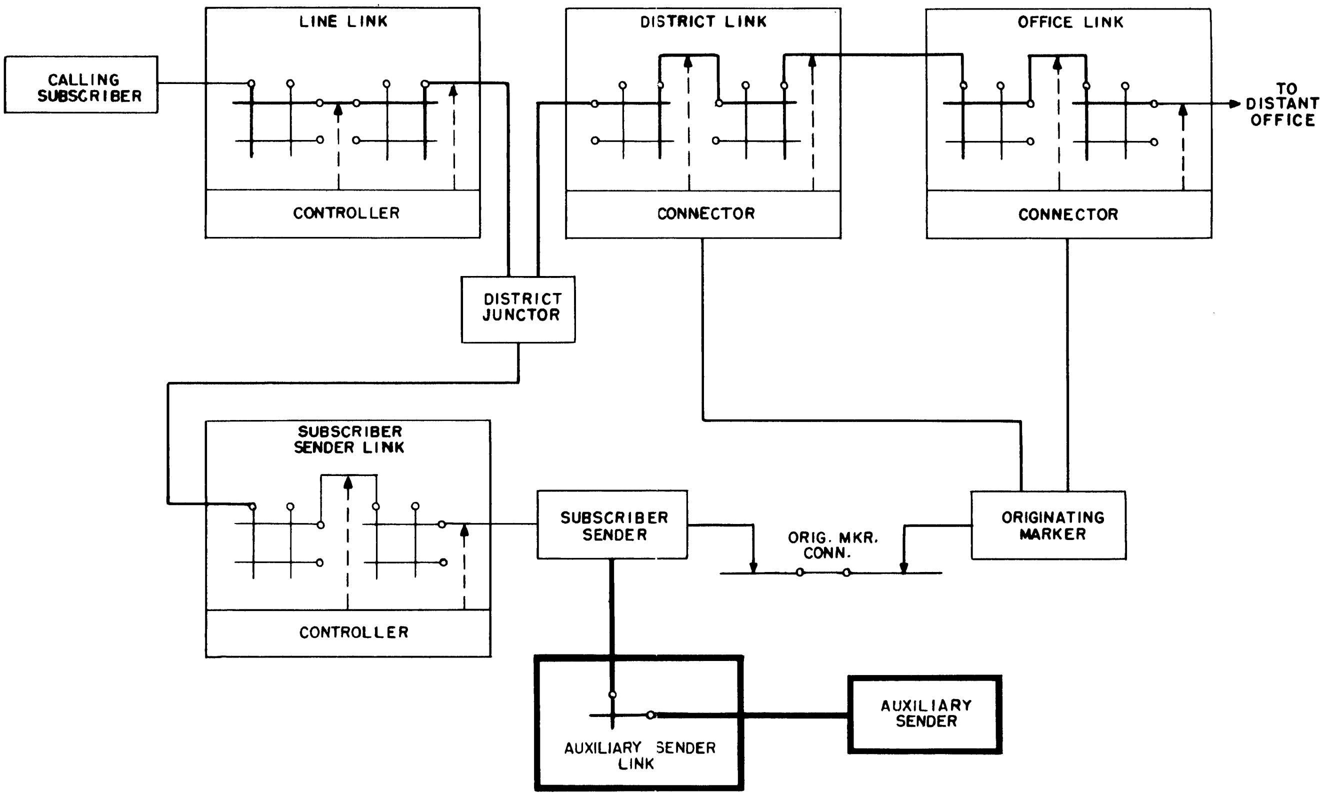


Figure 7-9 Diagram of Auxiliary Sender of the No. 1 Crossbar System.

Meanwhile, the subscriber sender continues to receive dialed digits and when the seventh digit is registered, it makes a bid for an auxiliary sender through the auxiliary sender link frame. Before the first pulse of the ninth digit, a connection is made to an auxiliary sender for registration of the ninth and tenth digits as they are dialed. If, for any reason, an auxiliary is not connected in time, the subscriber sender sends the call to overflow.

The auxiliary sender signals the subscriber sender when dialing is completed. The subscriber sender reacts by making PCI trunk test toward the auxiliary sender. The auxiliary sender then signals for a distant office sender via the subscriber sender, and when one is connected, gives the assignment signal to the subscriber sender. The eight digits in the subscriber sender are then PCI pulsed, in the order dialed, into the auxiliary sender. These digits are received in the auxiliary sender on either one of two dual function register circuits which are capable of receiving PCI digits and controlling the outpulsing of MF digits to the distant office. While one register circuit is receiving a PCI digit, the other register is controlling the MF outpulsing of the preceding digit and preparing to receive the next PCI digit. Since the MF outpulsing overlaps with the PCI inpulsing, this is referred to as the "overlap" method of operation. Therefore, the eight digits in the subscriber sender are MF outpulsed at the PCI rate. The two digits registered in the auxiliary sender are outpulsed at the regular MF rate.

After the eight digits in the subscriber sender and the ninth and tenth digits in the auxiliary are MF outpulsed, the auxiliary signals the subscriber sender that outpulsing is completed and both circuits release.

25. Seven-digit Call

The auxiliary sender may also be used to MF outpulse 7- or 8-digit calls. The only difference in handling this type of call compared with a 10-digit call is that the indication that an auxiliary sender is to be used comes from the originating marker rather than from the second dialed digit. Once the auxiliary sender is connected and a distant incoming sender is attached, outpulsing proceeds as described above.

26. Digit Deletion

There is a feature in the auxiliary sender which permits it to delete the first two (skip 2) or three (skip 3) digits received from the subscriber sender. On 7-digit calls, this feature enables the use of MF pulsing over direct trunks to No. 1 or No. 5 Crossbar offices which are equipped with MF receivers and are within the charging range of the originating office. For 10-digit traffic, the skip 3 feature may be used to delete the area code on calls going into an adjacent area through a "directional" CAMA crossbar tandem office used only for calls to that particular area.

7.2 CROSSBAR TANDEM SWITCHING SYSTEM

A. GENERAL

Crossbar tandem is a relatively young switching system. It first went into service in 1941. Crossbar tandem equipment is used primarily in panel, step-by-step, and crossbar areas to switch calls among offices by means of crossbar switches in a marker common control system. Its central location provides for the application of Automatic Message Accounting (AMA) to record billing data for local and toll calls. It permits the use of AMA on calls from panel offices for which local AMA has not been developed. It provides for the application of Traffic Service Positions to the tandem office to extend customer Direct Distant Dialing (DDD) to include customer dialing of special toll calls, Coin Distance Dialing (Coin DD), and local and toll dial assistance originated as Dial Zero Calls. With proper terminating equipment it also provides for switching intertoll trunks on a 2-wire basis.

The basic need for a local tandem switching system arises in large metropolitan areas where local telephone service is furnished by many central offices as illustrated in Figure 7-10. In such areas tandem systems are used:

a. To effect trunking economies by combining small amounts of interoffice traffic originating in the various central offices and routing this combined traffic over a common trunk group to the required destination, thus eliminating the necessity for inefficient, small, direct inter-office trunk groups.

b. To effect central office economies by serving as a machine language interpreter" between the different types of central offices, thereby eliminating the costly necessity of equipping every central office for direct communication with every other type of central office as illustrated in Figure 7-11.

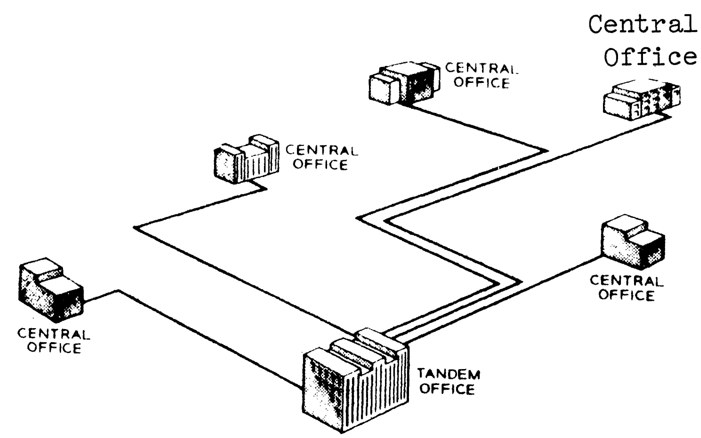


Figure 7-10 Local Tandem Switching

c. To effect overall service economies by centralizing equipment for rendering 1-way message service (weather reports, etc.) and equipment needed as normal adjuncts of telephone service (charging equipment, etc.). Centralization results in efficient use of such equipment as compared with furnishing the same at each local central office requiring it.

B. THE SYSTEM

The crossbar tandem is a 2-wire switching system, that is, it switches only one pair of voice transmission wires over which conversation flows in both directions. The crossbar tandem system functions in many respects like a No. 1 Crossbar office. The basic arrangement is shown in the upper portion of Figure 7-12. The lower portion of Figure 7-12 shows equipment elements required when AMA operation is provided for a crossbar tandem system. An incoming trunk is connected through a trunk link frame, office junctor grouping frame, office link frame and an outgoing trunk to another office. In operation, the incoming trunk is connected to a sender through a sender link frame. The sender registers the called number and other information required and connects to a marker through a marker connector frame. The marker receives information from the sender and supplies the sender with information it needs to complete the call. The marker selects an outgoing trunk to the desired destination and connects the incoming trunk through the trunk and office link frames to the outgoing trunk.

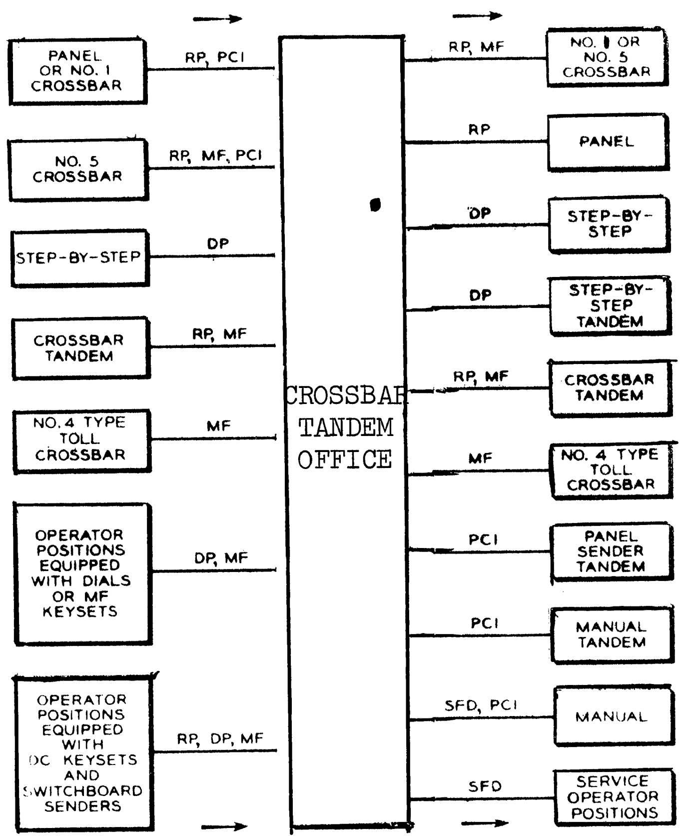


Figure 7-11 Block Diagram of Sources and Destinations of Traffic Routed through Crossbar Tandem Systems.

In the simplified block diagram of Figure 7-13 the switching network of the system consists of crossbar link frames. Incoming trunks from the calling central offices appear on trunk link frames and outgoing trunks to the called central offices appear on office link frames. Through a system of links and junctors, which interconnect the crossbar switches on these frames, any incoming trunk can be connected to any outgoing trunk. For each connec-

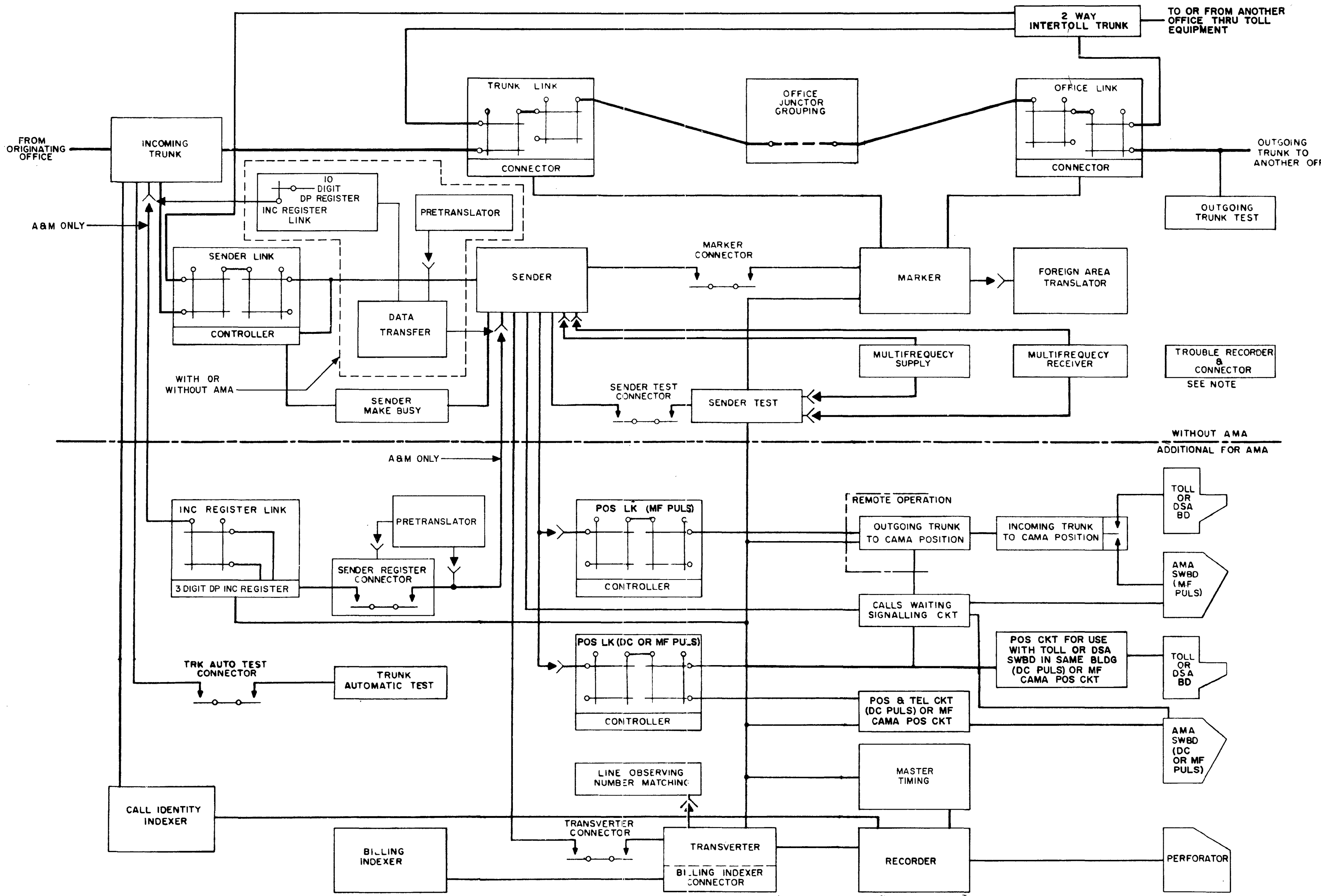


Figure 7-12 Block Diagram With and Without AMA

tion there are several possible paths (or channels) through these frames and, on a call, one of these paths is selected by the common control equipment: senders, markers, connectors, etc.

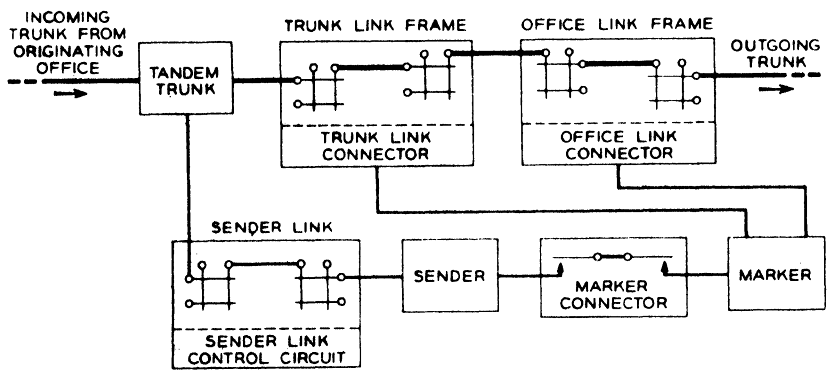


Figure 7-13 Simplified block diagram of crossbar tandem

To establish a path, the incoming trunk calls for the services of the common control equipment. This equipment consists of a samll number of elements (senders, markers, etc.), each of which is called into service for a relatively short time, performs its functions, releases, and is free to serve another call. The basic functions of these common control elements are:

1. Store the digits as they are received (sender function).

2. Translate these digits into switching control information (marker function).

3. Test for and select an idle outgoing trunk (marker function).

4. Test for and select a matching set of connecting links between the incoming trunk and the outgoing trunk (marker function).

5. Outpulse as required (sender function).

Over the years, this original switching plan of the crossbar tandem has proved to be highly satisfactory for meeting the first fundamental tandem system objective of enabling trunking economies to be effected in large metropolitan areas. Its switching speed, traffic capacity, and trunking flexibility are all adequate, since its control circuits are fast, and it can accommodate a maximum of about 3,000 incoming trunks and 4,000 outgoing trunks assignable in a wide range of group sizes.

1. <u>Frames and Framework</u>

Since it is not practical in this text to illustrate each type of switching frame used in crossbar tandem, nevertheless a few illustrations are provided to aid in visualizing how circuit elements such as relays, resistors, inductors, capacitors, electron tubes, etc. are first mounted in position on precisely drilled mounting bars which in turn are assembled in various units and finally are mounted on metal frame uprights. In crossbar tandem, frames measure 11 feet 6 inches high with sheet metal bases 10 inches wide and are of varying lengths. Most frames have their own fuse panels which are mounted on the top. Nomenclature is important. The name given to a type of equipment performing a specialized function in the system often reveals its purpose or use in that system. For example, Figure 7-14 shows a Trunk Link and Trunk LInk Extension Frames while Figure 7-19 depicts the Marker Frame. It is worthwhile to note from these figures and Figure 7-12 that link frame types contain crossbar switches primarily; while frames housing control equipment such as controllers, senders, markers, trunks, etc., contain circuit elements other than crossbar switches.

2. <u>Trunk Link</u>

The trunk link frame shown in Figure 7-14 consists of primary and secondary bays of switches and relay equipment comprising 200 links used for interconnection of incoming trunks and office junctors. The primary ends of the links are arranged to serve 160 incoming trunks (basic

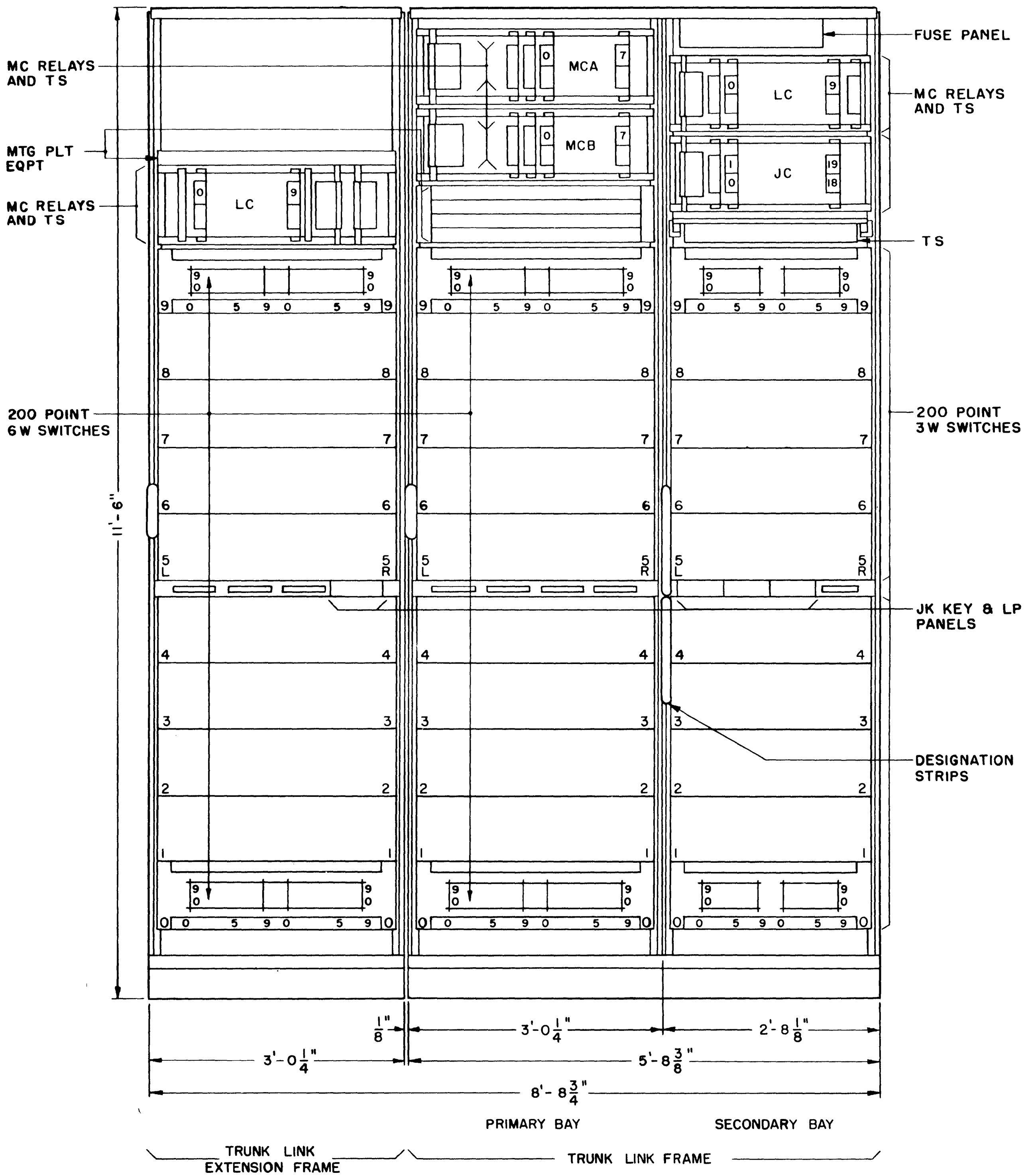


Figure 7-14 - Trunk Link and Trunk Link Extension Frames frame) or 320 trunks (with trunk link extension frame). The secondary ends of the links serve 200 office junctors. The trunk link frame is arranged to operate with a maximum of eight markers and 20 office link frames and will serve any combination of AMA and non-AMA trunks, limited only by the decade requirements and cabling considerations.

The trunk link extension frame provides for a maximum of 160 trunks to which the trunk links are given access by a multiple between the primary and primary extension switches.

The trunk link arrangement is symbolically represented in Figure 7-15.

3. Office Link

This 2-bay frame and one-bay office extension frame are the same as the corresponding frames used in No. 1 local crossbar offices. A second extension frame may also be furnished in tandem offices to provide increased trunk capacity.

The office link frame has a capacity of 200 links, the primary switches of which serve 200 office junctors. The secondary switches provide for 100 outgoing trunks if the switches are not split and a maximum of 200 or 300 outgoing trunks if the horizontal multiples of all switches are split. The extension frame has a capacity of 100 outgoing trunks.

On the basis of 200 or 300 trunks per frame and a maximum of 20 office link frames (as limited by the marker), the physical maximum number of outgoing trunks per marker group is 4000 with one extension frame and 6000 with two extension frames. To insure uninterrupted service, a test group of trunks is divided between two office link or extension frames, and the frames are furnished and operated in pairs.

The office link arrangement is symbolically represented in Figure 7-16.

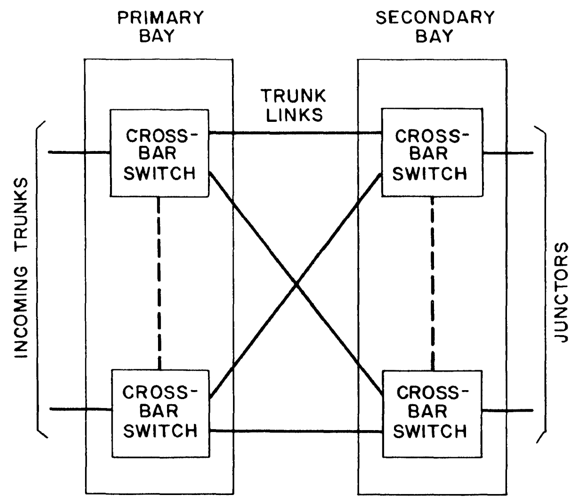


Figure 7-15 Trunk Link Frame - Primary and Secondary Bays Connected by Trunk Links

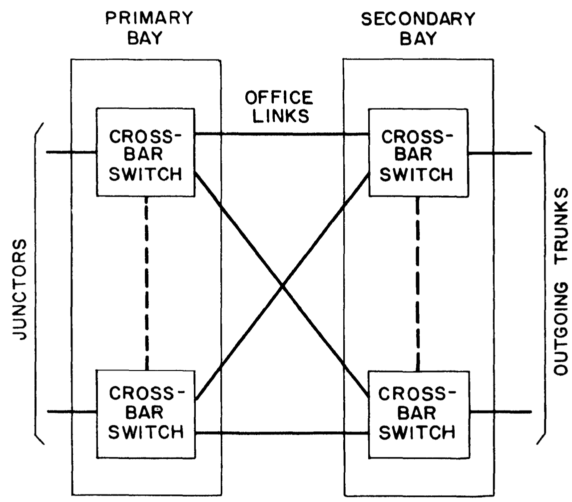


Figure 7-16 Office Link Frame - Primary and Secondary Bays Connected by Office Links

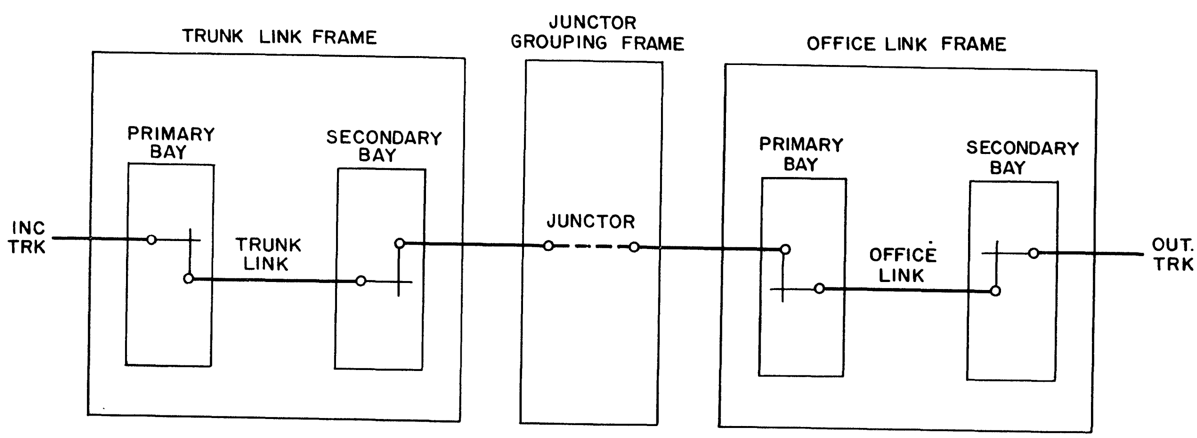


Figure 7-17 A Complete TJO Channel

4. Office Junctor Grouping Frame

This is a 2-bay frame on which are mounted terminal strips and jumper distributing rings used to interconnect the secondary of the trunk link frames with the primary of the office link frames in such a way as to obtain complete access of incoming trunks to outgoing trunks. In addition to this, the grouping frame is arranged so that as the size of the office increases, the effort required to change the junctor distribution is kept to a minimum. Figures 7-18a and 7-18b illustrate an initial and a growth distribution arrangement.

The junctor channel between the trunk link frames and the office link frames is referred to as a TJO channel. A channel consists of a trunk link, a junctor, and an office link connecting an incoming trunk to an outgoing trunk as represented in Figure 7-17.

5. Sender Link

This frame is a 2-bay structure. Four 200-point, 5-wire primary switches and four 200-point, 5-wire secondary switches, together with the sender subgroup connector multicontact relays and terminal strips, are mounted in one bay. The other bay contains a fuse panel, trunk group connector multicontact relays, and two controller circuits enclosed in a front casing and a rear enclosure.

The sender link frame is provided with ten groups of four primary-secondary links, each group having access on the primary switches to ten trunks and on the secondary switches to a total of 40 senders of either of two kinds. The frame serves a maximum of 100 trunks and has access to a maximum of 80 senders.

Each of the two controller circuits, A and B, serves half of the 40 links interconnecting the primary switch verticals with the secondary switch verticals. Each group of four links serving ten trunks is made up of two A and two B links.

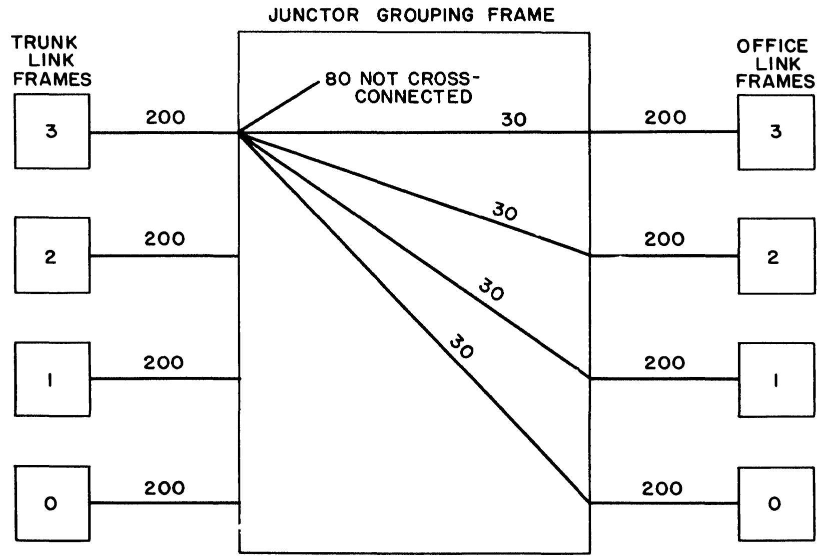


Figure 7-18a Junctor Groups - 4-4 Size Office

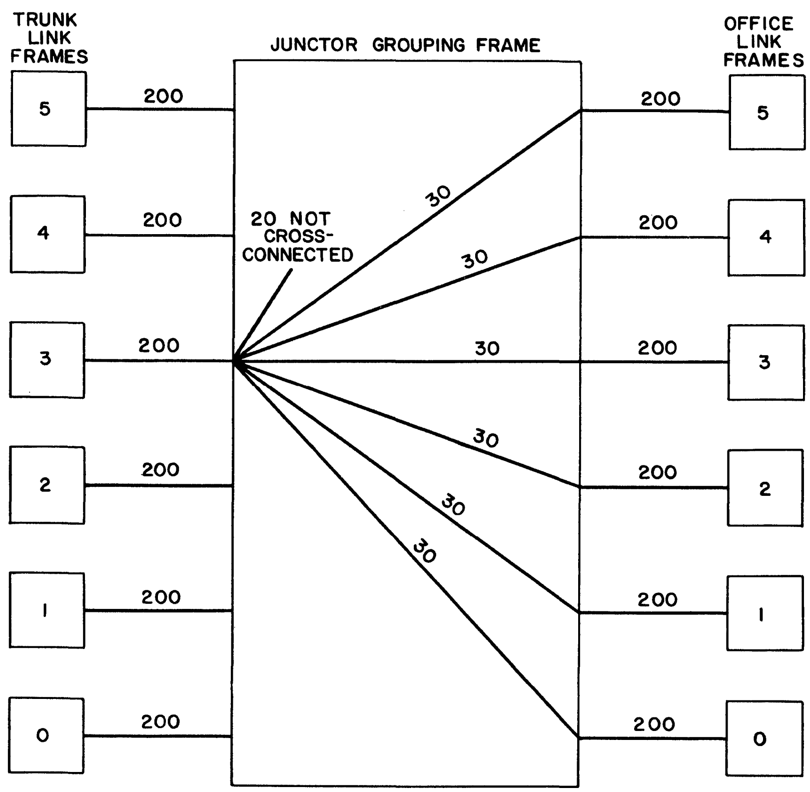


Figure 7-18b Junctor Groups - 6-6 Size Office (Initially 4-4 Size)

The ten horizontals of each secondary switch are cabled to ten senders of one kind or to ten senders of each of two kinds. These two kinds of senders may be revertive and dial pulse, revertive and multifrequency, dial pulse and multifrequency, or PCI arranged for AMA and multifrequency, etc. When there are two kinds of senders, the horizontal multiple strapping is cut at the point corresponding to the division between the links serving trunks requiring one kind of senders and those serving trunks requiring the other kind. Senders are treated in switch subgroups of five. Each switch subgroup of senders appears at secondary switch horizontals 0 to 4 or 5 to 9. Each group of four links has access to senders of one kind only. The multiples for the different kinds of senders are entirely independent of each other and each may appear on some frames to the exclusion of the other kind. The sender multiple for each kind of sender is arranged so that all sender subgroups have approximately the same number of appearances and are extended through the greatest possible number of frames.

6. Senders

A sender is used to assist in the completion of a call through the tandem office. The sender receives and stores information required by other circuits and controls the selection in the tandem office of a trunk to the desired terminating office.

The sender receives from the originating office the called number and the calling number (when the tandem office is arranged for automatic number identification (ANI) operation).

The sender receives and registers from the sender link frame, the trunk link frame number which serves the trunk, the trunk class mark, trunk data group number, rate class, if any, and other information required to complete the call.

After the sender registers the office or area and office codes, it connects through a marker connector to the marker. It transmits information to the marker and receives from the marker information that is required to complete the call.

There are four types of senders and sender frames available, namely: revertive, PCI, dial, and multifrequency pulse. The pulsing used in transmitting the called number from the originating office to the tandem sender indicates the type of sender.

The revertive pulse sender frame has a capacity of five revertive senders. This sender functions with trunks incoming from panel or crossbar offices that control the routing of the call partly or wholly on a revertive pulsing basis. It is used to complete calls to panel, crossbar, step-by-step, and manual offices.

The revertive sender is arranged to register seven digits and to complete calls by revertive pulsing, dial pulsing (4, 5 or 6 digits), and on a straightforward basis. PCI calls are completed by closing a circuit for the direct transmission of PCI pulses from the originating office over the tandem completing trunk.

The PCI, dial, and multifrequency pulse senders are arranged for AMA, but will also handle non-AMA calls. They are able to register and outpulse a greater number of digits than the revertive sender and to complete calls by revertive, PCI, dial, and multifrequency pulsing and on a straightforward basis.

The PCI sender frame has a capacity of three PCI senders. This sender is used in the completion through tandem of calls dialed by subscribers in panel and crossbar offices. PCI pulsing into the tandem office is used to obtain greater code capacity (640 as compared to 300 for revertive) and to permit outpulsing of party letters from the local office. It is arranged to register eight digits and to outpulse four to eight digits on a dial or multifrequency basis. The digits may be four or five numerals or four numerals and a party letter preceded, if desired, by 1-, 2-, or 3-code digits. The code digits may be transmitted as registered or converted to any other values by translation from the marker.

The dial pulse sender frame and the multifrequency pulse sender frame have a capacity of four dial pulse senders and four multifrequency pulse senders respectively. The dial pulse sender is used in the completion through tandem of calls from step-by-step subscribers, from manual, DSA and toll switchboards equipped with dials, from other senders arranged for dial pulsing. The multifrequency pulse sender is used in the completion through tandem of calls from senders arranged to transmit multifrequency pulses and from manual, DSA, and toll switchboards equipped for multifrequency keypulsing. These senders will accept three to eleven digits and will outpulse one to eleven digits. The outpulsed digits may be as registered, 1, 2, or 3 digits prefixed to the registered digits to be outpulsed, the first three digits changed and on area calls, the first three registered digits may be deleted and the next three digits code converted.

The dial pulse sender is arranged for bylink operation to avoid second dial tone to step-by-step subscribers. With this feature, the first three digits following the directing code are registered in an incoming register which is connected to the tandem incoming trunk by the incoming register link. Subsequent digits are dialed directly into the sender. The digits in the register are transferred to the sender through a sender register connector.

The association of trunk, trunk link, and sender link frames is by direct cabling. The 160-trunk capacity of the basic trunk link frame is accommodated on ten primary switches. The added 160 trunk capacity of the trunk link extension frame is accommodated on ten primary switches. Each switch accommodates 16 trunks in pairs on eight levels. The other two levels are used for discriminating purposes to serve the proper one of a pair of trunks involved in a given call. A group of ten trunks is considered to be of one type from the standpoint of sender requirements and code grouping as well as circuit features. It is cabled to appear as a primary switch group of ten trunks on the sender link frame. It is served, therefore, by that one type of sender to which it can give but one indication as to the associated trunk link frame number and code group. Because of this, trunks may have traffic characteristics differing in general between decades or groups of a maximum of ten trunks. These groups are cabled to the trunk link frames in such quantities that each frame serves trunks of varying characteristics in approximately the same proportion. To carry this plan of load distribution still further, the ten trunks of each group are terminated one in each of ten primary switches of the trunk link frame. Since the trunk link frame gives the marker indication by primary switch levels of certain characteristics of the associated trunks, it is necessary that both trunks on each level be of the same type in this regard.

7. Multifrequency Current Supply

When senders are arranged for multifrequency outpulsing, multifrequency current supply equipment is required. This frame consists of two 6-frequency oscillator units, an alarm and transfer unit, distributing resistance panels, and miscellaneous equipment.

8. Marker Connector

The function of a marker connector is to connect a sender to an idle marker for the selection of a trunk to the proper destination and for information necessary for completing the call.

The dial pulse and multifrequency senders transmit to the marker on certain leads on a two-out-of-five digits basis. The revertive and PCI senders transmit to the marker on certain leads on a two-out-of-seven digits basis. These different systems of transmitting to the marker result in these leads in the marker multiple differing in designation and use at the marker. Multifrequency senders, for example, when not arranged for foreign area translation, transmit to the marker on certain leads on a two-out-of-seven basis and on a two-out-of-five basis when arranged for foreign area translation.

9. Marker

In completing a call through a crossbar tandem office the marker is used to decode the office or area code, to select and test the corresponding outgoing trunk group and channels thereto, to set up information in the sender for handling the call, and to operate the proper select and hold magnets on the trunk and office link frames to connect the incoming trunk to the selected outgoing trunk. Calls may originate in step-by-step, crossbar, and panel offices, private branch exchanges, and at dialing and keypulsing switchboards. They may be completed to panel, crossbar, step-by-step, and manual call indicator offices, to private branch exchanges, and to official codes; they may be extended to panel sender, crossbar, step-by-step, and manual call indicator tandem offices, and to panel distant office equipment. Operator calls may be extended to manual straightforward positions.

In processing a call involving an area code or PBX indialing, the marker receives six digits. The first three digits are decoded and used to cause a translator to be connected to the marker. The translator registers and decodes the second three digits and causes an FAC code point in the marker to be grounded.

Routing information is obtained from two wires threaded through rings in a ring field consisting of nine horizontal rows of rings, each row containing from three to seven rings. Part of the routing information is stored by threading a wire connected to a code point through one or two rings in each row, as required, to a first string firing circuit terminal. The remainder of the routing information is stored by threading a second wire from a related second string terminal through one of two rings in each row, as required, to a second string firing circuit terminal. When the code point is grounded, a surge is sent through the first wire; a voltage is induced in every coil through which the wire is threaded, firing associated tubes which operate associated relays. The output of these relays are registered and the tubes and associated relays released. The related second string terminal is then grounded and the second string firing circuit sends a surge through the second wire which induces a voltage in every coil through which the wire is threaded, firing associated tubes which operate associated relays. The output of these relays is registered and completes the route information for the particular code point.

The marker frame consists of a single-bay marker control unit and a double-bay marker route unit shown in Figure 7-19.

10. Translator

The translator frame, is a single-bay frame used in conjunction with the marker to provide for 6-digit translation for a maximum of five foreign areas with 60 routes for each area. Its use provides for selecting the best route to a particular office in a foreign area where there are several routes by which the tandem office can reach the foreign area. It is also used for selecting a particular PBX when several share a 3-digit code.

11. Trunks

The trunk frames accommodate the numerous trunks used to provide incoming calls access to crossbar tandem switching equipment elements. The trunk frames are single-bay structures accommodating either 23-inch mounting plate units or 30-1/2 inch mounting plate units. The frames have capacities of 10, 20, 30, 40 or 60 trunks depending on the apparatus involved. Trunks are grouped in decades of one to ten trunks numbered 00 to 09, 10 to 19, etc. or 50 to 59 on the trunk frames. The trunks in a decade have certain common requirements and are handled on a decade basis at the various trunk appearances. At the trunk link frame, each trunk decade (00 to 09, 10 to 19) is connected at the trunk link frame so as to contribute one trunk to each of the ten primary switches on the frame. Each primary switch accommodates a maximum of sixteen trunks, two on each level from 2 to 9. Trunks 00 to 09 will normally appear as the first of the trunks on a level and

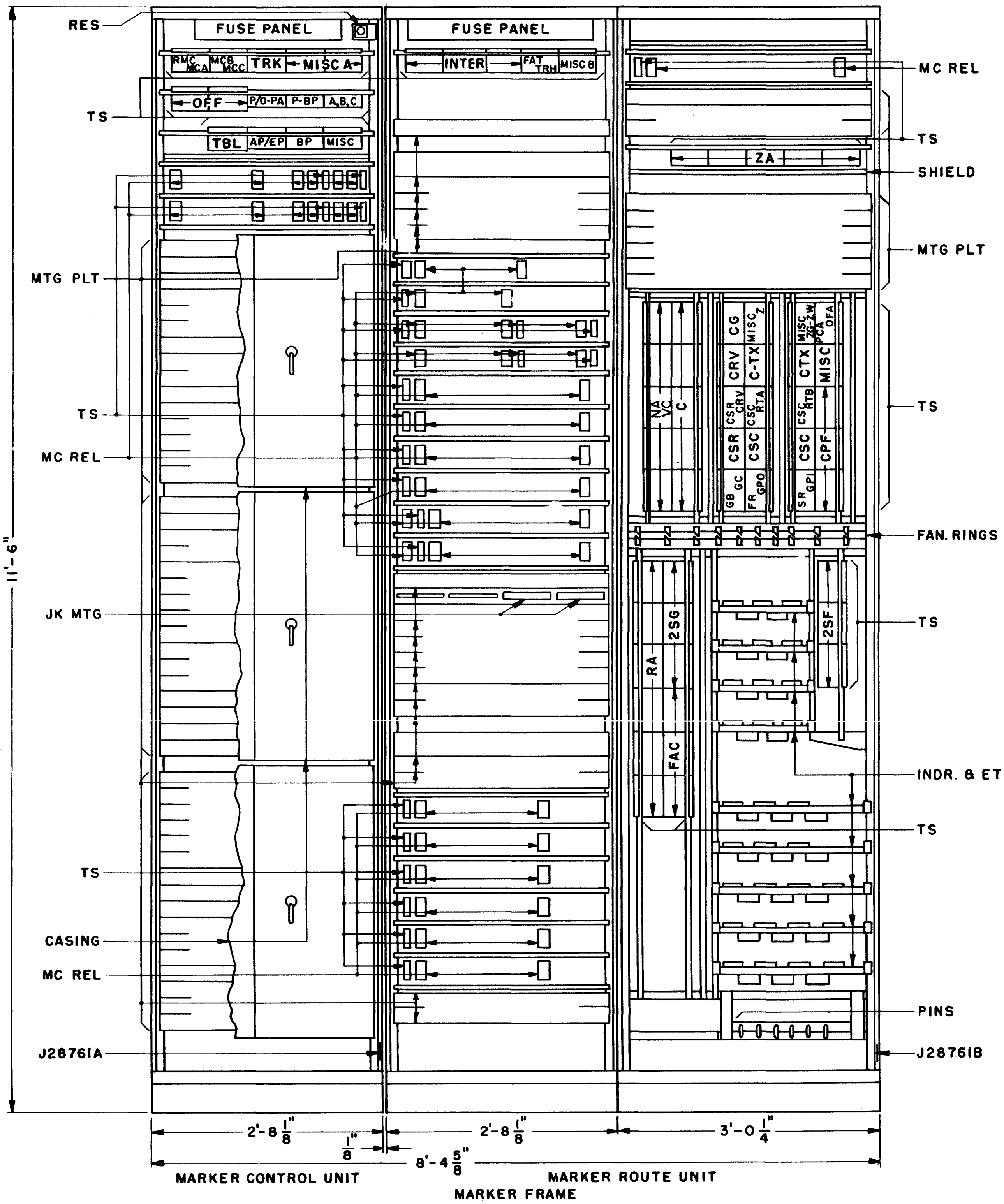


Figure 7-19 - Marker Frame

trunks 10 to 19 as the second. The trunk numbering consequently indicates by the units digit, 0 to 9, the trunk link primary switch on which it appears and by the tens digit, even or odd, the position on the level.

Trunk frames fall into four general categories, Non-AMA, AMA, 100B TSPS, and 2-way.

12. Non-AMA Trunks

The non-AMA trunk frames are remote-control zone registration, through supervision, repeater supervision, simplex or composite supervision, PCI pulsing, MF pulsing, and Extended Area Service, Loop or E&M.

Remote-control zone registration trunks are used for calls from panel offices arranged for remote-control zone registration. Charge pulses are sent to the originating office according to the rate cross connections in the trunk and the duration of the call. In the case of 2-rate trunks, the marker determines whether the lower or higher rate is effective.

Reserve trunks are provided to handle calls for remote-control zone registration trunks which are under routine test. They are automatically substituted for any associated service trunk under test and are arranged to assume, automatically, the particular rate schedule of the trunk for which they may be substituted at the time.

The through supervision trunks are used in completing calls from No. 1 Crossbar or panel offices.

The repeated supervision trunks are used on calls involving revertive, dial or multifrequency pulsing from crossbar, panel, step-by-step, and No. 4 type offices, and from operators.

The simplex or composite supervision trunks are used on dial pulsing or multifrequency pulsing calls from local or toll offices and may be arranged to rering forward with a simplex ringing signal.

The PCI pulsing trunks are used with PCI senders in completing calls from panel, No. 1, and No. 5 Crossbar offices on a non-AMA basis.

The MF pulsing trunks are used on calls from a toll switchboard in the same or adjacent building.

The Extended Area Service (EAS) trunk accommodates E&M or loop lead supervision trunks, arranged for dial pulsing and convertible to MF pulsing.

13. AMA Trunks

The AMA trunk frames are of three types PCI, dial pulsing, and multifrequency pulsing accommodating 30, 20 and 20 incoming trunks, respectively, and the common relay interrupter and miscellaneous equipment. These trunks are used on calls from subscribers in panel, step-by-step, and crossbar offices and control the recording of the call by the associated AMA equipment.

An AMA trunk functions the same as a non-AMA trunk in establishing a connection through the trunk and office link frames to an outgoing trunk. On seizure, a sender arranged for AMA is attached through a sender link. In processing the call, the trunk identified itself to the recorder through the call identity indexer causing the trunk number to be perforated as part of the initial entry. After the call is answered, the trunk again calls in the recorder to perforate the trunk number with the answer time entry. By means of the trunk number the separated elements of the call are brought together in the accounting center for billing purposes.

When a call originates in a step-by-step office, a DP trunk is seized after a directing code is dialed by the subscriber. In the interdigital time between this directing code and the area or office code, the trunk causes a register link to seek an idle register and a sender link a sender. It is intended that a register be connected in the interdigital time and record the three digits of the area or office code. The sender must be connected before these three digits are recorded in the register. When the register has recorded three digits, it signals the sender to record the remaining digits. Subsequently the area or office digits are transmitted to the sender through a sender register connector and the register disconnects. As soon as these digits are recorded in the sender, a marker is called in and the call is processed as for other trunks.

Special toll trunks cover the handling of calls such as person-to-person, reverse-charge, charge to third party, or credit card charge. The customer dials a directing digit followed by the called number. The directing digit directs the call to the tandem office over trunks associated with the traffic service position. On seizure, the trunk is connected to a tandem sender by way of its associated sender link and controller circuit. After the calling and called numbers are received by the sender, it signals the trunk circuit to connect to an idle operator's position through its associated switchboard link and connector circuit. The position requests the services of a data transfer circuit which connects to the trunk and sender circuits and transfers the call data to registers at the selected position. The operator is then connected to the transmission circuit for talking to the calling customer, while the sender calls a marker to set up a channel to the desired outgoing trunk. The trunk circuit assists in setting up this connection by identifying itself to the marker, closing the first crosspoints in the trunk link frame, and supplying means for maintaining the connection through the trunk and office links for duration of the call.

Recording-completing trunks provide service for customers who desire operator assistance. The customer dials an operator code and is routed to the tandem office over a recording completing trunk associated with the 100B traffic service position.

When a customer dials the operator code, a recording completing trunk in the tandem office is seized which causes a tandem sender to be connected. After ANI (Automatic Number Identification) information is recorded, the sender passes a position request signal to the trunk. After receiving the call details, the position enables conversation to take place between the calling customer and the operator.

The customer informs the operator of the called number and whether the call is person to person, station to station, station paid, collect, or special, and she then keys this information into her position register. When the position is reattached, the position calls in the data transfer circuit and the called number is passed from the position register through the data transfer circuit.

There are a few types of calls which the traffic service position operator will not complete. They are: overseas calls, marine operator calls, conference calls, mobile telephone calls, and sequence calls. In these cases, the operator initiates a transfer of the call. The trunk starts a trunk finder which cuases a cord-type tollboard operator to take up the call. The 100B TSPS operator will be bridged on the transfer connection and will pass the call details. After this she releases her position, leaving the transfer connection under joint control of the calling customer and the cord-type toll switchboard operator.

Centralized dial coin trunks are furnished in a tandem office to permit the handling of calls dialed by coin subscribers. When the incoming coin trunk is seized at the tandem office, it connects to a sender through the sender link frame. From the sender link, the sender receives information identifying the trunk class and its data group number. The sender receives and registers the called number followed by the station paid start pulse consisting of 1500 and 1700 cps. After this the sender requests ANI from the originating office. Following receipt of the ANI information, the sender signals the trunk to bid for a position which in turn bids for a data transfer circuit. The data transfer circuit, when seized, closes through a number of transmitting and receiving leads between the sender, the trunk, the rater, and the position. The sender passes the called and calling number information as well as the station (1+) mark to the position. The sender passes to the rater the first six digits of the called number, a 7- or 10-digit mark, class of service, recorder number and the station mark. The rater also receives the office index from the trunk and combines this with the recorder number to determine the originating rate center from which the call came. From the above date, the rater determines the rate treatment number which is used by the computer to indicate the charges for the duration of the initial and overtime periods. In addition, the rater determines the duration of the initial period to set the trunk timer for the initial period. Should the call be to a vacant code, the sender requests the marker to set up the call to a VACANT CODE announcement. Should the call be to a point which cannot be rated automatically, it must be manually rated by the operator.

14. Traffic Usage Recorder

The traffic usage recorder frame is used to measure usage of various circuits by scanning on a 100-second cycle and recording busies on traffic registers. The crossbar switches are divided into scan and register switches which provide for scanning a maximum of 3600 circuits and provide access to a maximum of 1200 traffic usage registers. Circuits having holding times over 10 seconds are given one scan switch appearance and the 100-second scanning rate provides accurate hourly measurements in terms of hundred call seconds (CCS). Circuits having holding times of 10 seconds or less are given ten equally spaced appearances on the switches and are scanned at a 10-second rate to obtain the desired accuracy.

The traffic usage recorder equipment also controls the cameras used to photograph traffic usage registers or regular traffic registers. The traffic register equipment provides for obtaining traffic data, such as overflow, group busy, peg count, load and usage. A single-sided distributing frame is furnished adjacent to the traffic registers for terminating the many leads from the connecting circuits and for flexibility of cross connections between the traffic registers and the connecting circuits.

15. Service Observing

Multiline service observing equipment for incoming trunks provide for service observing at a No. 12 service observing desk in the same or another building. This equipment consists of small surface-wired units and patching facilities mounted in relay rack bays. Each multiline service observing circuit has a maximum of 50 loop connectors arranged for patching to the relay-rack appearance of the trunks to be observed.

16. Floor Alarms

The floor alarm unit accommodates the alarm relay equipment for a variable number of frames and aisles of equipment distributed over a maximum of two floors. It provides audible and visual signals under trouble conditions and supplements the alarms appearing on the individual frames. The audible signals by means of distinctive tones indicate the type of alarm. The visual signals in the form of floor and aisle pilots using differently colored lamps indicate the general nature and location of the trouble. The alarms may be transmitted to an alarm receiving center by means of alarm sending and transfer equipment when unattended operation of the tandem office is required.

17. Power

The power requirements for crossbar tandem offices are similar to local No. 1 Crossbar offices and the same power plants may be used if available. For a new office a 302A plant for 24 and 48 volts is used. For zone resigtration trunk timers or master timers, a source of 22 volts ac is required. This is supplied from a relay rack mounted 506A power plant unit. A

504B plant is required to furnish 115-volt, 60-cycle current from the office battery during commercial power failure or low voltage to the 506A power plant and to the perforator cabinet output reel motors. For zone registration charging pulses a 170-volt supply, tapped at 135 volts, is required. Various circuits require + 130 volts. This voltage is supplied by 405A or 410B power plants. Low tone and ringing are taken from an existing local office ringing plant. The 48-volt talking battery required for some trunks is obtained through filters.

For a comprehensive look at the power plants mentioned above refer to "Telephone Power Plants," Chapter 18.

C. SYSTEM MAINTENANCE

As in all switching systems a variety of test equipment form an integral and indispensable part of the system. Test frames detect and localize malfunctions and other circuit deficiencies in the system. Corrective action is then applied by the maintenance personnel.

1. Incoming Trunk Test

The incoming trunk test frame, is a single bay of equipment used for testing the incoming trunks in the terminating office. It is associated with these trunks through the incoming trunk test connector frame and makes its tests automatically or repeatedly as desired. One frame has a basic capacity of 4000 trunks but may be arranged for an additional 4000 if required. A supplementary teletypewriter frame may also be provided for automatically printing records of transmission tests.

2. Sender Test

The sender test frame, associated connector frame, the supplementary test frame, and the register test connector frame, provide for testing PCI, revertive pulse, multifrequency pulse and dial pulse senders, local CAMA operator positions, trunks to toll or DSA switchboards equipped for CAMA operation, incoming registers, and transverters. Remote multifrequency pulsing positions are not tested by this test frame. The testing of outgoing trunks to remote positions and the operation of these positions is done at the manual outgoing trunk test frame.

3. Trouble Recorder and Connector Frames

The trouble recorder frame, the associated trouble recorder connector frame, are used to record automatically troubles encountered during the establishment of service and test calls. A record is made by punching holes in a card by means of a perforator. The record card is printed so that the information recorded can be read directly by a maintenance man.

4. Sender Make-busy

The sender make-busy frame, is a single-bay frame accommodating a jack field, registers, and relay equipment. The primary function of the sender make-busy frame is to provide sender make-busy jacks for use in removing any sender from service. Associated with these MB jacks are SS lamps which light to indicate as well as to identify stuck senders; SC lamps which light to indicate as well as to identify stuck senders involved in delayed assignments of PC1 calls and CP keys affording means of canceling the automatic priming feature of any stuck sender when it is desired to trace the trouble. There are sender subgroup make-busy jacks, jacks to reduce the timing intervals of the senders, a load register lamp per group of senders, and an alarm which operates when a predetermined number of sender subgroups become busy.

D. CROSSBAR TANDEM SWITCHING TELEPHONE CALLS

The path of an ordinary telephone call requiring a 3-digit translation is illustrated in Figure 7-20. The sequence of connections are numbered to aid in tracing the path.

The call arrives in the tandem office over an incoming trunk and leaves over an outgoing trunk. The incoming trunk may be selected by an operator, a local office, a tandem office, or a dial toll office. The procedure in the tandem office is the same in any case.

As shown in Figure 7-20, each incoming trunk has two major appearances in a crossbar tandem office; one on the trunk link frame (used for the talking connection) and one on the sender link frame (used for passing information to the common control equipment). The trunks are arranged in decades on the sender link frame to permit the sender link to provide to the sender information which is common to ten trunks.

The sender link frame is the first of the trunk appearances to be used. It consists of two sets of crossbar switches, primary and secondary. The incoming trunks appear on the primary switches and the senders on the secondary.

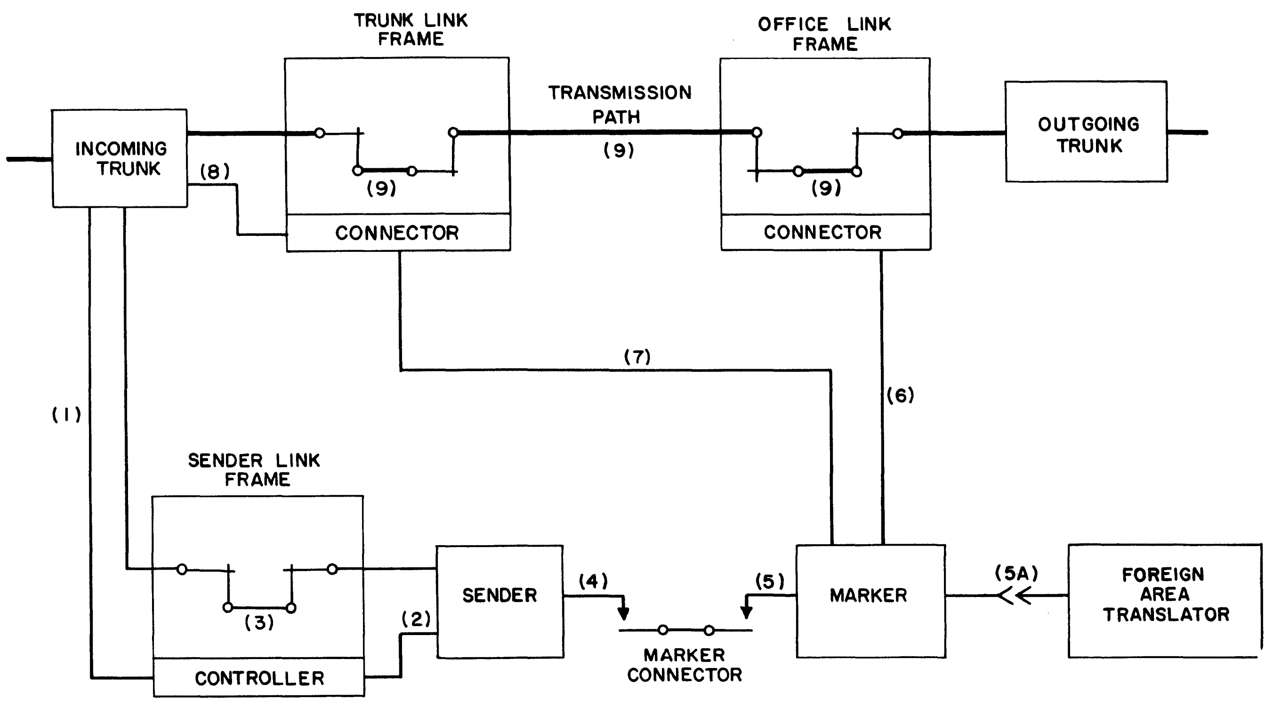


Figure 7-20 Path of a Call Through a Crossbar Tandem Office

As soon as an incoming trunk is seized, it signals a sender link controller (connection 1) to connect an idle sender for registering the incoming pulses. The sender link controller tests for and selects an idle sender (connection 2). The controller then sets up the connection through the crossbar switches of the sender link (connection 3). This completes the function of the sender link controller which releases from the connection and is free to serve other calls.

As soon as the sender is attached, it signals the originating operator or preceding office sender to begin pulsing. When three digits have been received, the sender signals the marker connector (connection 4) to seize an idle marker (connection 5).

The sender passes the first three digits (the code) to the marker along with the information derived from the decade arrangement on the sender link frame. The marker (1) decodes the information received from the sender, (2) operates one of its route relays from which it derives the information required for routing the call, and (3) passes the outpulsing instructions to the sender.

The marker then seizes the office link connector that has access to the pair of office link frames on which the outgoing trunk group is terminated (connection 6). As soon as it is connected to the pair of office link frames, the marker does two things simultaneously; (1) it seizes the trunk link connector that serves the trunk link frame on which the incoming trunk is terminated (connection 7) and (2) it starts testing for an idle outgoing trunk. (The marker knows the number of the trunk link frame from information stored in the sender which was obtained from cross-connections associated with the sender link decade arrangement.) The marker then instructs the incoming trunk through the sender to connect to the trunk link connector (connection 8), which in turn cuts through to the marker the test leads associated with the trunk links that serve the switch on which the incoming trunk is terminated.

When the pair of office link frames was seized, the marker also started testing for an idle outgoing trunk, as mentioned above. At this point, the marker signals the sender to release the marker connector which in turn releases the marker. This completes the first or decoding stage of the marker operation. The marker connection is now free to serve other calls. The marker may also serve another call but only up to the point where the outpulsing instructions are passed to the sender. For the call in progress, the marker maintains a path to the sender via the trunk link connector, the incoming trunk, and the sender link (connections 7, 8 and 3).

When the outgoing trunk is seized and made busy, the trunk selection relay in the marker indicates whether the trunk is located on the even or odd office link frame. The marker then causes the trunk link frame to cut through the test leads associated with the junctors to that office link frame.

The office link frame cuts through to the marker the test leads associated with the office links serving the selected outgoing trunk.

The marker now has access to the test leads for the trunk links, junctors, and office links, and it proceeds to set up the connection from the incoming trunk to the outgoing trunk. It makes the channel test by testing groups of three leads simultaneously, selects one group, and then closes the crosspoints to establish the selected channel (connection 9). The marker signals the sender that the path has been established and then releases from the trunk link and office link frames.

The sender then sends a signal forward and upon receipt of a go signal it outpulses as it had been directed by the marker. After outpulsing is completed, the talking path is cut through. The sender and sender link then release and the call is under control of the incoming trunk.

When the incoming trunk receives a release signal from the calling end, it releases the switches through the office.

1. Call Requiring 6-digit Translation

A call requiring 6-digit translation follows the same method of operation as described above for a call requiring 3-digit translation up to the point of marker seizure. Since this sender is arranged for 6-digit translation and the first three digits of this call are of the form NOX/N1X[1], the sender waits for six digits before calling in a marker.

The marker decodes the first three digits and operates an area relay rather than a route relay. The operation of this area relay causes the associated foreign area translator to be called in (connection 5A).

The fourth, fifth, and sixth digits are sent to the foreign area translator which translates them to one of 60 route indications. The marker uses this information to operate a route relay and the call is completed as described above.

2. Remote Control Zone Registration

The calls thus far described have involved no charging functions at the crossbar tandem. All charging was handled at the originating offices. Crossbar tandem can also handle calls where the message registers at the local office are controlled by signals from the crossbar tandem equipment. This is known as remote control zone registration.

Calls using remote control zone registration are handled by revertive pulsing trunks and senders. The trunks have options for various initial and overtime intervals and for various numbers of registrations for the initial and overtime periods. A trunk may be arranged for one or two rates. To indicate more than two rates, separate trunk groups to tandem must be used. Where a trunk is arranged for two rates, the marker examines the called code and determines which rate is to be applied.

3. Coin Zone Dialing with Local Office Operator Assistance

Crossbar tandem can also handle coin zone calls with the assistance operators located at the local originating office or in a near-by building.

[1]NOX/N1X Where area codes take this form
N = Any number from 2 to 9
X = Any number from 0 to 9

This type of call is dialed by a customer at a coin station and is routed to crossbar tandem by the local office. An operator is called in to request and monitor the initial deposit and to time the overtime on calls which exceed the initial period. The operator must also compute, request, and monitor overtime charges.

This arrangement is limited to a maximum of four charges per trunk group, and only traffic originating in panel and No. 1 Crossbar offices can be served.

This traffic is handled at crossbar tandem by PCI trunks and senders. The sender is arranged to delay outpulsing on these calls until it has received a go ahead signal from the operator.

4. Centrex Features

a. Inward Dialing

The association of crossbar tandem and PBX's (Private Branch Exchange) is shown in Figure 7-21. It is possible to employ crossbar tandem to dial direct to PBX extensions where a central office code is shared by more than one PBX. This is accomplished by assigning to the PBX a number series within a central office code used for PBX purposes at the crossbar tandem, with each extension assigned a standard seven digit number. As many as sixty P.B.X.'s can share one central office code. The marker will recognize the shared office code and arrange for six-digit translation using the office code and first three digits of the extension number. This permits reservation of numbers in groups of ten, so that the entire number series is used most efficiently.

For P.B.X. indialing, six digit translation is required for local type codes that are assigned to more than one P.B.X. and on a nonshared basis when the number of digits to be outpulsed to that P.B.X. varies on different calls. For example, six-digit translation is required on nonshared codes when the tandem office does not outpulse any digits to reach the P.B.X. attendent (access to the attendent is on a separate trunk group) and does outpulse one to four digits to reach the extension. Two marker seizures are required on indialed calls requiring six-digit translation.

If a home area code plus an office code that is shared by several P.B.X.'s is received in the tandem, the marker sets up a connection to an appearance on the office link frame which is connected back through the office to the incoming trunk. This "loop around" operation causes the home area code to be deleted during the first connection through the office so that the call can be completed to the P.B.X. in the usual manner during the second connection. Three marker seizures are generally required for this type of call.

5. Other Features of Crossbar Tandem

In addition to the major adjuncts to basic crossbar tandem, toll, CAMA and the Traffic Service Position, there are a number of other features or changes of significance, many of which have been added recently to the tandem switching system. Most do not involve extensive new equipment as such, but rather changes or additions to already existing equipment. Of note is the following, with some mention of the equipment area affected:

a. PBX In and Out Dialing

This feature promotes means for dialing to and from PBX extensions without calling in the PBX attendant. For indialing each extension is assigned a 7-digit number which may be dialed by any authorized customer on either a local or toll basis. The first three digits make use of an unused office code in the area and several PBX's can share these digits by assigning each a block in the 10,000 numbers.

For outdialing the extension will dial an exit code (usually "9"), receive second dial tone from crossbar tandem and then proceed with dialing on local, toll or assistance calls in the usual way. Charging is by message register on one message unit nonovertime calls and by CAMA on all others.

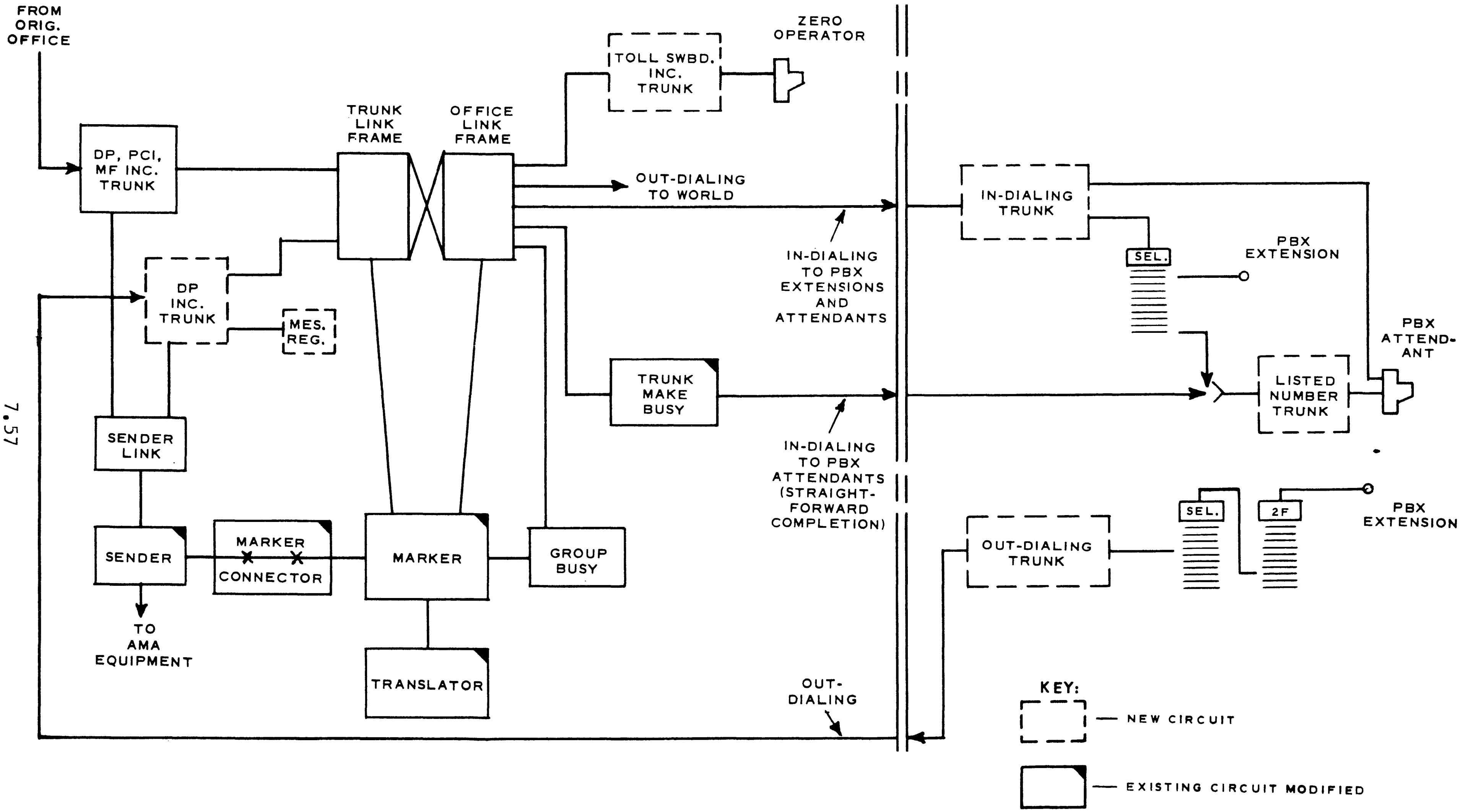


Figure 7-21 PBX In- and Out- Dialing Through Crossbar Tandem

E. CENTRALIZED AUTOMATIC MESSAGE ACCOUNTING

Centralized Automatic Message Accounting (CAMA) features have been introduced into the crossbar tandem system making it possible to provide the centralized facilities of AMA to all offices using the tandem office. Figure 7-22 depicts crossbar tandem with the first version of CAMA. A broader and more detailed description of CAMA is given in Chapter 14. However, in a limited manner, it would be appropriate to add that when a crossbar tandem office is arranged for AMA, additional functions and frames are required to record data for billing purposes and to complete special calls with the aid of a traffic service position operator. Billing data is recorded as perforations on paper tape as are local offices arranged for AMA. The tapes are processed in accounting centers on the same machines used in processing local AMA tapes.

The elements of an AMA call recorded for billing purposes include the called and calling subscriber numbers, the time of answer, the time of disconnect, the called area, message billing index, and the trunk number.

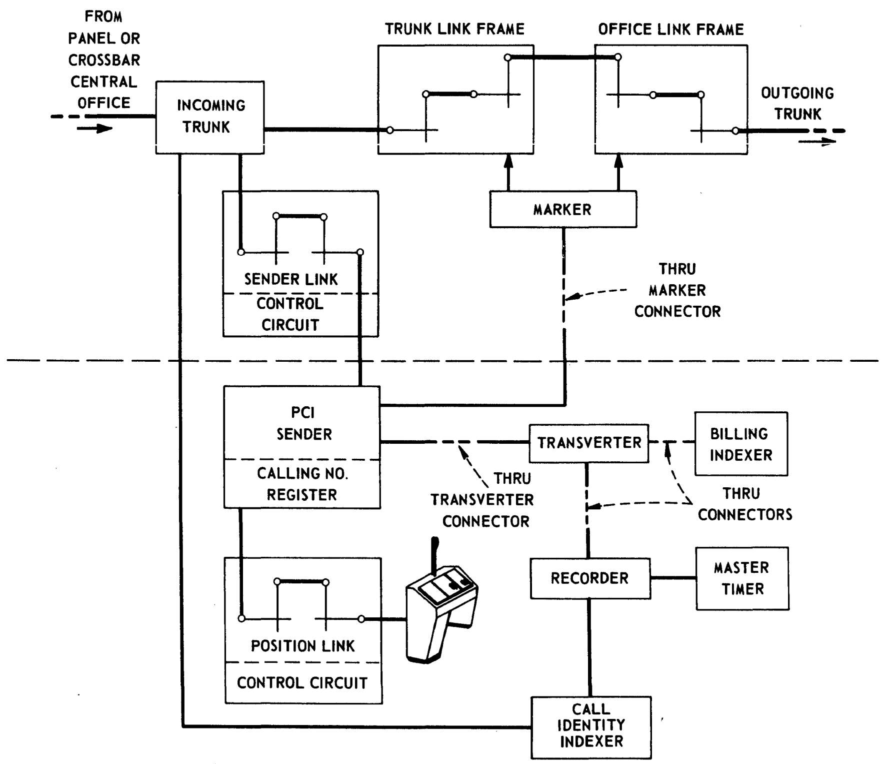


Figure 7-22 Functional block diagram of crossbar tandem with the first version of CAMA

On AMA calls, the calling number may be registered by an operator or by multifrequency pulsing from an originating local office arranged for automatic number identification. For operator identified calls, the sender causes the position link to connect the subscriber to an operator at the CAMA switchboard.

The AMA equipment consists primarily of a switchboard, perforators, position links, transverters, master timer, transverter connector, billing indexer, recorder, call identity indexer, 3-digit incoming register and link, sender register connector, 10-digit incoming register and link, data transfer, rater, timer link, and charge computer frames. The three digit incoming register and link (3-digit register) and its associated sender register connector are used in step-by-step areas to avoid second dial tone. The 10-digit incoming register and link equipment is also used in step-by-step areas; however, all digits are registered in the register and upon completion of dialing, this information is transmitted to the MF sender by way of the data transfer circuit.

CHAPTER 8

NO. 5 CROSSBAR SYSTEM

8.1 INTRODUCTION

The No. 5 Crossbar system was originally developed to fill a need for a system especially suitable for isolated small cities and for residential areas on the fringes of large cities. The design of the system was influenced by the special characteristics of telephone traffic in these regions. The percentage of calls completed to subscribers in the same office was expected to be relatively high. It was recognized that the system would have to interconnect with existing offices of all types. In addition, the tendency toward extension of dialing areas indicated that a local system with some provision for tandem or intertoll switching would simplify trunking, relieve the load on regular tandem offices, and reduce backhaul. This meant that where toll requirements are small, the No. 5 office could be established as a toll center with control switching point (CSP) features. Finally, the new concept of extended subscriber dialing demanded automatic recording of call details.

In addition to the requirements outlined above, the system also has built into it other features that adapt it to new concepts of telephone service. Improvements and added features have widened the application of the No. 5 equipment. It is presently being used to handle traffic that varies from large metropolitan business exchanges to small rural centers of a few hundred lines.

The No. 5 Crossbar system is first of all a highly efficient local telephone switching system which can operate with all present local, tandem, and toll switching offices, except that it cannot direct calls through a panel 2-wire office selector. Table 8-1 shows the usual kinds of pulsing, or manner of operation, for the various combinations of No. 5 Crossbar and connecting offices.

No. 5 Crossbar has several features that distinguish it from previous local systems. The more important ones are:

a. Utilization of common control to a higher degree than any other electromechanical system

TABLE 8-1

TYPE OF PULSING USED BETWEEN NO. 5 CROSSBAR OFFICES AND OTHER TYPE OF OFFICES.

Type of Connecting Office	No. 5 Crossbar Office Type Received	No. 5 Crossbar Office Type Outpulsed
No. 5 Crossbar	MF DP RP FSP	MF DP RP FSP
No. 1 Crossbar	RP MF	MF RP DP
Crossbar Tandem	MF DP RP	MF DP RP PCI
No. 4 Toll Crossbar	MF DP	MF DP
Panel	RP MF	RP
Panel Distant Office Tandem	RP	No Provision
Panel Sender Tandem	RP DP	PCI
Step-by-Step Local	DP MF	DP MF
Step-by-Step Intertoll	DP MF	DP MF
Manual Local	MF	PCI Straightforward
Manual Toll	MF DP	Straightforward PCI

LEGEND: DP - Dial Pulsing PCI - Panel Call Indicator
MF - Multifrequency RP - Revertive Pulsing
FSP - Frequency Shift Pulsing

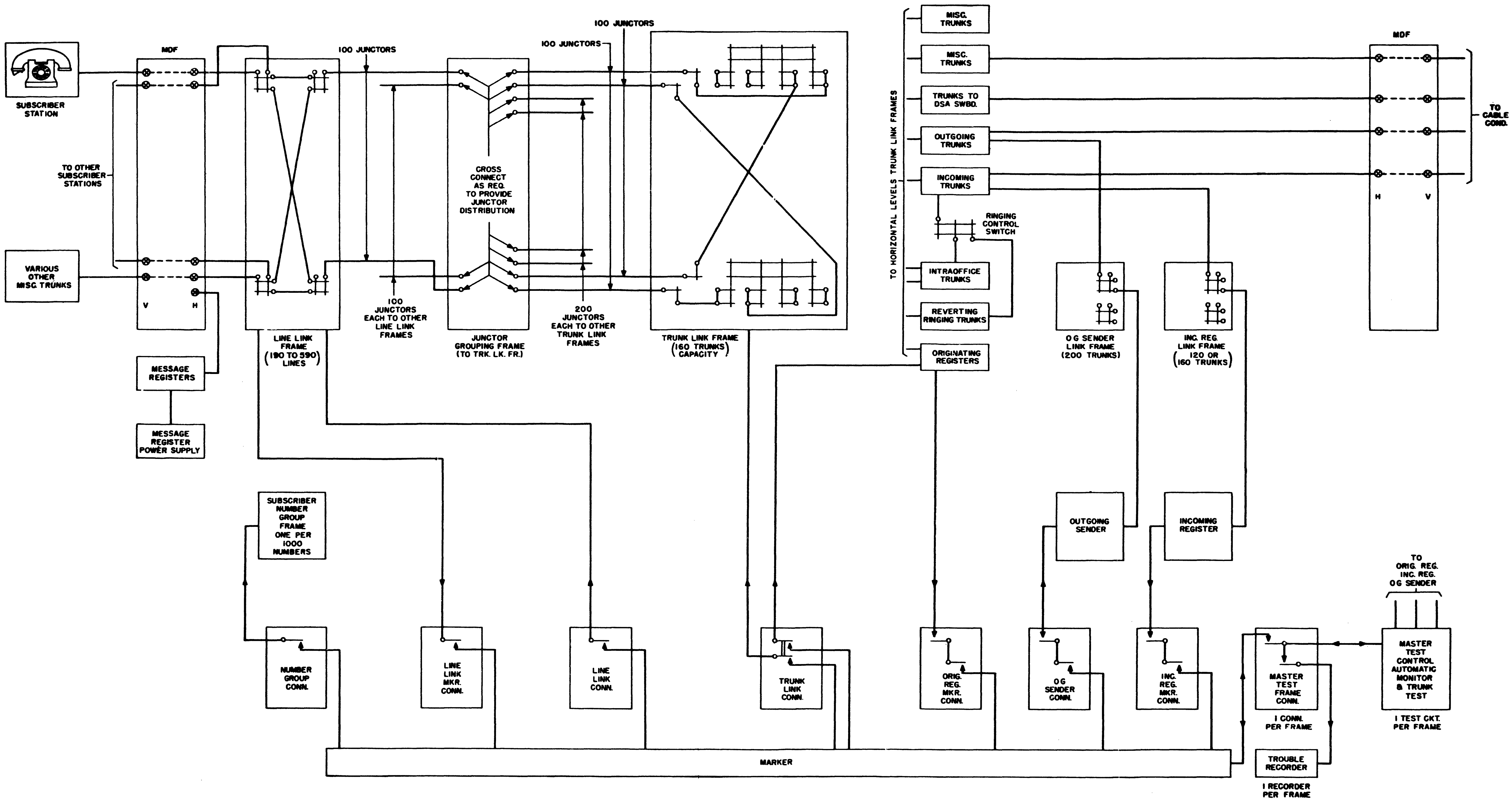


Fig. 8-1 - Equipment Schematic of No. 5 Crossbar Office

Figure 8-1

b. A unique switching plan. A single switching train is used for all traffic whether incoming or outgoing, or switched through.

c. Improved distribution of usage over various equipment units by means of rotating sequence and memory circuits.

d. Provision of toll and tandem switching features with the same common control equipment as is used for local traffic.

e. Improved trouble detecting features including automatic recording of failures on punched cards and automatic monitoring of pulsing circuits.

f. Provision of features essential to the expansion of operator and customer toll dialing; eleven digit capacity, alternate routing, code conversion, marker pulse conversion, six digit translation, and other similar features.

8.2 SWITCHING PLAN

The No. 5 system uses the fundamental two link frame, four-stage, switching network, but unlike other familar systems, employs a single switching network to handle all types of calls; incoming, outgoing or switched through. In addition, the connection of the subscriber to the dial register circuit is also made through this switching network. This eliminates the line link and sender link controllers, as well as the sender link frames required in the No. 1 Crossbar system. The functions of the controllers has been transferred to the markers while the function of the sender link frames has been consolidated with the switching network. A generalized block diagram is shown in Figure 8-1.

A. LINE LINK

The crossbar switches on the line link frame are divided functionally into line switches and junctor switches, as shown in Figure 8-2. Subscriber lines are connected to the line switch verticals. Line links, which are merely connecting wires, interconnect the line switches and junctor switches in a standard linkage pattern of 100 links. The basic line link frame provides 290 line terminations, ten no-test verticals and 100 junctor terminations. Since the calling rate and holding time habits of subscribers may vary widely in different areas, provision is made for adding supplementary line switch bays of 100 or 200 line capacity in order to increase the line capacity of the frame to meet traffic requirements. These supplementary bays will increase the capacity of the basic frame from the 290 line minimum to 590 the line maximum. Figure 8-3 illustrates schematically a line link frame arranged for 490 lines. With the introduction of the wire-spring line link frame, a feature was added whereby line switch bays may be split between two line link frames. This feature along with the change in the size of the basic frame from a two-bay to a possible one-bay frame permits the line link frames to be furnished in sizes varying from a minimum of 190 lines and 10 no-test verticals to a maximum size of 590 lines and 10 no-test verticals, in increments of 50 lines. Line link sizes in 50 line increments are illustrated in Figure 8-4.

The line link frames just described are the frames that are used for two-wire subscriber lines or trunks. When it is necessary to switch four-wire traffic, a separate network, using line link frames of 190 line capacity using 5-wire switches is furnished.

Line links appear on the horizontals of the switches; ten line links on each switch. These ten line links are distributed among the ten junctor switches, one link to one horizontal on each of the ten junctor switches in a standard linkage pattern. This system of links permits each line on a line link frame to reach anyone of the 100 junctors serving that frame.

In addition, to the switches, line relays and control relays are also mounted on the frame. The hold magnets on the line switches are equipped with off-normal springs which serve as cutoff relays for the line circuit.

No. 5 Crossbar differs from earlier systems in that the same link frame can serve customers who have various classes of service. For example: flat rate, message rate, or coin. In the initial design, provision was made for a maximum of 30 classes of service on each line link frame and the associated marker group. As the system further developed and new features and services were introduced, the number of classes of service were also increased; first to 60 classes and ultimately to 100 classes, with 20 treatments for each class of service.

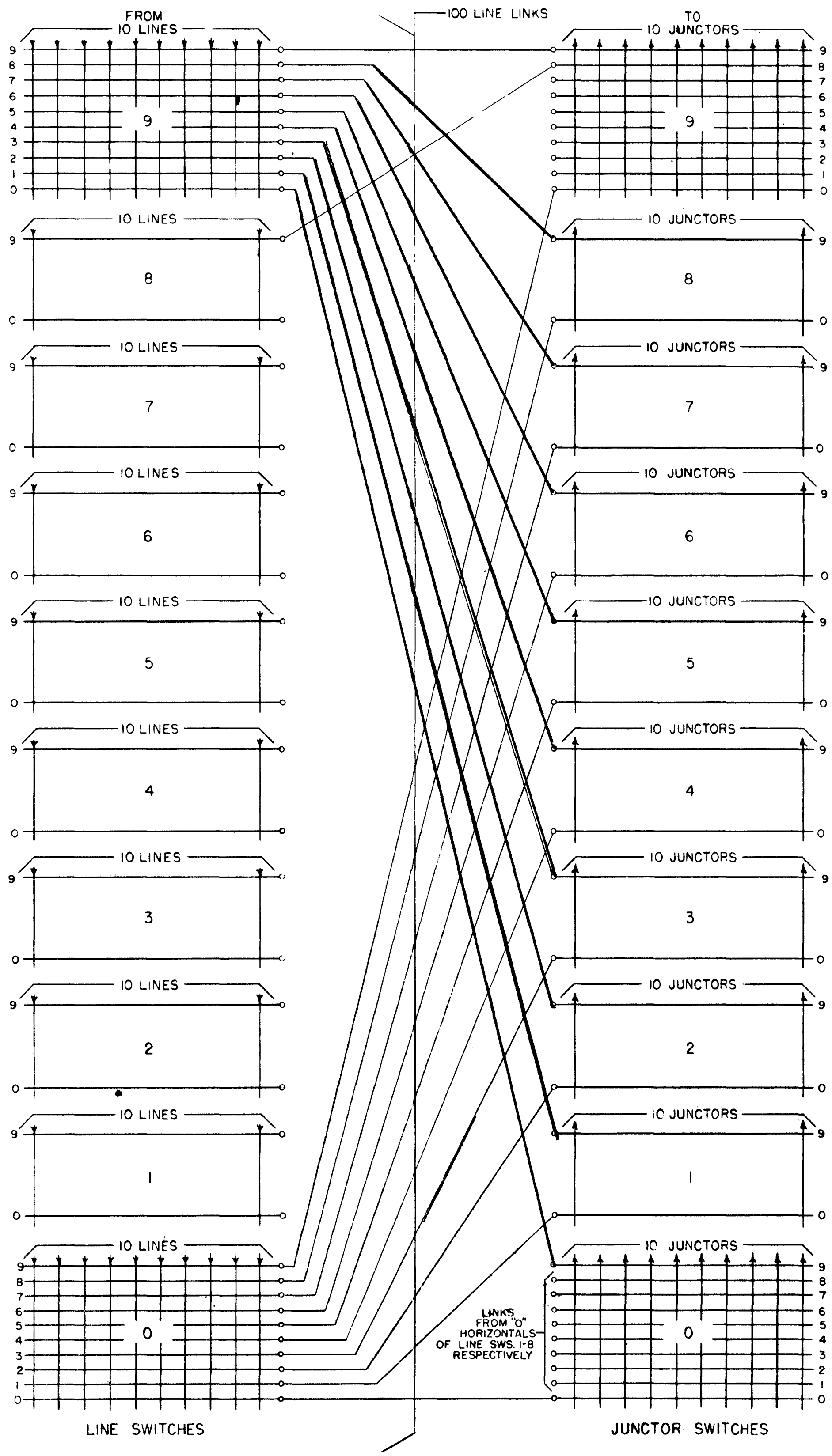


Figure 8-2 - Line Link Distribution

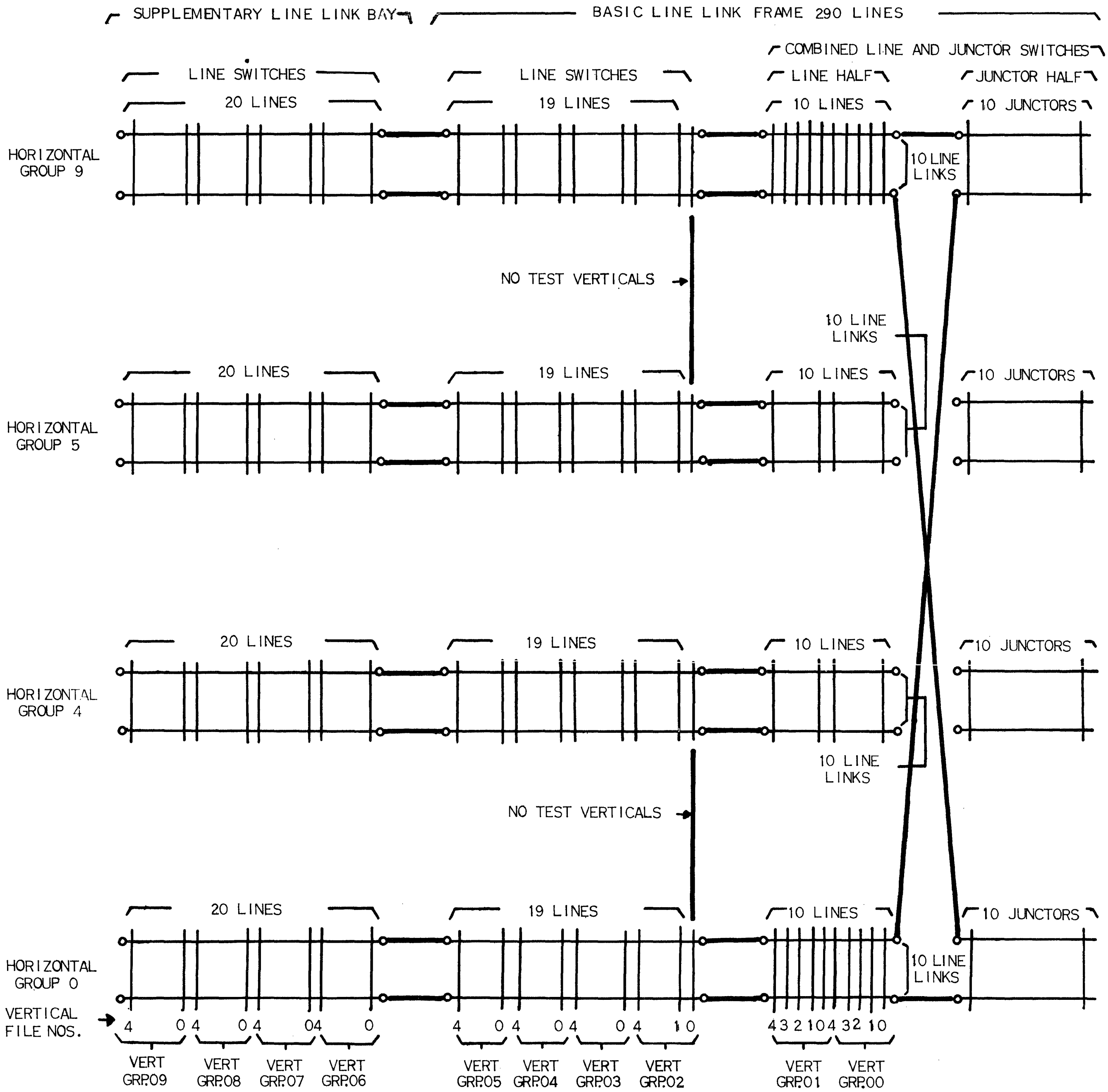


Figure 8-3 Line Link Frames Schematic Frame Arranged for 490 Lines

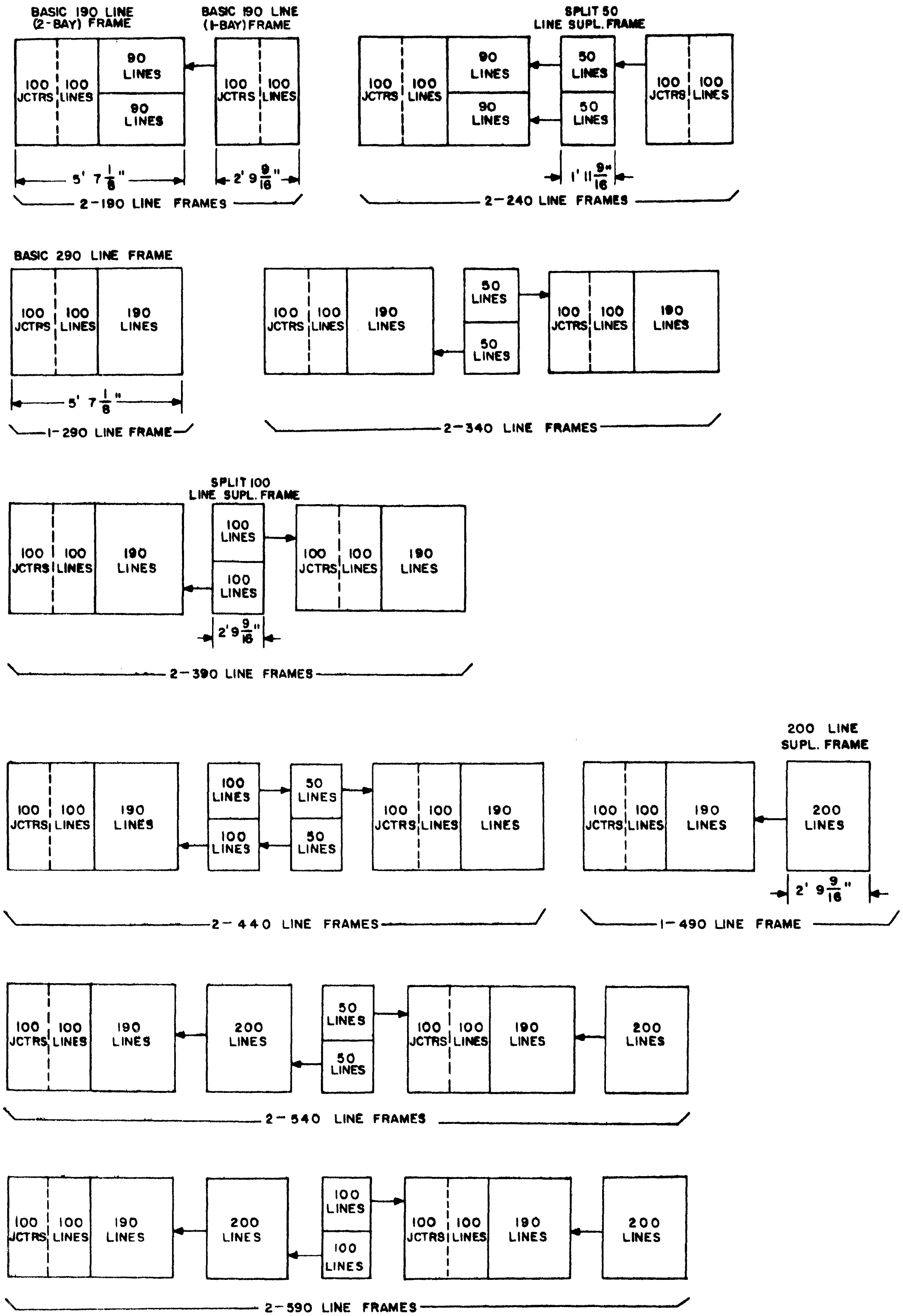


Figure 8-4 - Association of Line Link Basic and Supplementary Frames for 50-line Increments

B. TRUNK LINK

The crossbar switches on the trunk link frames are divided functionally into junctor switches and line switches, Figure 8-5.

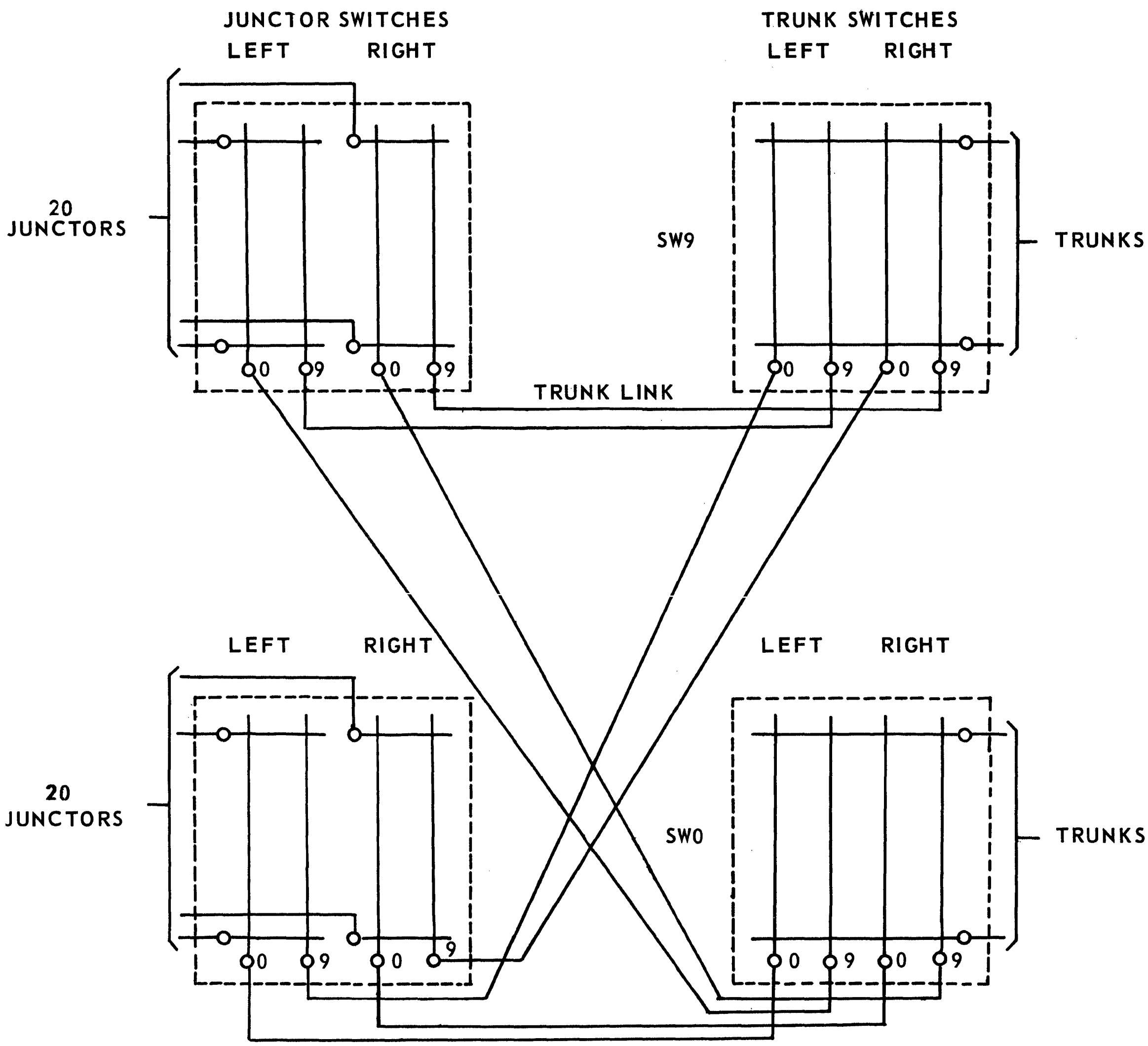


Figure 8-5 Trunk Link Distribution

Originating registers and trunks are connected to the trunk switch horizontals and junctors to the junctor switch horizontals. Trunk links, which are merely connecting wires, interconnect the junctor switches and the trunk switches.

The basic trunk link frame is a two-bay framework with each bay mounting ten 200 crosspoint switches. The 10 switches in one bay are six-wire switches and are used to provide terminations for 160 trunks.[1] The ten 200 point switches on the other bay are three-wire switches, used as junctor switches. While these switches are physically 200 crosspoint switches, their horizontals are split between the 10th and 11th vertical so that electrically there are 20 switches of the 100 crosspoint size. 200 junctors from the line link frame are terminated on the 20 horizontals of these 20 junctor switches. The junctor switches are designated 0 to 9, left and right.

The system of trunk links that permits any trunk on the trunk link frame to be connected to any of the 200 junctors serving that frame is similar in principal to that used on the line link frames. The links from the left junctor switches are terminated on the verticals on the left half of the trunk switches while the links from the right set of junctor switches are terminated on the verticals on the right half of the trunk switches.

Each line link frame has 100 junctor terminations which are used to connect to the trunk link frames in the office. Since each trunk link frame has 200 junctor terminations for connecting to the line link frames, the ratio of line link frames to trunk link frames in an office is generally 2 to 1. There are no half frames. In an office with 13 line link frames for example there would be seven trunk link frames.

The 100 junctors from each line link frame are divided into approximately equal groups, with one group going to each trunk link frame. The number of junctors in a group depends on the number of trunk link frames in the office. However, there will always be a minimum junctor group size of ten junctors for access from one line link frame to any particular trunk link frame.

When there are ten or fewer trunk link frames in an office, each junctor group has ten or more junctors. For example, in an office with eight trunk link frames and 16 line link frames, each junctor group contains either 12 or 13 junctors. Figure 8-6 illustrates the junctor distribution for two trunk link frames and four line link frames.

[1] The 160 trunk capacity is for two-wire trunks; however, when four-wire trunks are required, a 200 trunk capacity arrangement is used consisting of a basic 100 trunk frame and a 100 trunk buildout frame.

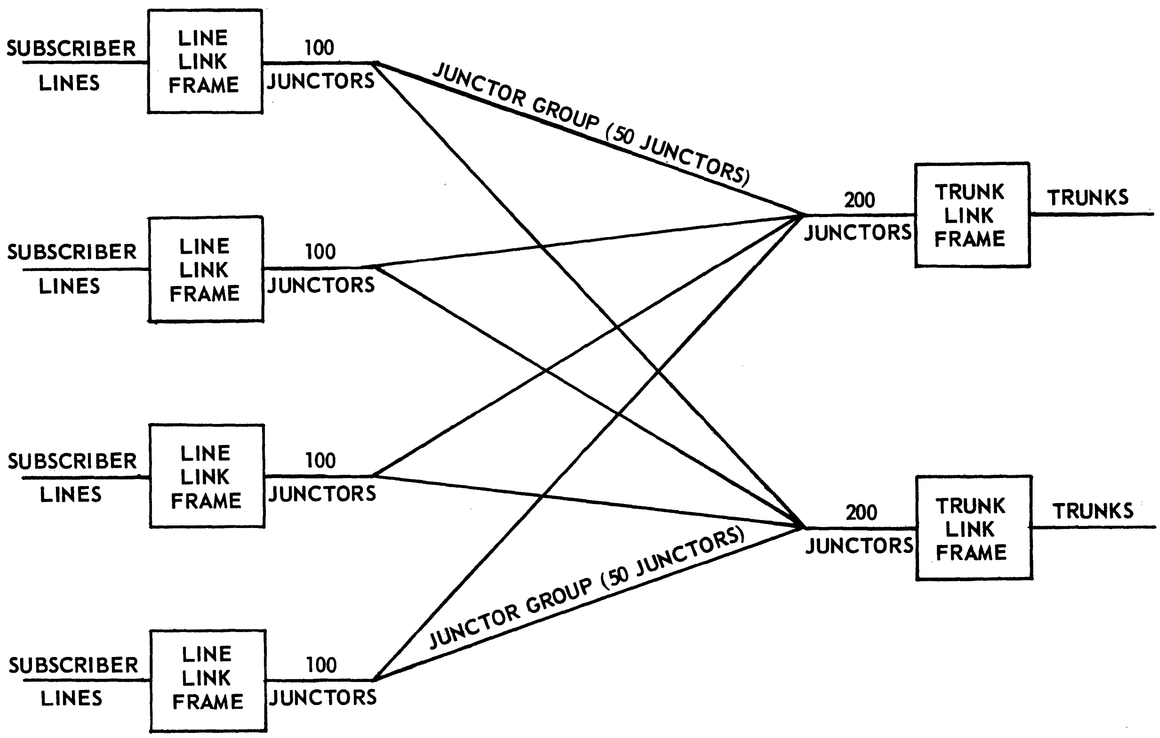


Figure 8-6 Junctor Distribution (4 Line Link and 2 Trunk Link Frame)

However, in an office with 11 to 20 trunk link frames, each junctor from the line link frames are multipled to two trunk link frames in order to have at least ten junctors per group. In order to accommodate the two appearances on the trunk link frames it is necessary to provide additional junctor switches, for the trunk link frames. These additional switches are mounted on the extension trunk link frame. In an office with 20 trunk link frames and 40 line link frames, each junctor group contains 10 junctors. Figure 8-7 illustrates the junctor distribution for 20 trunk link frames and 40 line link frames. In this case, the number of junctors in a group is determined by dividing 100 by the number of pairs of trunk link frames. The maximum office size is 60 line link frames and 30 trunk link frames. In an office of this type the trunk link frames are furnished in groups of three.

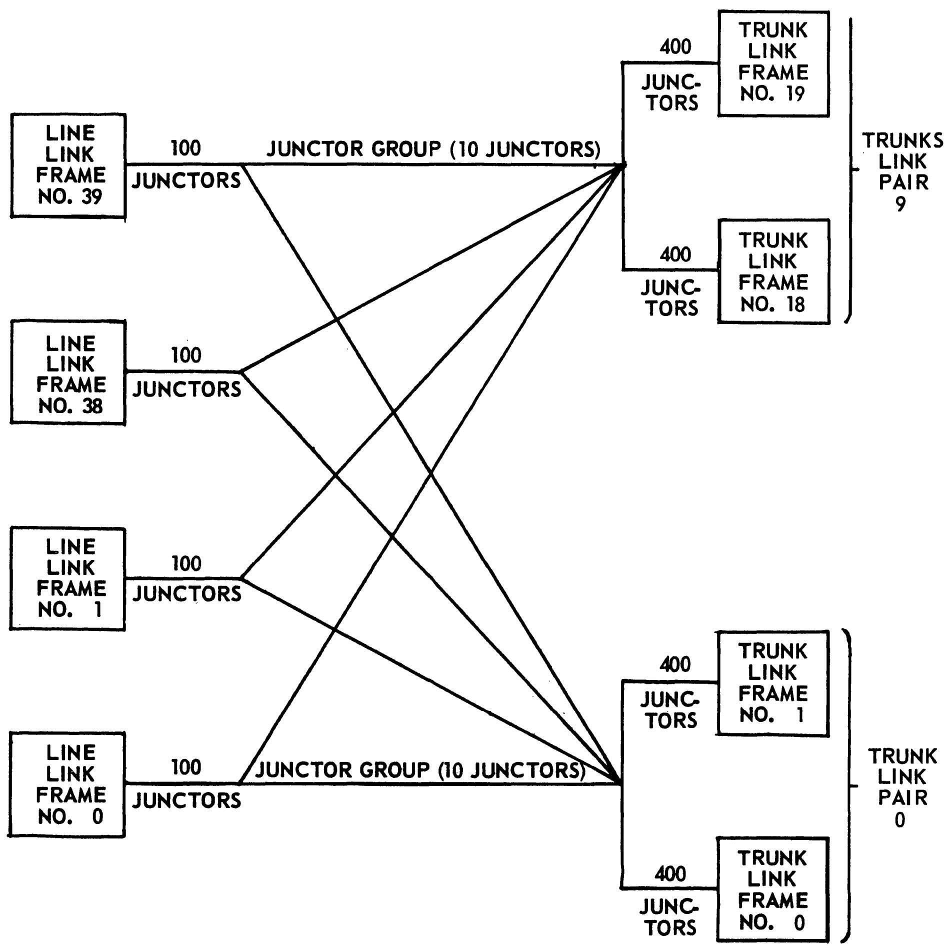


Figure 8-7 Pairing of Trunk Link Frame (40 Line Link and 20 Trunk Link Frames) Initial Installation.

C. EXTENSION TRUNK LINK

As stated previously, when 11 to 20 trunk link frames are involved, each junctor is multipled to two trunk link frames in order that each junctor group contain a minimum of ten junctors. This requirement reduces the junctor capacity of the basic trunk link frame by 50 per cent, and it is therefore necessary to provide additional junctor switches for each trunk link frame in order to balance the traffic between junctors and links. These additional switches are mounted on the extension trunk link frames which, if possible, are located adjacent to the junctor switch bay of the trunk link frame. The extension frame consists of ten 200 point switches, the same as the junctor switches on the trunk link frame. These switches have their horizontals split and have a capacity for 200 junctors on the horizontal of the ten electrical switches. These 200 junctors and link terminations along with the 200 junctors on the trunk link frame provide a total of 400 junctors for the combination.

When an office has from 21 to 30 trunk link frames, two extension trunk link frames are associated with each trunk link frame; now by furnishing the trunk link frame in groups of three, there will be 600 links and 600 junctors per group. The 600 junctors from the ten groups of trunk link frames will accommodate the 6000 junctors from the 60 line link frames.

1. Channels

A channel is a combination of a line link, a junctor, and a trunk link that can be formed by crosspoint closures, into a transmission path that interconnects a line and a trunk. Each line link, junctor, and trunk link consists of a tip, ring, and sleeve lead with a switch appearance at each end.

The ten or more junctors in a group connecting a line link frame with a trunk link frame are distributed over the ten junctor switches of both the line link and trunk link frames, the junctor switch number being the same on both ends of each junctor. There are ten line links serving each particular subscriber line on the line link frame, and these are also distributed over the ten junctor switches. A typical channel for a 20 line link arrangement is shown in Figure 8-8. The line link to trunk link channel distribution is shown in Figure 8-9.

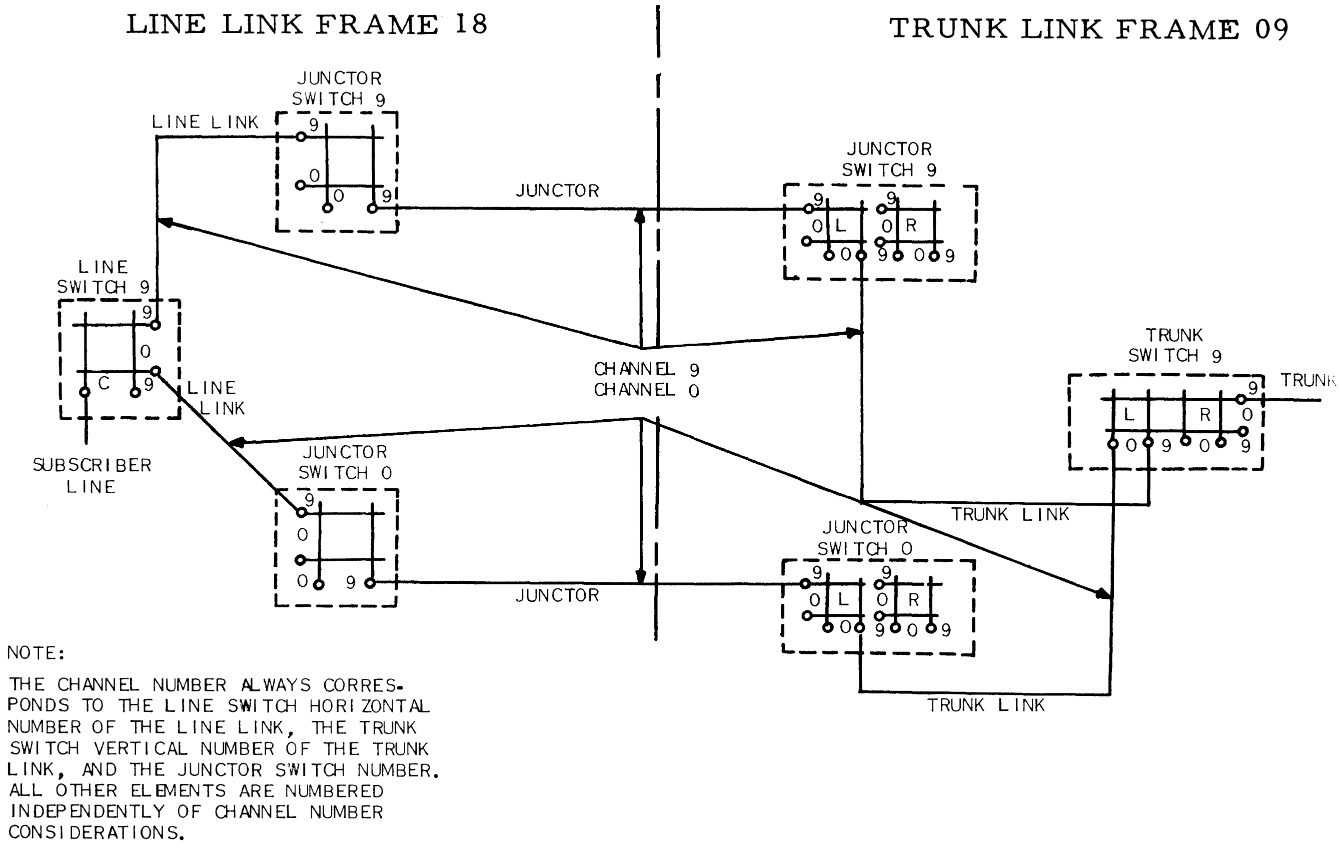


Figure 8-8 Channels for 20 Line Link-10 Trunk Link Frames

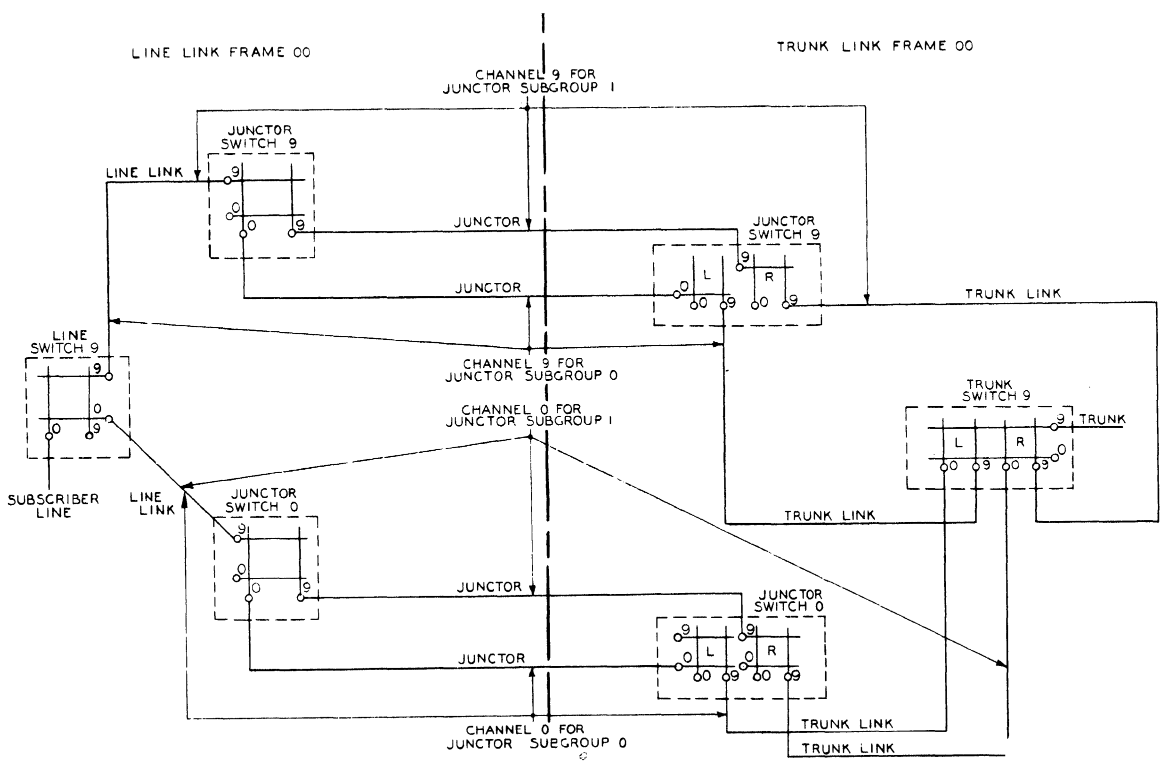


Figure 8-9 Channel Distribution -- Line Link to Trunk Link Frames

D. TRUNKS

The following is a list of principal categories of trunks. Many miscellaneous types are not listed.

(1) Intraoffice trunks handle traffic between customers served by the same marker group[1]. Each trunk requires two trunk link frame locations, an A appearance for the calling customer, and a B appearance for the called customer. These trunks are usually divided into three groups; message rate (AMA or message register), flat rate, and coin.

(2) Outgoing interlocal trunks are used to transmit calls outgoing from the No. 5 Crossbar office to a connecting office. The types of outgoing trunks used depend on the traffic in an individual office. Usually, there is one group of trunks for flat rate and message rate traffic and another for coin traffic.

(3) Incoming interlocal trunks carry the traffic incoming to a No. 5 office. There are two general types of these trunks, namely nontandem and tandem. The nontandem-type trunks carry only the calls completing to customers in the office, and these trunks have one location in the office. This location is on the trunk link frame. The tandem-type trunks carry calls completing to customers in the office and also calls which are switched through when the No. 5 office functions as a tandem switching point. Tandem trunks have two frame locations in the office, one on the line link frame for switching calls through, and the other on the trunk link frame for calls that terminate in the tandem office.

(4) Two-way interlocal trunks are provided on small trunk groups when it is uneconomical to use one-way trunk groups. The trunks are arranged for bylink operation with either loop or CX (E and M lead) signaling to SXS offices.

[1] A common group of markers which serve one or more central offices. A marker group is arranged to handle a maximum of six office code groups spread over six number series with a maximum of 40,000 numbers. The term marker group is also used to refer to the equipment served by a marker group.

(5) Intermarker group trunks handle traffic between two No. 5 Crossbar marker groups located in the same building. The following three types of trunks are used for this traffic.

(a) Customer to customer.

(b) Customer to trunk.

(c) Trunk to customer.

(6) Operator, special service, and recording completing trunks are used by DSA operators to handle assistance traffic. There are usually separate groups of trunks for various classes of service.

(7) Tone trunks are used to give line busy on intra-office call, overflow, (paths busy), partial dial, and vacant code tones. Again there may be coin and noncoin groups of these trunks.

(8) Common overflow trunks are provided as a final route when all permanent signal holding or non-coin combination tone trunks are busy or to return an announcement when dial tone delays are excessive under extreme conditions. This trunk returns a reorder (120 IPM) signal to a calling party.

(9) Intertoll trunks are used to switch toll calls between toll centers. These trunks are of three general types, as follows.

(a) One-Way Incoming Trunks: These have three frame locations in an office: two line link frame locations for calls switched through the No. 5 office as a toll center, and one trunk link frame location for calls terminating in the toll center.

(b) One-Way Outgoing Trunks: These have one trunk link frame location for calls outgoing from the No. 5 office as a toll center, and one jack location at the toll switchboard for operator-handled outgoing calls.

(c) Two-Way Trunks: These have all of the locations mentioned above.

Since interlocal and intertoll trunks employ different supervision and inpedance characteristics, one type may not be switched directly to the other type without conversion arrangements.

(10) Junctor Circuits: These circuits are combinations of outgoing and incoming trunks in the No. 5 office, permanently wired back-to-back, or their equivalent in design. Their functions are as follows:

(a) Operator Junctor: This circuit functions to complete calls on a tandem basis from a switchboard located in the same building as the No. 5 switches to customers located in other local offices.

(b) Operator Toll Junctor: The functions of this circuit are similar to those of the operator junctor, except that the trunks involved are of the intertoll type.

(c) Coin Junctor: This circuit functions to provide for coin operation (coin collect, coin return, coin test, etc.) for local coin calls to be routed over outgoing trunks not arranged for each coin service.

(d) Coin Zone Junctor: Besides being capable of performing the functions of a coin junctor, this circuit is arranged to call in an operator for the initial and overtime charges for coin zone customer-dialed calls.

(e) Message Register Junctor: This circuit functions to provide message register charging facilities for customer calls to be routed over trunks not arranged for message register service.

(f) AMA Junctor: This circuit functions to provide AMA charging facilities for customer calls to be routed over trunks not arranged for AMA service.

(11) Coin Supervisory Circuits

Coin supervisory circuits handle all the coin operations except those taken care of by the originating register. In operation, when required, one of these circuits is connected to a trunk that is serving a coin call. The duties of this circuit are to collect the coins at the end of a completed call for which a charge is made, and to effect coin return when the call is not completed or is one for which no charge is made.

In offices with coin overtime, this circuit makes coin test and collects the coin for the initial and subsequent periods. If a deposit is not made for an overtime period, the circuit signals for an operator to come in on the connection.

E. COIN SUPERVISORY LINKS

These links connect coin trunks to coin supervisory circuits. The frame is similar to the incoming register link frame, and the circuit arrangements are the same. However, because the holding times of coin supervisory circuits with coin trunks are very short, a group of ten coin supervisory circuits can serve as many as 480 trunks.

F. MESSAGE REGISTER

Calls involving one message unit may be recorded by AMA equipment or on message registers.

Message registration is accomplished over a single-sleeve lead which permits line link frames with 3-wire switches to serve all classes of lines. The message register service charging arrangement involves a cold-cathode vacuum tube. Selective operation of either a tip-party or a ring-party register on 2-party lines is obtained.

A distinguishing feature of the switching train is that, unlike other local systems, supervisory and charging circuits are not an integral part of the switching train, as in the case of the panel district selector or the No. 1 Crossbar district junctor circuit. The supervisory and charge features are functions of the various trunk circuits which connect to the trunk levels of the trunk link frames. By this arrangement trunks may be provided in type and quantity as dictated by the requirements of a particular telephone company.

8.3 CONTROL EQUIPMENT

A. MARKERS

The marker is the most active piece of common control equipment in the office. It is used one or more times in the completion of every call. Different offices have various numbers of markers depending on the size of the office and the amount of traffic. All the markers and their associated equipment serve up to a maximum of 40,000 numbers, make up a marker group.

There are three types of markers: (a) combined (manfacture discontinued), (b) dial tone, and (c) completing. The combined marker performs all the marker jobs while the dial tone and completing markers divide the jobs of the combined marker between them.

The dial tone marker, as the name implies, is used exclusively on dial tone connections while the completing marker performs all the other marker jobs. Economic and traffic conditions determined whether an office had a single group of combined markers or a subgroup of dial tone and a subgroup of completing markers. In general, the combined marker proved more economical only for very small installations, such as those requiring three or less markers. Small installations now use an Originating Line Identifier Unit and its associated completing marker for establishing the dial tone connection.

Each marker normally completes each of its various functions in less than one second; therefore, a small number of markers can serve a large office.

The principal functions of the dial tone marker are:

(a) To respond to demands for dial tone by determining the location of the calling line on the line link frame.

(b) To establish a connection between the calling line and an originating register.

(c) To transfer the calling line location and customer class-of-service information to the originating register. (The register stores this information and after dialing is completed, passes it to a completing marker for use in routing and recording the call.)

The principal functions of the completing marker are as follows:

(a) To determine the proper route for the call from the area or office code digits of the called number and the class of service of the calling customer.

(b) To establish the connection from a calling customer to a trunk or from a trunk to a called customer.

(c) To connect to the proper number group to determine the location of the called line on the line link frame.

(d) To determine from the class of service and the destination the proper charge condition for the call.

(e) When outgoing pulsing is required, to select an outgoing sender of the proper type. The marker then passes information to the sender which the sender transmits when the connecting office equipment is ready.

(f) To recognize line busy, vacant numbers, and intercept conditions, and to control hunting operation in terminal hunting groups.

(g) To complete a call regardless of certain trouble conditions.

(h) To call in the trouble recorder which makes a record of the marker progress if its operation is abnormally delayed or if certain trouble conditions are encountered.

Special Features in the Marker

Two markers (0 and 1) in a group of combined or completing markers are usually equipped with special features for handling certain test calls. These calls are set up by operators, testmen, or maintenance men and are of the following types:

a. No-test calls originated at the test desk or a DSA switchboard.

b. No-hunt calls originated at the outgoing trunk test frame or the message register rack.

c. Special hunt test calls originated at the local test desk.

B. ORIGINATING REGISTERS

Originating registers furnish dial tone to subscribers and record the digits that are dialed. After dialing is completed, the called number is transmitted from the register to the marker. These registers also make party test to determine whether a tip or ring party is making the call. Originating registers appear on trunk link frames and are connected to the subscriber's line by the combined or dial tone marker when the customer lifts the receiver off the hook. A No. 5 Crossbar office which includes any coin lines must have all the originating registers in the office arranged for coin operation.

C. PRETRANSLATORS

Pretranslator circuits may be provided in offices located in areas where some calls require the dialing of more digits than others. The originating register circuit may be arranged to seize the pretranslator after either the second or third digit has been dialed. From these digits, the pretranslator determines how many more digits the register should expect before seizing a marker.

When the volume of calls of this nature is not great and the numbering plan is not too complex, pretranslation can take place in the originating register. The register can be arranged to determine how many digits it should receive from the first digit or from a limited combination of the first and second digits.

On calls to stations where a party letter is part of the directory number, the register has to wait for an extra digit. This situation is known as stations delay. The pretranslator recognizes stations delay from the dialed code and informs the register to wait for a possible additional digit. If the No. 5 office handled FACD (Foreign Area Customer Dialing) traffic, pretranslators are always required.

D. NUMBER GROUPS

The number group translates subscriber directory numbers into line equipment locations of subscriber lines. (The line equipment location identifies the line link frame location of a subscriber line.) The number group also supplies the proper ringing control information and other information concerning the called number, such as whether it is in a terminal hunting group or in a physical, theoretical or extra theoretical office.

A number group serves 1000 consecutive directory numbers. For example, one number group will serve directory numbers 2000 to 2999.

The number group is also used on tandem or toll through-switched calls. On these calls the number group supplies the marker with the line link location of the trunk seeking a path through the office. Each trunk requires two appearances in the number groups. Each trunk uses the same hundreds, tens and units numericals in each of the two number groups assigned to trunk numbers.

E. OUTGOING SENDERS

An outgoing sender is employed on all calls requiring pulsing to connecting offices. The marker transfers the required digits of the called number to a sender which is connected to an outgoing trunk. (The function of the sender is to furnish the pulses which control the operation of the switching equipment in the connecting office.) The type of connecting office (step-by-step, panel, manual, or crossbar) determines what kind of sender should be used to transmit the called number. Therefore, five different types of outgoing senders are provided in a No. 5 Crossbar office, as listed below:

a. Dial Pulse (DP)

b. Multifrequency (MF)

c. Revertive pulse (RP)

d. Panel call indicator (PCI)

e. Frequency Shift Pulse (FSP)

F. INTERMARKER GROUP SENDERS

The intermarker group sender is used for traffic between two different No. 5 Crossbar marker groups housed in the same building. It serves in two capacities; as an outgoing sender for the calling marker and as an incoming register for the called marker. These senders transfer information from one marker group to the other by means of connectors rather than by pulsing.

G. OUTGOING SENDER LINKS

Outgoing sender links connect outgoing and intermarker group senders to outgoing trunks. Information from a sender to a trunk is transmitted through this sender link.

One sender link frame mounts ten 200 point crossbar switches. All types of senders may be located on one sender link frame. The senders connect to horizontals, the trunks to verticals of the switches. Control is by the markers.

H. INCOMING REGISTERS

Incoming registers record the pulses on calls received over incoming trunks from operators or connecting offices. Since these pulses are incoming from various types of offices, the following different incoming registers are provided to record them:

a. Dial pulse (DP)

b. Multifrequency (MF)

c. Revertive pulse (RP)

I. INCOMING REGISTER LINKS

The incoming register links connect incoming trunks to incoming registers. This connection is made without the use of a marker. Information from incoming trunks to incoming registers is transmitted through these links.

The link frames use 200 point crossbar switches to connect a maximum of ten incoming registers of one type to trunks connected to verticals of the switches. The number of trunks served by a group of ten registers can be increased by associating several frames into a "link group."

Cross-connections associated with the individual trunks advise the selected register of the trunk's class and trunk link frame number. If the trunk is used for through switching, a trunk number will also be derived in the register. These facts about the trunk will be given to the marker to enable it to set up the call.

When the incoming register link frame handles calls dialed directly by subscribers in step-by-step offices, the connection from the trunk to the register through the crossbar switch may not be closed when pulsing of the first digit starts. For this type of call an early "by-link" path is provided through trunk and register preference relays to start registration of the first digit before closure of the final pulsing path through the link switch.

J. CONNECTORS

A connector is a relay-type switching device for interconnecting, for a short interval of time, two equipment elements by a relatively large number of leads.

A specific method is used in naming these connectors. If more than one type of equipment can originate action toward another type, the connector is named according to both the originating and terminating action; for example, in connectors such as the line link marker connector with the word "marker" in the title, the action terminates in the marker and is originated by the line link frame. The originating circuit must be mentioned because other circuits can originate action toward the marker. Other connectors of this class are the originating register marker connector and the incoming register marker connector. Eight principal types of connectors are shown in Figure 8-10.

Similarly, when only one type of equipment can originate action toward another type, the connector is named according to where the connector action terminates.

For this reason the connectors from markers to other frames do not contain the word "marker" in the title. Connectors in this class are the line link, trunk link, number group, and outsender connectors.

K. FOREIGN AREA TRANSLATORS

A foreign area translator frame and associated connectors contain circuits which operate in conjunction with the markers to permit routing calls to other national numbering areas if there is more than one trunk route available to the numbering area. Arrangements are provided for translation into a maximum of six foreign areas.

Where only one route is available to each numbering area, or one combined route is available for a number of areas, the marker can route calls to them without using the foreign area translator. However, if different AMA charge treatment is required for two or more destination codes reached over a single route to a foreign area, the foreign area translator will be required.

8.4 SYSTEM MAINTENANCE

The basic provisions for the maintenance of No. 5 Crossbar system offices consist of:

(a) Testing equipment for the various circuits and associated apparatus.

(b) Arrangements for providing evidence and information about failures occurring on service and test calls.

(c) Provisions for removing equipment from service.

The master test frame which incorporates all of the above features is located in the maintenance center. Included in the apparatus of this frame is a recording device which automatically provides, in the form of punched cards, both information concerning failures or service calls and the results of certain test calls.

Some of the other testing equipments used include:

(a) Test lines for use in making tests of the operating and signaling features of local and intertoll trunk circuits.

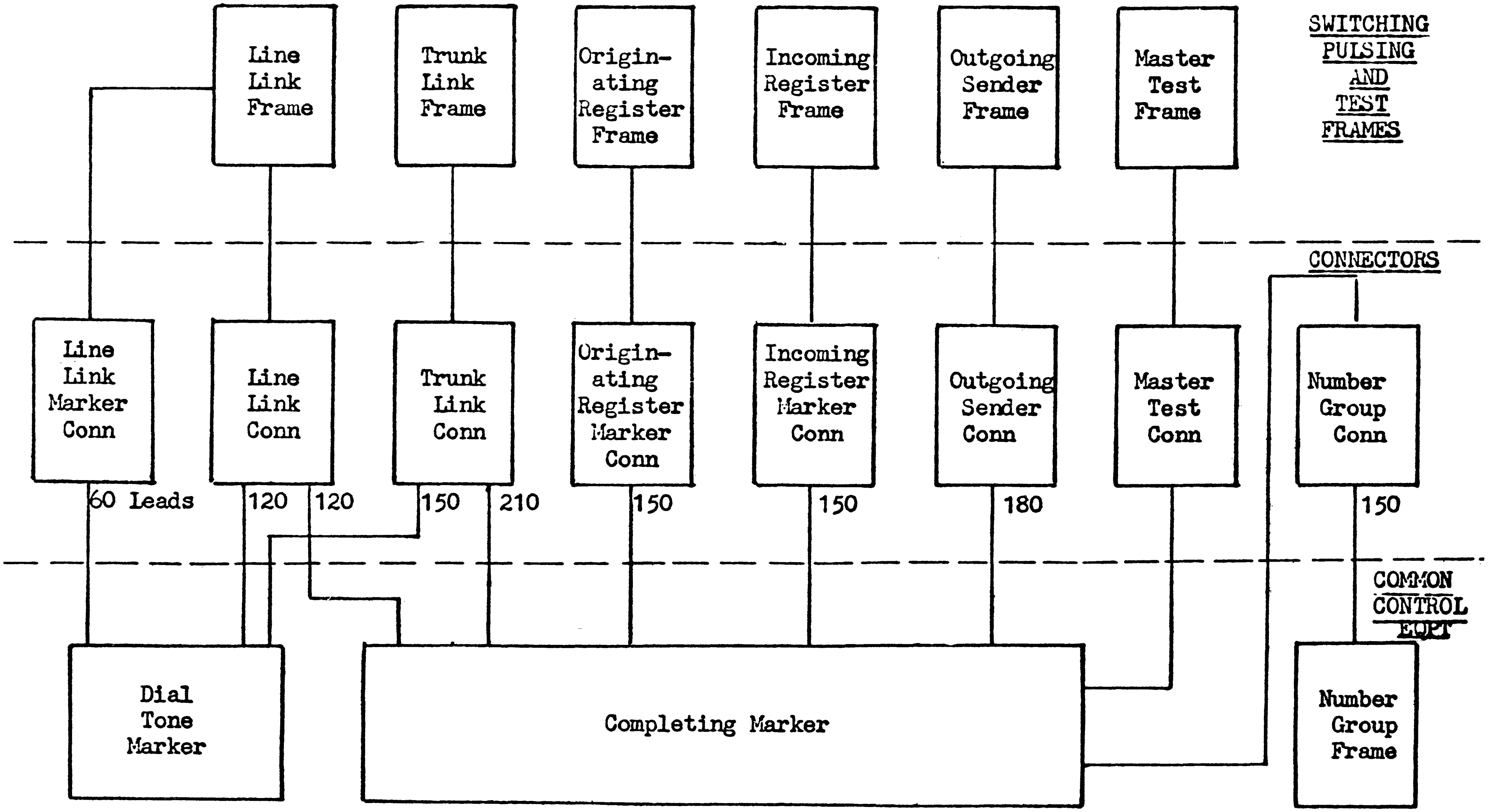


Figure 8.10 The Eight Principal Types of Connectors Used in the No. 5 Crossbar System

(b) Test circuits for checking foreign area translator code cross connections.

(c) Equipment for automatically testing intraoffice type trunks, customer to customer intermarker group type trunks, and outgoing interoffice type trunks.

(d) Several portable test sets.

An alarm system giving audible and visual signals is provided to alert the central office force of the occurrence of trouble conditions and to direct them to the proper location. The direction is accomplished by a pilot lamp indicating the floor involved and the pilot lamps at main aisles and cross aisles.

8.5 NO. 5 CROSSBAR SYSTEM SWITCHING TELEPHONE CALLS

The calls handled by a No. 5 Crossbar office are of four general types: intraoffice, outgoing, incoming and tandem or through switched.

All calls require the use of a register for counting and storing digit information. Originating registers are used to count and store digits from subscribers while incoming registers count and store digits from other offices.

A. DIAL TONE CONNECTION

The originating registers are assigned to the trunk switches of the trunk link frames. A connection from the subscriber lines to the originating registers requires the selection and closure of a channel. A marker is required for the channel selection as well as register selection and calling line identification.

See Figure 8-11 for the block diagram showing the sequence of connection for the dial tone job. When a subscriber removes the receiver from the switch hook, a line relay is operated which causes the line link frame to inform the line link marker connector that a marker is required. The line link marker connector selects an idle dial tone or combined marker, connection #1.

In order to establish a dialing connection between the subscriber's line and an idle originating register, the marker must determine the equipment location of the calling line, select an idle register and then determine that a channel between the line and the register can be obtained.

The marker tests for the calling line location through the connection set up by the line link marker connector. While the marker is recording this information, it is also selecting an originating register, connection #2. The originating registers are distributed as evenly as possible over all the trunk link frames. The selection of an idle originating register is a two-step operation. The first step consists of the marker selecting an idle trunk link frame that has an appearance of one or more idle originating registers. The second step is the selection of a particular register on the selected trunk link frame.

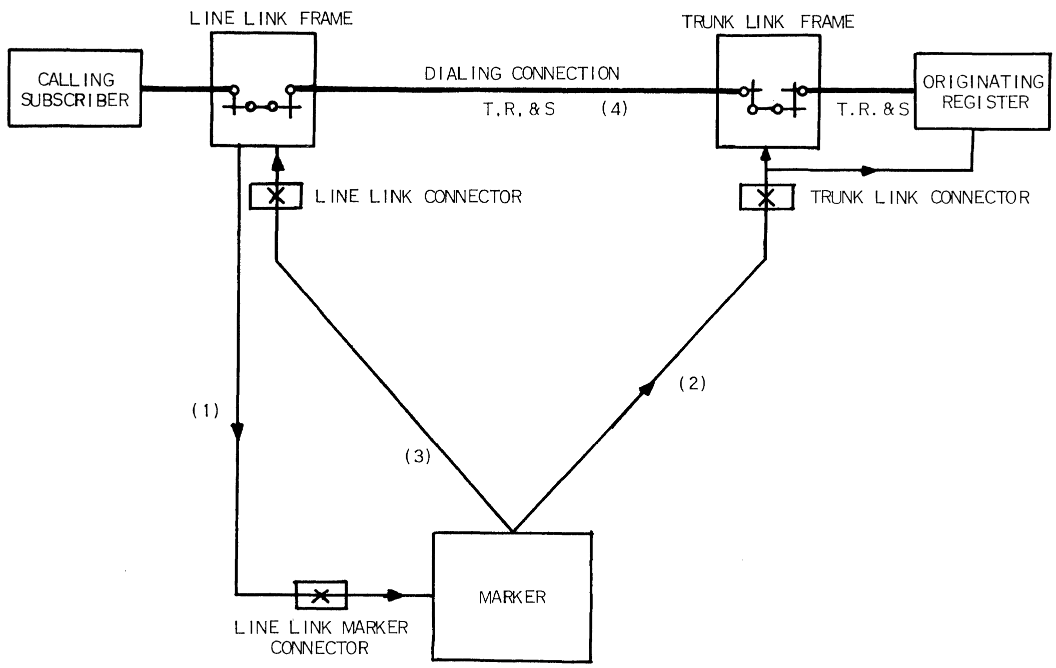


Figure 8-11 Establishing Dialing Connection

After the marker has selected the trunk link frame, the marker then returns to the line link frame via the line link connector, connection #3. Through this connection, the marker will be able to complete the subscriber line identification and also control the closing of the contacts on the crossbar switches, for the selected channel.

The marker must select an idle channel between the subscriber's line and the selected originating register. When the marker finds an idle channel, it operates the select and hold magnet required for channel closure. The marker indicates to the originating register the identity of the line link used in the channel, the equipment location, and class of service of the calling line. The register stores this information for later use.

Before the marker transfers control of the channel to the originating register, it checks the connection for continuity, crosses or false grounds. The marker, upon satisfying itself that it has established a valid connection, releases its associated connectors and itself leaving the control of the channel with the originating register. The register furnishes dial tone to the subscriber and is now ready to receive the digit information from the subscriber's set.

This completes the dial tone connection. The digits which the subscriber dials or keys into the originating register are stored in the register for later marker use. As soon as dialing is completed, the register will seize a completing marker and transmit to it all registered information. This information consists basically of (a) class of service of the calling subscriber, (b) line link location of the calling subscriber and party identification, and (c) dialed digits.

The preceding operation is standard regardless of the type of call being initiated. Since the originating register initiates action to obtain a completing marker at completion of dialing it must be able to determine how many digits are to be dialed for each call. While most calls will consist of seven digits: three for an office code identification and four numericals, the register may be required to complete calls on the basis of 3 to 11 digits.

In order to determine the number of digits to be received on each individual call, a pretranslation of the dialed information is performed. Pretranslation is the process of determining from the first 1, 2, or 3 dialed digits, how many digits the register should expect to receive on that particular call. When the number of calls that differ from the normal seven digits is small and the numbering plan is not too complex, pretranslation can take place in the originating register. For more complex numbering plans, or a large volume of calls using a variable number of digits, a separate pretranslator is provided. This circuit is called in by the originating register through the pretranslator connector after the first two or three digits have been set in the register. The pretranslator determines from these digits how many digits should be dialed and tells the register the number of digits that it should receive before calling in the completing marker.

B. OUTGOING CALL (INTEROFFICE)

Outgoing calls are established to connecting offices or to operators for some type of service assistance. It is necessary to establish a connection from the subscriber's line to one of the outgoing trunks that terminate in the connecting office or operator's position. It may also be necessary to determine what, if any, charge is to be made and how to send the digits of the called number to the connecting office. Figure 8-12 shows the sequence of connections for an outgoing call.

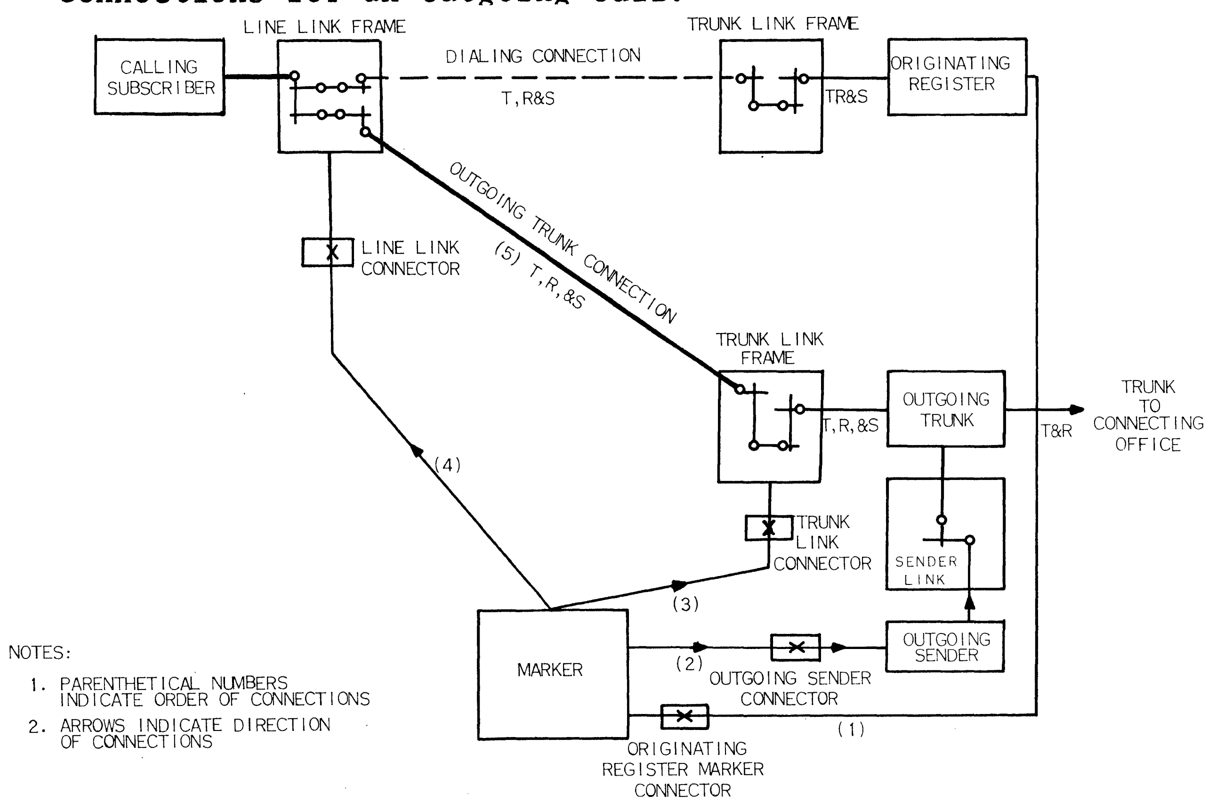


Figure 8-12 Outgoing Trunk Connection

After the originating register has recorded the proper number of digits, it signals its originating register marker connector that a completing marker is required. The originating register marker connector selects an idle completing marker and establishes a connection from the originating register to the marker (Connection #1). The originating register then transmits to the completing marker all of the stored information; class of service, line link location, party identification, channel number and digit information.

The marker obtains routing instructions from a route relay which is operated by relating the called office code to the calling subscriber's class of service. This route relay will instruct the marker as to what type of pulsing to use and which group of outgoing trunks are going to the proper termination. The marker then proceeds to test for and select an idle outgoing sender of the proper type (Connection #2). Once the marker has determined the availability of an outgoing sender, it then proceeds to test the office for location of idle outgoing trunks and idle trunk link frames serving those idle outgoing trunks. The marker then selects a particular outgoing trunk and trunk link frame to serve this call using the same technique as in the selection of an idle originating register (Connection #3). It then causes the sender link frame to set up a connection between the outgoing trunk and the outgoing sender. While this connection is being completed, the marker seizes the line link connector associated with the subscriber's line link frame (Connection #4). Information as to the equipment location of the calling subscriber was obtained from the originating register. The marker now tests for and selects an idle channel from the calling subscriber to the outgoing trunk. When the marker finds an idle channel, it operates a select and hold magnet required to close through the channel; testing the channel for validity. The marker then tests for continuity before transferring control to the outgoing sender (Connection #5).

While the marker was setting these latter connections, it was instructing the outgoing sender on how to handle this particular call. It informed the outgoing sender of the digits dialed, which digits if any are to be deleted, what digits, if any, to prefix, and the type of test or supervisory signals required by the connecting trunks. The marker then releases its associated connectors and itself, leaving the outgoing sender in charge of the call. The outgoing sender will test and outpulse to the terminating office in accordance with the class instructions it received from the marker.

C. INCOMING CALL

An incoming call is the completion, in a called office, of an outgoing call from a connecting office. In the called office, the trunk from the originating office is termed an incoming trunk. The incoming connection consists of a channel between the incoming trunk and the called subscriber. Refer to Figure 8-13 for the block diagram showing the sequence of connections for an incoming call.

As soon as the incoming trunk is activated by a call originating in a connecting office, it seizes an incoming register through an incoming register link, connection #1. As soon as the incoming register has been seized, it signals the connecting office that it is connected to the trunk and ready to receive digit information. As soon as the register has received the proper number of digits, it signals the incoming register marker connector that a connection to a completing marker is required, connection #2. The incoming register marker connector selects an idle completing marker and establishes a connection from the incoming register to that marker. The incoming register then transfers information from its memory circuit to the completing marker. This information consists of the dialed digits, the class of the incoming trunk, and the trunk link frame number on which this trunk is assigned.

The marker first seizes the connector of the trunk link frame associated with the incoming trunk, connection #3. From the trunk class indication and the digits received, the marker selects the number group frame in which the called number is assigned, connection #4. As soon as the connection is established the marker transfers the hundreds, tens, and unit digits information into the number group. The number group translates and returns to the marker information concerning the line link equipment location of the called subscriber, the type of ringing that will be required for this subscriber along with other information for the marker to establish the validity of the call.

The marker then seizes the connector associated with the called subscriber's line link frame, connection #5, and proceeds to test for and select an idle channel from the incoming trunk to the called subscriber. When this channel has been selected, closed, and tested, connection #6, it transfers control of the channel and of the call to the

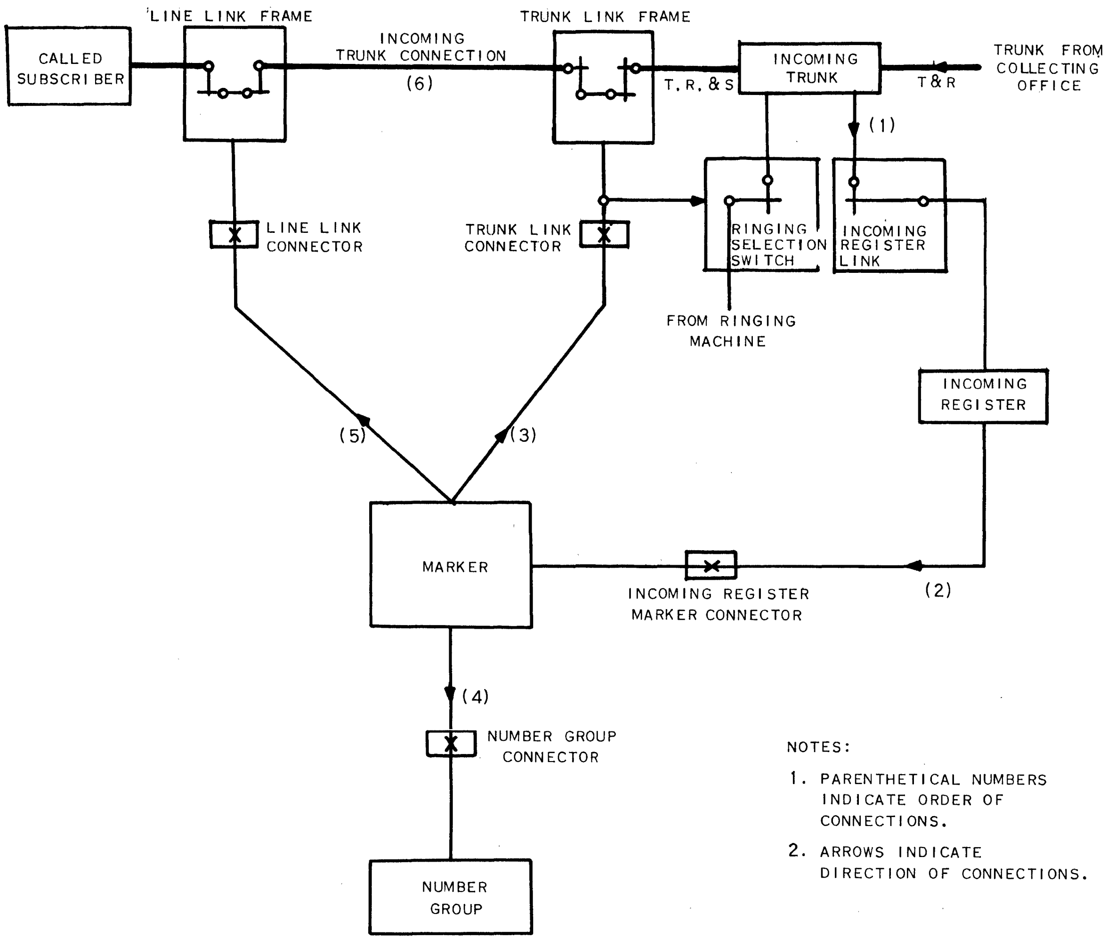


Figure 8-13 Incoming Trunk Connection

incoming trunk. The marker sets the ringing selection switch with the proper type of ringing for the called subscriber. The marker upon having completed its useful functions, releases itself and all control equipment leaving the path from the incoming trunk to the called subscriber under control of the trunk which will apply ringing tone to the called line.

D. INTRAOFFICE CALL

An intraoffice call is one that is placed from one subscriber to another subscriber within the same marker group. Since a channel can only be established between a line link termination and a trunk link termination, it will be necessary to establish two channels through the office. The trunk used for this purpose must have two trunk link appearances in order to terminate and form a loop around for the two channel connections; refer to Figure 8-14 for the block diagram showing the sequence of connections for an intraoffice call.

This call starts in the same manner as the outgoing trunk connection in that the originating register upon receipt of the proper number of digits, signals the originating register marker connector for a connection to a completing marker, connection #1. The information stored in the originating register is then transferred to the marker over this connection.

The marker upon examining the office code and subscriber's class of service for route relay operation, which will provide the marker with routing instructions, finds that the office code represents a call to its own equipment. The routing instruction gives the marker the location of the intraoffice trunks to be used for this call. It proceeds to test and select an idle intraoffice trunk on one of the idle trunk link frames, connection #2.

The marker then by using the office code and the thousands digits selects the proper number group and receives from the number group the line link location of the ringing combination of the called subscriber, connection #3. The marker then seizes the line link frame of the called subscriber by seizing the proper line link connector, connection #4, tests and selects a channel from the called subscriber to the B-appearance of the intraoffice trunk and sets the ringing selection switch for the proper type of ringing, connection #5.

The marker then proceeds to seize the line link frame of the calling subscriber, connection #6, testing for and selecting an idle channel from the calling subscriber to the A-appearance of the intraoffice trunk on the trunk link frame, connection #7. All required connections having now been established, the marker releases itself and all control circuits leaving the trunk in charge of the connection to the office.

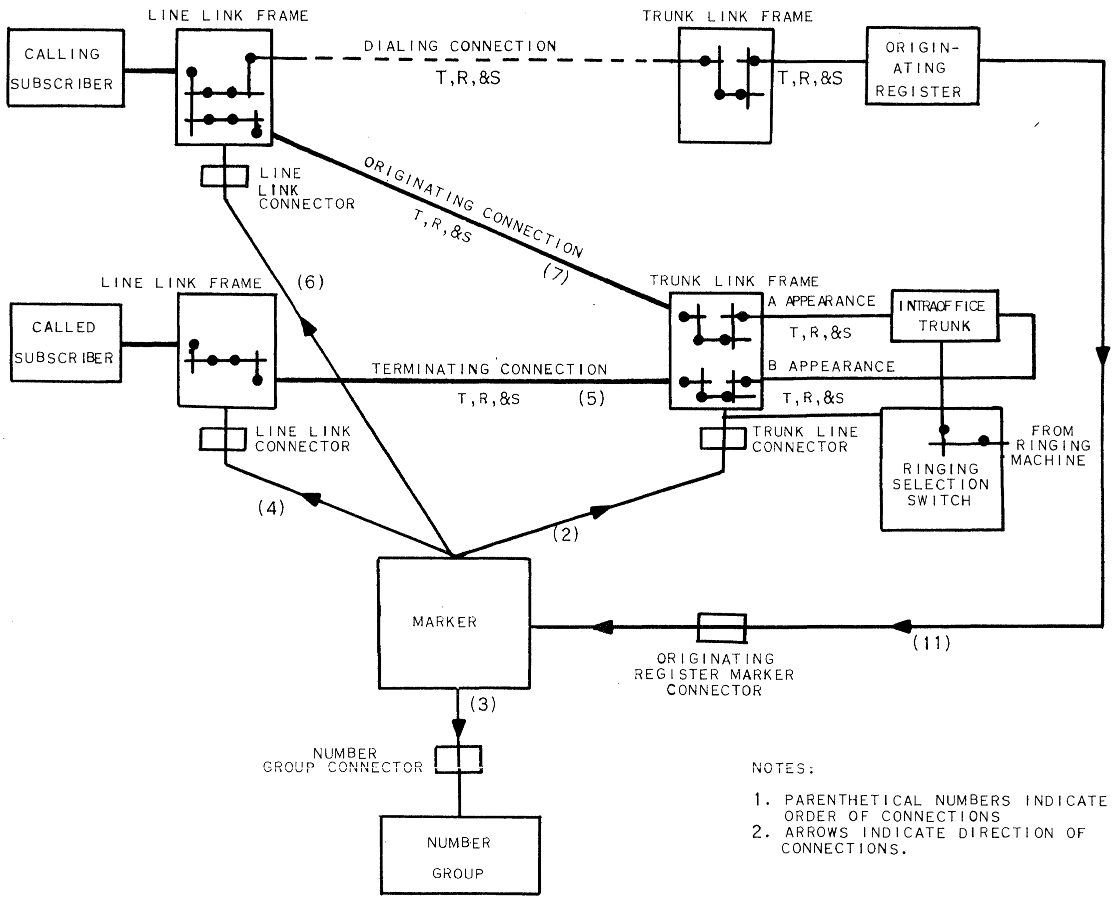


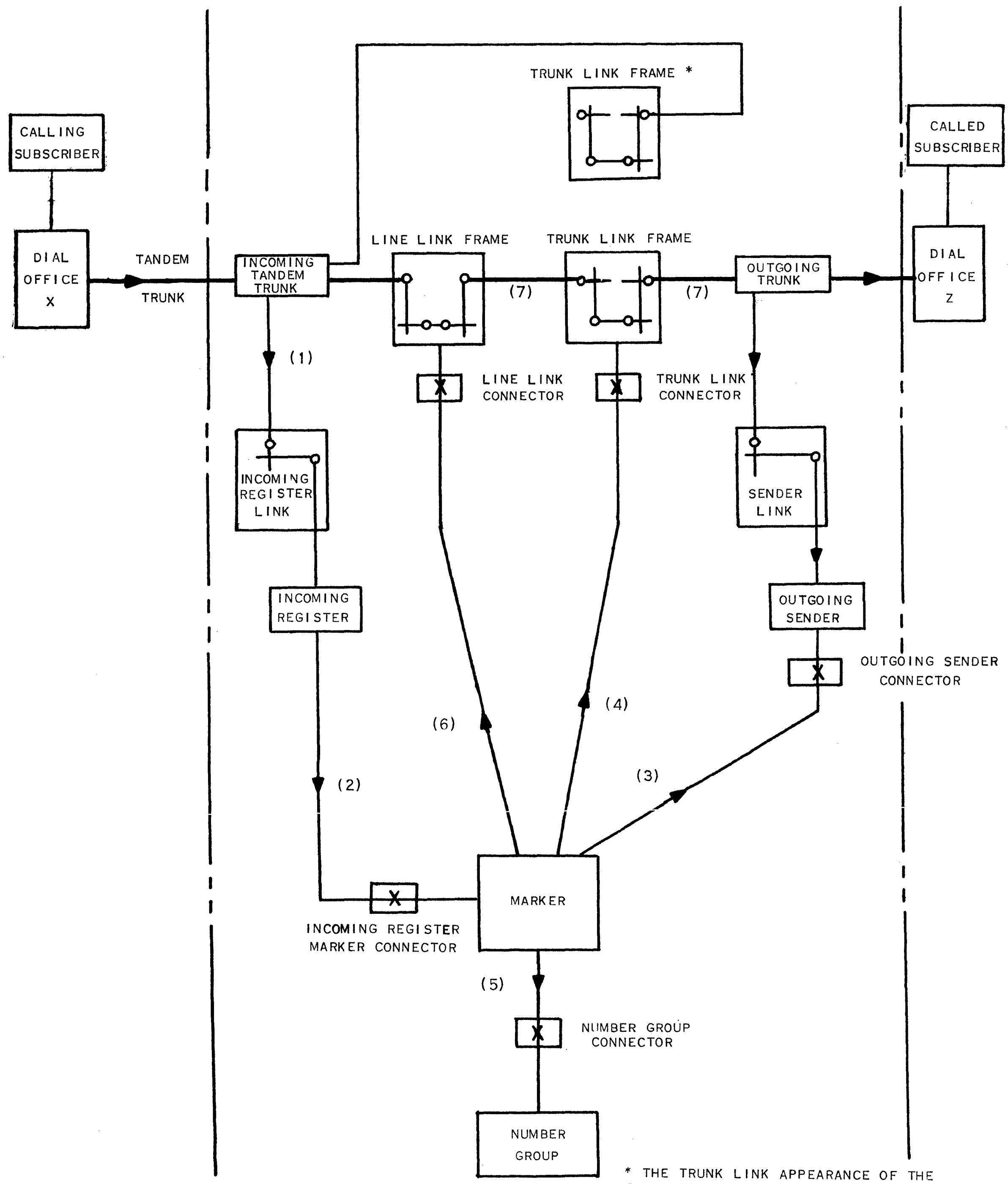
Figure 8-14 Intraoffice Trunk Connection

8.6 TANDEM OR TOLL THROUGH SWITCH CALL

Since it is not economical to have direct trunks between all central offices, intermediate switching points are provided to handle traffic between offices that have no direct connection. This type of operation is known as tandem or through switching. A local No. 5 Crossbar office may be arranged to serve tandem as well as toll center traffic for surrounding offices.

A No. 5 Crossbar office can be used to provide this tandem switching service in addition to its regular functions. An incoming trunk arranged for handling tandem traffic at a No. 5 Crossbar office with tandem switching features can also handle traffic for completion to this office, since it is generally economical to combine these two types of traffic over the same trunk group. To permit this dual use, it is necessary to provide such trunks with both trunk link and line link frame locations in the No. 5 office with tandem switching features. The trunk link frame location is used when a call coming in on a tandem trunk terminates in the No. 5 Crossbar office. When the incoming call is to be switched to a connecting office through the No. 5 Crossbar office, the line link frame location is used.

Figure 8-15 is the block diagram showing the sequence of a call through an office arranged for through switching. An incoming trunk is seized at the connecting office and in a manner similar to a regular incoming call. It, in turn, seizes the incoming register (Connection #1). Digit information is stored in the register as in other incoming calls. At completion of dialing the register seizes a marker and transfers all of the stored information to the marker in conventional fashion (Connection #2). The additional information that is transferred in this type of call are the three digits that represent the trunk identification. The marker upon looking at the office code and the class of the incoming trunk will go through route relay operation which will identify this call as a tandem type of call. The marker will then test for and select an idle outgoing sender (Connection #3). The next action by the marker is to test and select an outgoing trunk to the proper termination, (Connection #4), and establish the connection from the outgoing trunk to the outgoing sender through the outgoing sender link frame. Using the three digits of the trunk number, the marker seizes the number group frame assigned to trunk numbers (Connection #5), and receives from it the line link location of the incoming trunk. This location is always furnished in duplicate, in two separate number groups. To increase the possibility of completing a toll call, the trunk is assigned two separate line link locations. Each of the two number group locations of the toll trunk will translate one of the line link locations. If a marker has trouble in establishing a connection on its retrial, it will go to the other number group and thereby obtain the other line link location of this trunk. The tandem trunks have an identical line link location in both number groups.



NOTES:
1 PARENTHETICAL NUMBERS INDICATE ORDER OF CONNECTIONS

2 ARROWS INDICATE DIRECTION OF CONNECTIONS

* THE TRUNK LINK APPEARANCE OF THE TANDEM TRUNK IS USED FOR CALLS TERMINATING IN THIS NO. 5 CROSSBAR OFFICE.

Figure 8-15 Tandem or Through Switched Call

The marker now seizes the line link frame on which the incoming trunk is assigned as shown in connection #6. The marker now tests for and selects a channel in conventional manner from the incoming trunk assignment on the line link frame to the outgoing trunk assignment. Upon completing test of this channel and transfer of outpulsing information to the outgoing sender, the marker releases itself and all of its connectors; the call now proceeds the same as an outgoing call.

8.7 OTHER TYPES OF CALLS

With slight modifications in the techniques of handling calls, No. 5 Crossbar is able to perform many other useful types of call switching. Many of the functions performed in these calls are identical to the functions relating to the previously described calls.

A. REVERTING CALL

A reverting call is one that takes place between subscribers who share the same party line. A connection is set up to a reverting trunk for provision of talking battery and supervisory functions.

This call is very similar to an intraoffice trunk connection except that a trunk with only one trunk link appearance is required and only one channel is set up from the one line serving both parties, to the reverting trunk. The block schematic for this type of call is shown in Figure 8-16 and differs only slightly from Figure 8-14. After the marker has received the line link location of the called subscriber from the number group frame and it finds that this location matches the location of the calling subscriber, as given to it by the originating register, the marker then releases, connection #2 and proceeds to go through the trunk selection the second time; this time selecting an idle reverting trunk. After the marker seizes the line link frame and tests for and closes a channel in the usual manner, it releases itself and its connectors leaving the reverting trunk in charge of the call.

The operating procedure when multiparty lines are furnished is for a steady tone to be returned to the calling subscriber. This is the signal to the calling subscriber to dial the party code digit numerical that appears on his dial. Upon receiving this one-digit information, the reverting trunk now returns busy tone and sets up a ringing

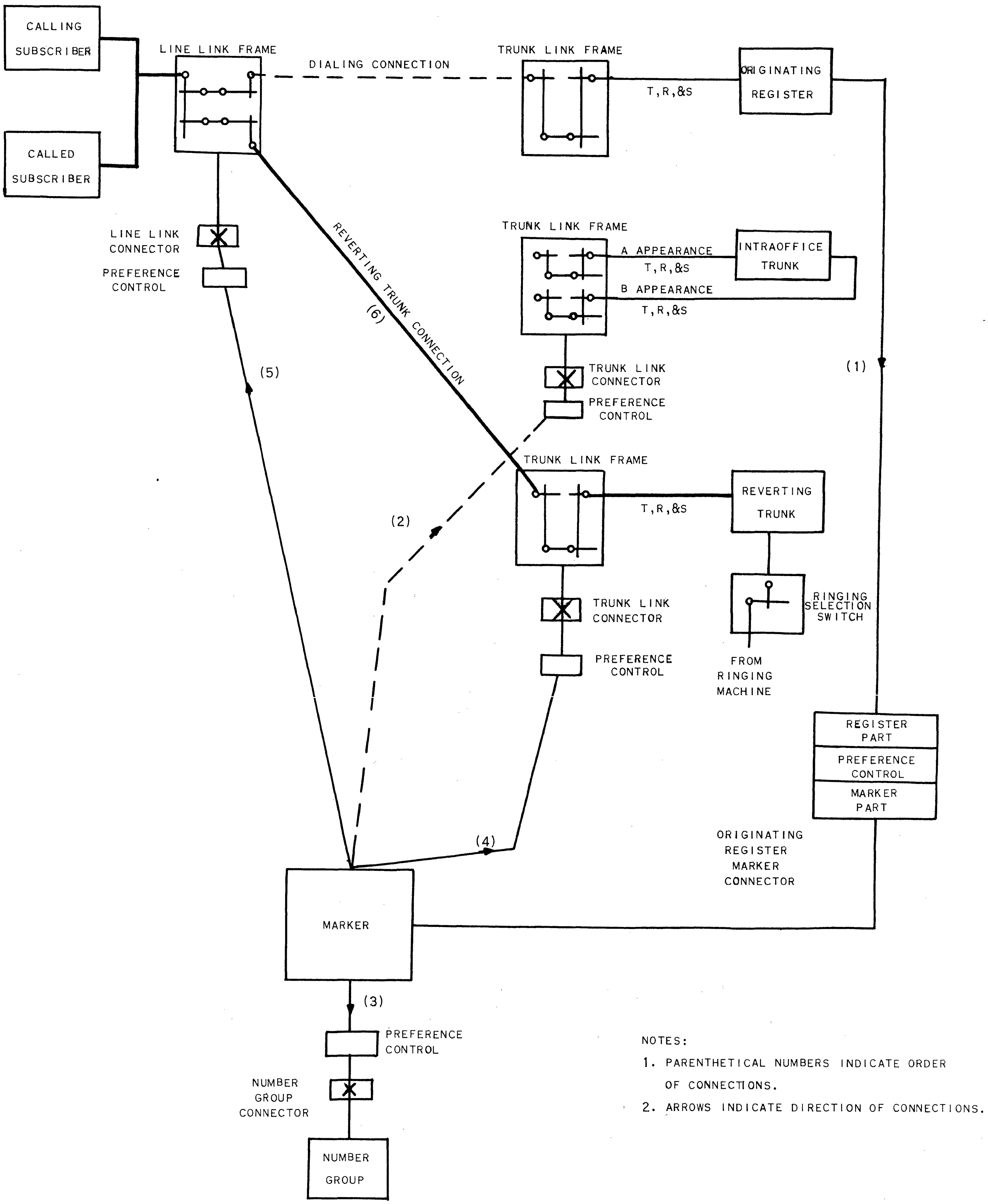


Figure 8-16 Reverting Trunk Connection

selection switch for the calling subscribers ringing code. The subscriber hangs up and the trunk will alternately ring the called and calling subscribers lines, tripping the ringing as soon as the receiver has been lifted at the called subscribers line.

B. INTERMARKER GROUP OPERATION

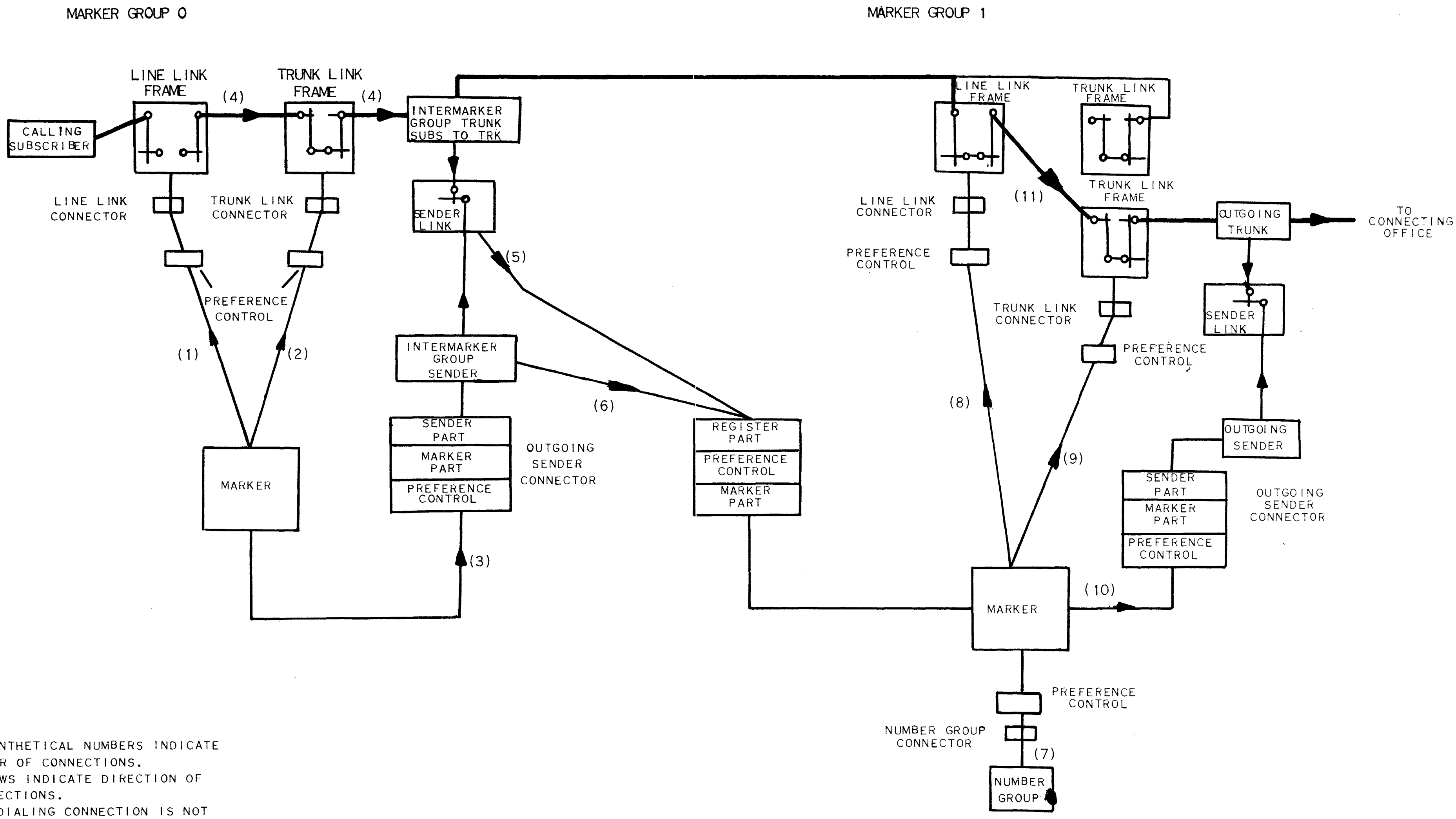
Intermarker group operation is where a call is completed from one marker group to another marker group within the same building. This call may be from a subscriber, from a subscriber to a trunk or from a trunk to a subscriber. For illustration we will use a call from a subscriber to a trunk. The block schematic for this call is shown in Figure 8-17.

By inspection of Figure 8-17 we will see that each intermarker group trunk appears in one marker group as an outgoing trunk and in the other marker group as an incoming tandem type of trunk, except for assignment to the incoming register link frame. This call differs from a regular outgoing or tandem call in the fact that the outgoing sender is replaced by an intermarker group sender which is assigned in the first marker group as an outgoing sender and used in the second marker group as an incoming register. With the intermarker group sender connected in this manner, it is not necessary to actually outpulse and again receive the pulsed digit information. It will simply take the information it receives from the completing marker and through the incoming register marker connector transmit this information to a completing marker in the second marker group.

This type of operation reduces the number of incoming registers and incoming tandem trunks that would be required in the second marker group. It will also permit the outgoing trunks to a particular connecting office to appear in only one of the marker groups within the building.

C. OPERATOR JUNCTOR OPERATION

Operator junctors are trunks that originate at the toll and DSA switchboards and terminate in the crossbar No. 5 office. These trunks are used by the toll and DSA operators to gain access to the outgoing trunks in the crossbar No. 5 office. Since the operator junctor is a type of tandem trunk, a No. 5 office must be equipped for tandem operation in order to use it. The block schematic for operator junctor operation is shown in Figure 8-18.



NOTES:

1. PARENTHETICAL NUMBERS INDICATE ORDER OF CONNECTIONS.
2. ARROWS INDICATE DIRECTION OF CONNECTIONS.
3. THE DIALING CONNECTION IS NOT SHOWN.

Figure 8.17 Intermarker Group Trunk Connection Customer to Trunk

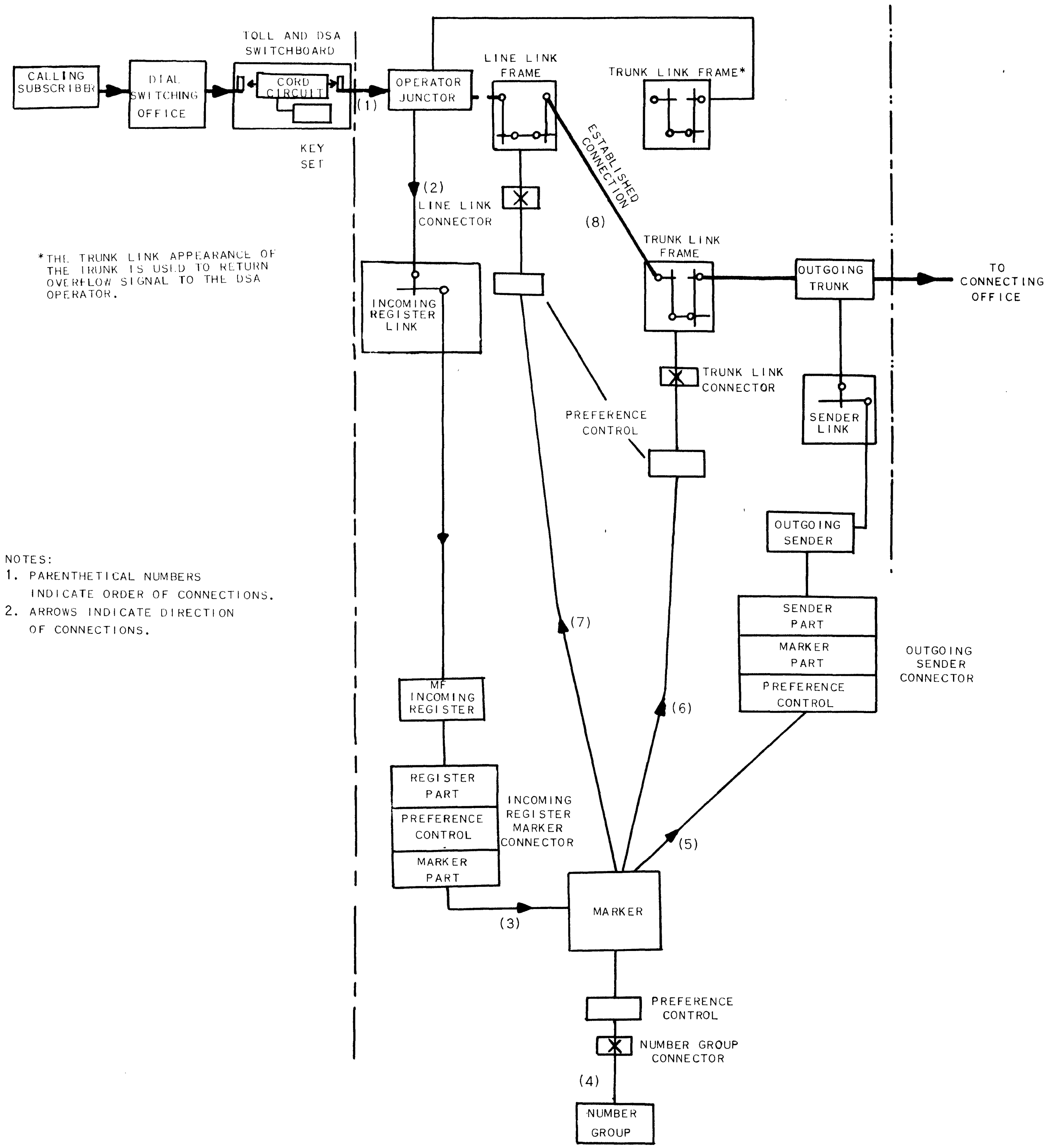


Figure 8-18 Operator Junctor Operation

In completing such a call the operator will always use multifrequency pulsing regardless of the type of pulsing required at the terminating office, since the crossbar No. 5 common control equipment will outpulse whatever is required.

D. COIN JUNCTOR OPERATION

The coin junctor is a unit of equipment used for handling outgoing interoffice and subscriber to trunk intermarker group coin traffic. Coin junctors can be used as alternate routes for groups of regular outgoing coin trunks. With this arrangement, outgoing trunks that handle coin and noncoin traffic do not need coin features. The block schematic of the coin junctor operation is shown in Figure 8-19.

This type of operation requires that two channels be selected through the switching network. One channel from the subscriber to a coin junctor, the second channel from a coin junctor to a noncoin outgoing trunk. It will be noted that the coin junctor acts as both an outgoing and an incoming trunk in the No. 5 office. One group of outgoing trunks will handle both coin and noncoin traffic.

E. PULSE CONVERSION OPERATION

The pulse conversion operation is an assistance to the operator in converting the multifrequency pulses from her key set to dial or revertive pulses as required for the terminating office. It does not require the selection of a path through the crossbar No. 5 office. The trunk selected by the operator terminates in the connecting office but has an appearance in the crossbar No. 5 office so the common control equipment in the No. 5 office is able to receive and transmit pulses over the trunk. The block schematic for this operation is shown in Figure 8-20.

The operator selects an outgoing trunk to the desired termination. However, the trunk does not close a path through to the connecting office. The trunk has an appearance on the incoming register link frame and signals it that a connection to an incoming register is desired. When the register is attached, it will signal the operator to start pulsing. After pulsing has been completed the register will seize a completing marker and transfer to it the stored information located in the register. From the class of the incoming trunk the marker will recognize this as a pulse conversion type of call and will act accordingly.

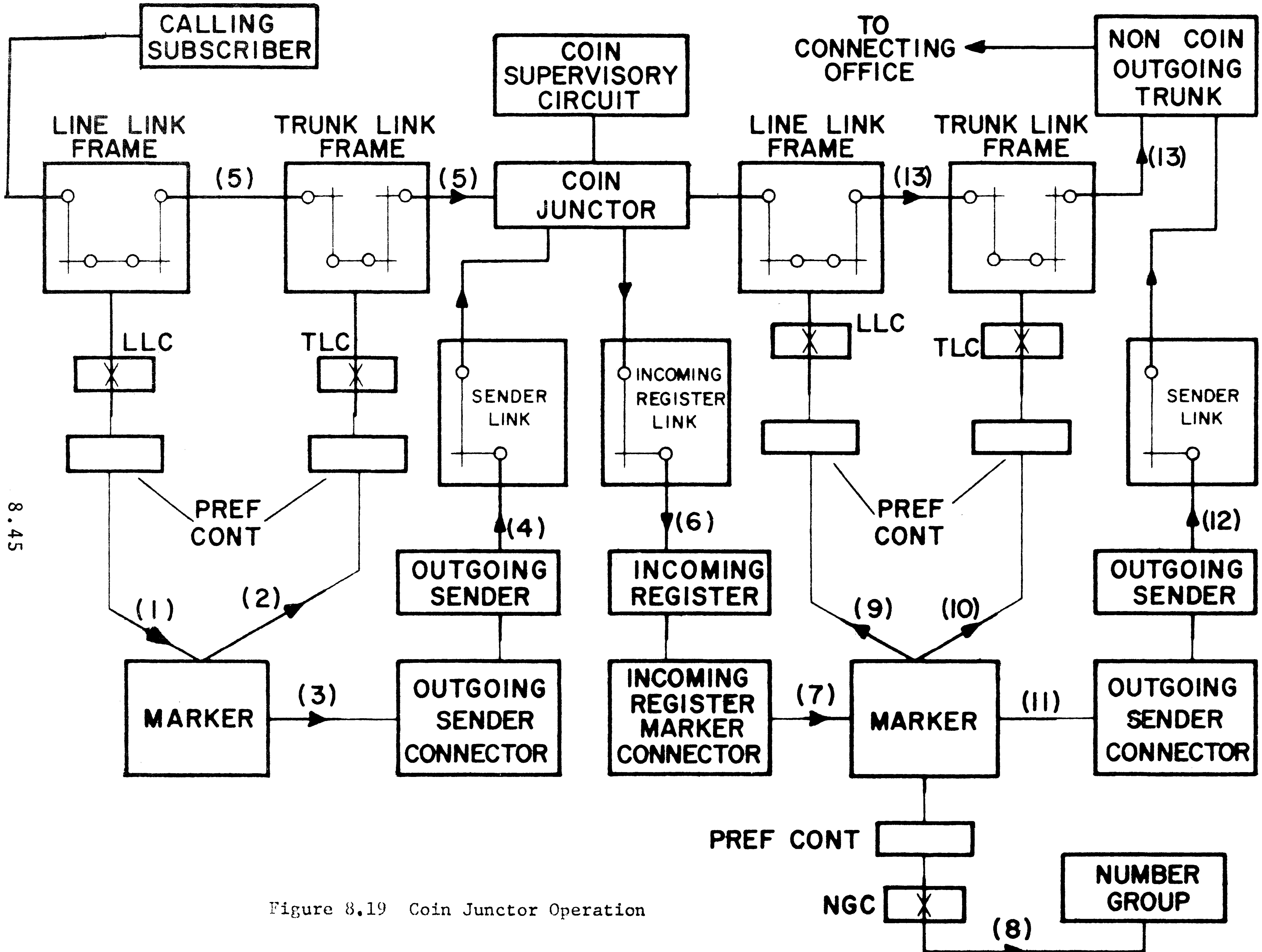


Figure 8.19 Coin Junctor Operation

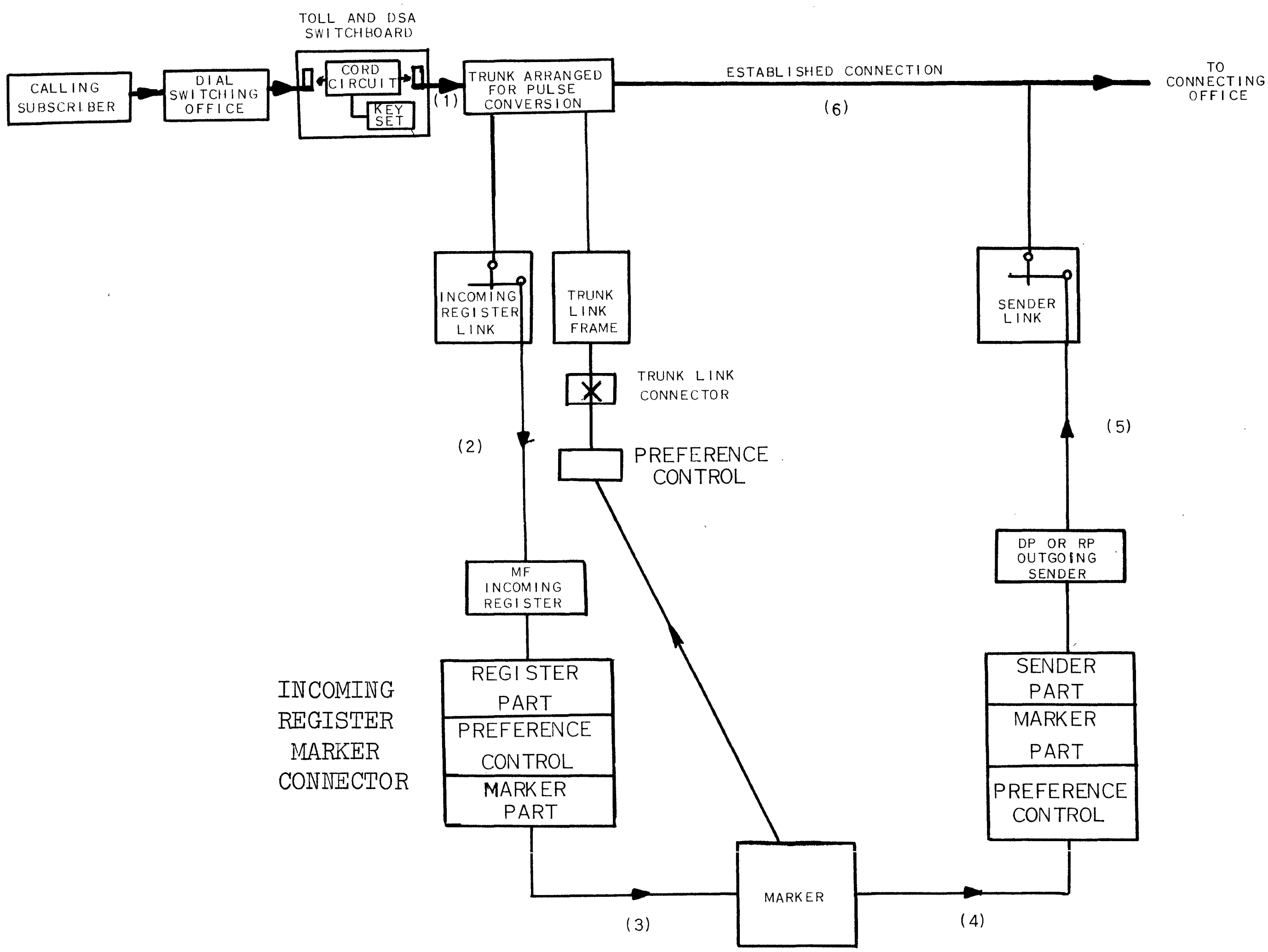


Figure 8-20 Pulse Conversion Operation

While the common control equipment of the No. 5 office was used to convert MF pulsing to RP or DP pulses, no use was made of the switching network.

8.8 NO. 5 CROSSBAR OFFICE ARRANGED FOR CENTREX SERVICE

Centrex for No. 5 Crossbar offices has gone through three basic phases of development. These phases are defined in the following steps.

a. Phase I circuits contain centrex features developed with attendant transfer as the basic mode of operation.

b. Phase II circuits were developed on a standard basic with attendant transer as the basic mode of operation with several additional features.

c. Phase III circuits were developed with dial transfer as the basic mode of operation enabling more efficient operation and considerable savings over Phases I and II. Figure 8-21 shows Phase III circuits for use only in new centrex offices or in existing No. 5 Crossbar offices arranged for 100 classes of service that may be used to provide centrex service.

Centrex facilities enable a PBX customer to obtain a flexibility of operation previously unobtainable with normal PBX facilities. Centrex facilities permit incoming calls to be completed to an extension without the aid of an attendant (direct-inward-dialing); permit calls to be transferred from one extension to another without the aid of an attendant (dial transfer); and also enables direct distance dialed calls to be automatically billed to individual extensions.

In the No. 5 Crossbar system these facilities are divided into two general categories. Centrex CO enables the PBX customer to use No. 5 Crossbar switching equipment located on telephone company premises whereas Centrex CU provides for the equipment to be located on his own premises.

In this specification, the extensions associated with one customer which are served by a Centrex CO are referred to as Centrex stations and constitute a customer group.

A. METHOD OF OPERATION - GENERAL

The method of operation, described in this section, covers the dialing arrangements which are required to initiate and to transfer calls from Centrex lines as well as the No. 5 Crossbar system operation which is required to handle calls originating from and completing to Centrex CO and Centrex CU lines.

In addition to the operation described in this section of the specification, a Centrex CO can be arranged to transfer incoming calls automatically to an attendant when the call encounters a Centrex line which is either busy or doesn't answer. It also can be arranged to transfer the listed directory number (LDN) calls to a Centrex line when the attendant's position is not occupied.

B. DIALING ARRANGEMENTS

This section covers only the dialing arrangements which are required to initiate a call in order to gain access to the No. 5 Crossbar switching equipment. The arrangements which are required for transferring calls are covered in the transfer portions of the description of system operation. These dialing arrangements are used with both the rotary dial and TOUCH-TONE sets.

The Centrex line dials "0" when he requires the assistance of a Centrex operator; "9" when he calls a party whose line terminates outside of his customer group or when he requires the assistance of a DSA or toll operator; and a IXX code when he calls a party whose line terminates in a distant PBX or Centrex office which is connected by direct tie lines to the customer's Centrex CO or CU. The 1XX codes may also be used for special services. The Centrex station dials four- or five-digits of the called number when he calls a party whose line terminates in the same customer group. (Four-digit numbers restrict the Centrex CO to 7000 Centrex numbers since digits 0, 1 and 9 cannot be used as the thousands digit. Five-digit numbers enable the Centrex CO to use the full 40,000 number capacity of a marker group for Centrex numbers.)

C. CENTREX CO SYSTEM OPERATION

In Centrex CO operation, Centrex lines are assigned line link frame appearances with a class of service and rate treatment identification which enables the dial tone marker to identify them as Centrex lines and also to determine their associated customer group.

All Centrex lines have directory numbers assigned to them but the attendant's number or numbers are normally the only ones which are listed in the telephone company's directory.

Although the full seven digits of the directory number are required for direct-inward-dialed calls, only the last four or five digits are dialed for calls between Centrex lines in the same customer group (intracustomer group calls).

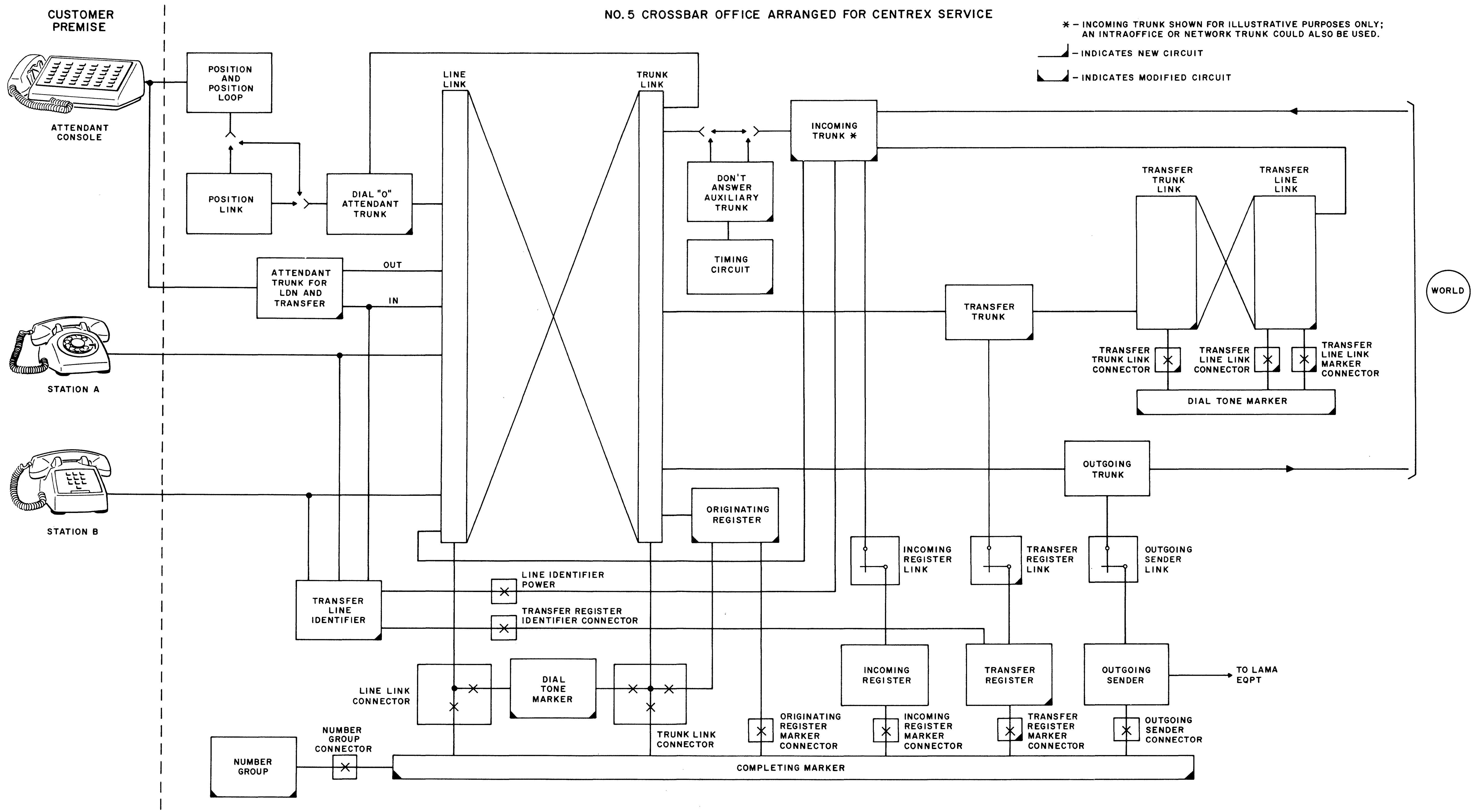


Figure 8.21 - Phase III Offices

In Centrex operation, the originating register assumes that the calling line is a Centrex line and that only four digits will be dialed unless it receives information to the contrary.

If the customer group is arranged for five digit numbers, the originating register receives an appropriate indication from the dial tone marker.

If the originating register receives the digits 0, 1 or 9 as the first digit, it realizes that the call is not an intracustomer group call and takes the required action.

If a regular customer line is connected to the originating register, the originating register recieves an indication from the dial tone marker that the calling line is not a Centrex line.

D. OUTGOING, INTRAOFFICE, INTERMARKER GROUP CALLS

Outgoing, intraoffice, and intermarker group calls from Centrex lines are handled in essentially the same manner as they are handled for basic customer service. However, originating register request and dial tone connection are handled differently.

The signal generated by the calling Centrex line causes the line link frame to ask the dial tone marker for a connection to an originating register. When the connection is established, the originating register sends dial tone to the calling Centrex line as a signal to begin dialing.

The calling Centrex line dials "9" into the originating register and waits for a second dial tone or will continue to hear the initial dial tone.

The originating register determines, from the digit 9, that the call will complete outside of the customer group and will not break dial tone or send a second dial tone as a signal to start dialing the number of the called party. The remainder of the operation is the same as for the basic customer services. When these calls require the use of automatic message accounting facilities, they are handled the same as any other call which requires the use of these facilities.

E. DIRECT-INWARD-DIALED CALLS (INCOMING AND INTRAOFFICE)

Direct-inward-dialed calls, both incoming and intraoffice, are handled the same as regular incoming and intraoffice calls.

F. INTRACUSTOMER GROUP CALLS

Intracustomer group calls are handled essentially the same as intraoffice calls. For intracustomer group calls, however, the calling Centrex line dials only the four or five digit number of the called Centrex line. When the originating register receives the digits of the called number, it connects to a completing marker and passes the digits to it along with a translation mark which informs the completing marker that it will receive only four or five digits. At the same time, the originating register line memory frame passes the calling Centrex line's line link frame termination and class-of-service to the completing marker. Then the completing marker which receives the digits, selects an intraoffice trunk and proceeds to establish the transmission path the same as for an intra-office call. Before the transmission path connection is established, however, the completing marker matches the class of service of the calling line. If both classes of services are identical, the completing marker is satisfied that the called line is in the same customer group as the calling line and establishes the transmission path connection.

G. LISTED DIRECTORY NUMBER CALLS (LDN)

LDN calls originate from a customer outside of the customer group and complete to a Centrex attendant.

The customer places an LDN call when he wished to obtain the number of a Centrex line; when he wishes to be connected to a Centrex line and doesn't know the seven digit number required for direct-inward-dialing; and when he wishes any of the various services previously available from a PBX operator. In Centrex CO operation the attendant may be assigned to an attendant console or a 608 type switchboard.

I. LDN CALLS TO AN ATTENDANT EQUIPPED WITH A CONSOLE

These calls are handled similar to direct-inward-dialed calls. However, the incoming or intraoffice trunk is connected to an attendant trunk instead of to a Centrex line.

The attendant trunk is assigned two link frame appearances and may connect either to a specific console or through the Centrex position link frame to any of a number of consoles. One of the line link frame appearances enables the attendant to receive LDN calls, and to initiate the dial transfer operation, and the other appearance enables the attendant to originate calls from the console.

(a) Attendant trunk connects to a specific console.

When the connection between the attendant trunk and the incoming or intraoffice trunk is established, the attendant trunk signals the attendant by flashing a lamp at the console.

(b) Attendant trunk connects to a console through the Centrex position link frame.

When the connection between the attendant trunk and the incoming trunk is established, the attendant trunk requests the Centrex position link frame to connect it to a console. The Centrex position link frame selects an idle console and connects the attendant trunk to it. The attendant trunk then signals the attendant by flashing a lamp at the console.

J. TRANSFER CALLS

In Centrex CO operation several types of transfer calls can be handled. These types of calls include dial transfer by a Centrex line to another Centrex line, dial transfer by a Centrex line to an attendant, and attendant controlled transfer.

K. CALL TRANSFER INDIVIDUAL - BY A CENTREX STATION TO ANOTHER CENTREX STATION

This type of transfer enables a called Centrex line (station B) to transfer a call from the calling customer (station A) to another Centrex line (station C) without the aid of an attendant.

This section divides the method of operation for dial transfer calls into the following five segments:

1. Transfer Request Connection.

2. Transfer Register Request.

3. Line Identification.

4. Transfer Dial Tone Connection.

5. Transfer Transmission Path Connection.

Incoming and intraoffice calls can be transferred but intermarker group calls cannot. Since the method of operation is the same for transferring both incoming and intraoffice calls, only incoming calls will be discussed.

1. Transfer Request Connection

The transfer request connection includes both the original transmission path connection between the incoming trunk and station B and a connection between the incoming trunk and a transfer trunk through the transfer line link and transfer trunk link frames. When station B desires to transfer a call to station C, he flashes his switchhook as a signal to the incoming trunk that the call is to be transferred. (The incoming trunk has both a trunk link frame appearance and a transfer line link frame appearance.)

Upon receipt of the signal, the incoming trunk causes the transfer line link frame to connect to a dial tone marker through a transfer line link marker connector. The transfer line link frame, through this connection, asks the dial tone marker for a connection to a transfer trunk.

The dial tone marker connects to the transfer trunk link frame through the transfer trunk link connector and selects an idle transfer trunk (the transfer trunk also has a regular trunk link frame appearance). The dial tone marker then connects the transfer trunk to the incoming trunk through the transfer trunk link and transfer line link frames. (Junctor grouping frames are not used with transfer line link and transfer trunk link frames.) The transfer line link frame also passes the trunk link frame number of the incoming trunk to the dial tone marker which in turn passes it to the transfer trunk where it is stored for subsequent use.

2. Transfer Register Request

The transfer trunk requests its associated transfer register link frame to connect it to a transfer register. When the connection is established, the transfer trunk passes both its own trunk link frame number and the incoming trunk's trunk link frame number to the transfer register where they are stored for subsequent use.

3. Line Identification Connection

The line identification connection includes the original transmission path connection between the incoming trunk and station B, a connection between the line identification power supply and the incoming trunk, and a connection between the line link frame which contains station B's line termination and the transfer line identification frame.

The transfer register connects to the transfer line identifier frame through the transfer register identifier connector and requests an identification of station B's line termination on the line link frame. At the same time, the transfer register causes the transfer register identifier connector to signal the transfer trunk that a line identification is to be made.

The transfer trunk signals the incoming trunk, through the transfer trunk link and transfer line link frames, to connect the line identification power supply to station B's line link frame termination through the original transmission path connection.

The line identifier power supply then supplies an identifying signal to the line link frame termination of station B. The line link frame uses this signal to connect to the transfer line identifier frame. The transfer line indentifier frame scans the terminations on this line link frame and when it detects the signal through a termination, it passes the location of it to the transfer register frame.

When the line identification connection is established, the transfer trunk causes the incoming trunk to remove station A from the transmission path and place him on hold.

4. Transfer Dial Tone Connection

When the transfer register receives the location of station B's line link frame termination, it connects to a completing marker through the transfer register marker connector and passes both this information and the trunk link frame number of the transfer trunk to it.

The completing marker now releases the original transmission path connection between the incoming trunk and station B and establishes the transfer dial tone connection between the transfer trunk and station B through the trunk link, line link, and junctor grouping frames. When the completing marker establishes this connection it receives the class of service of station B's line link frame termination and passes it to both the transfer trunk and transfer register where it is stored for subsequent use. The completing marker then releases from the call and prepares to handle other calls.

The transfer register, having previously been connected to the transfer trunk through the transfer register link frame, sends dial tone over the transfer trunk to station B as a signal to begin dialing the number of station C.

5. Transfer Transmission Path Connection

The transfer transmission path connection is between the incoming trunk and station C through the trunk link, line link, and junctor grouping frames.

This connection along with the portion of the transfer request connection between the incoming trunk and the transfer trunk and the portion of the transfer dial tone connection between the transfer trunk and station B, will permit private consultation between stations B and C.

When the transfer register receives all the digits of the number, it again connects to a completing marker through the transfer register marker connector. The transfer register then passes station C's number, station B's class-of-service and the trunk link frame number of the incoming trunk to the completing marker. The completing marker obtains the line link frame termination of station C from the number group frame and establishes the transfer transmission path connection. The completing marker then causes ringing to be applied to station C and releases from the call. Although the transfer transmission path has been established, station A is retained on hold by the incoming trunk and is unable to talk to station C. Private consultation, however, is possible between stations B and C.

Station B informs station C that station A wishes to talk to him. If station C agrees to talk to station A, either station B or C flashes the switchhook as an indication to the incoming trunk to remove station A from hold and to add him to the transmission path (add-on).

Station B now either releases from the call or remains in the path and engages in a three-way conversation with stations A and C. If station C does not answer or his line is busy, station B flashes his switchhook as an indication to the incoming trunk to remove station A from hold and reconnect his to station B. This connection is established through the path used by station B for private consultation with station C. The transfer transmission path connection between the incoming trunk and station C, however, is released.

If either station B or station C disconnects from the call during conversation, the associated portion of the transmission path is released. If station C wishes to transfer station A to another Centrex line, he flashes his switchhook and the complete dial transfer operation is repeated.

If station B wishes to retransfer station A to another Centrex line, when station C disconnects from the call, he flashes his switchhook as a signal to the transfer trunk to originate the retransfer. Since the identification of the line termination of station B has already been accomplished during the first request, that portion of the operation is not repeated.

L. CALLS TRANSFERRED TO AN ATTENDANT

This type of transfer enables station B to transfer a call to an attendent. Like an LDN call, the attendant may be equipped with a call director, a regular station set, or a console.

1. Calls Transferred to an Attendant Equipped with a Call Director or Regular Station Set

Station B initiates a transfer to the attendant in the same manner as a transfer to station C. However, when the transfer dial tone connection is established and dial tone is returned to station B by the transfer register, station B dials the digit "O" instead of the last four or five digits of the listed directory number.

The completing marker, when it receives the digit "O", generates the last four or five digits of the attendant's listed directory number and obtains from the number group frame both the line link frame termination and an indication that this termination is a listed directory number. The completing marker signals the incoming trunk to remove station A from hold and establishes the transfer transmission path between the incoming trunk and the attendant.

Station B informs the attendant that station A wishes to be transferred and disconnects from the call.

The attendant flashes her switchhook and completes the transfer the same way a regular Centrex line (station C) completes a second transfer.

2. Calls Transferred to an Attendant Equipped with a Console

   These calls are handled similar to the calls transferred to an attendant equipped with a call director or regular station set.

   The transfer transmission path connection, however, is between the incoming trunk and the attendant trunk. The attendant trunk connects to the console and flashes the attendant the same as during an LDN call.

   Also, the attendant, instead of flashing the switchhook, to initiate the second transfer, depresses a start in key on her console.

M. ATTENDANT CONTROLLED TRANSFER CALLS

A Centrex CO office may serve customer groups which permit calls to be transferred only by an attendant. Although Centrex lines in these customer groups cannot use the dial transfer method to transfer a call to an attendant or other Centrex lines, they can transfer a call to an attendant by merely flashing the switchhook.

When station A requests to be transferred, station B flashes his switchhook as an indication to the incoming trunk that he wishes to make a transfer. The transfer request, line identification, and transfer dial tone connections are established the same as for a regular dial transfer call.

When the completing marker establishes the transfer dial tone connection, it determines from station B's class of service that he is unable to complete the transfer by dialing and signals the transfer register that the call will be transferred by an attendant. The completing marker then releases from the call.

When the transfer register receives the signal from the completing marker, it withholds dial tone from station B and again connects to a completing marker through the transfer register marker connector.

The transfer register then generates a digit "O" and passes it to the completing marker along with the trunk link frame number of the incoming trunk and station B's class of service.

When the completing marker receives the digit "O" it establishes the transfer transmission path in the same way it establishes the path when station B initiates the transfer by dialing "O". The remainder of the call and the subsequent transfer by the attendant, also are handled the same as when station B indicates the transfer by dialing "O".

N. CENTREX CU OPERATION

In Centrex CU operation, a PBX is located on the customer's premises and functions with a No. 5 Crossbar marker group to provide the Centrex facilities.

The PBX, however, must be arranged to accept direct-inward-dialing before it can realize the full capacities of these facilities.

Calls from Centrex lines that are assigned to a Centrex CU are handled the same as calls from PBX extensions assigned to a PBX which does not have access to the Centrex facilities.

The PBX may be assigned either a separate office code or groups of four or five digit numbers within an office code which is shared with other PBX's or regular customers.

At the present time, only the PBX attendant can transfer calls.

O. PBX ASSIGNED A SEPARATE OFFICE CODE

This arrangement permits direct-inward-dialing calls, either incoming, intraoffice, or LDN calls, to be switched through the No. 5 Crossbar marker group similar to a tandem call. The outgoing dial pulse sender passes the digits to the selectors of the PBX over regular outgoing trunks.

However, the number of PBX's which can be served by a No. 5 Crossbar marker group is limited by the marker group capacity of six office codes.

P. PBX ASSIGNED GROUPS OF NUMBER WITHIN A SHARED OFFICE CODE

This arrangement requires line link pulsing facilities which are described in another section of this specification. The number of PBX's which can be served by a No. 5 Crossbar marker group is limited only by the marker group capacity of 40,000 numbers.

8.9 ADDITIONAL CUSTOMER SERVICE - LINE LINK PULSING

Line link pulsing (LLP) facilities enable PBX's which are served by a No. 5 Crossbar marker group to receive direct-inward-dialed calls to the individual PBX extensions.

These facilities are used in marker groups which are not arranged for Centrex operation and also may be used in marker groups arranged for Centrex operation when a PBX customer desires to retain his PBX and use it as a Centrex CU.

The fundamental capacity of a No. 5 Crossbar marker group arranged for line link pulsing is essentially the same as a marker group arranged for basic customer service. However, a maximum of 30 customer line appearances per line link frame may be used for line link pulsing lines to PBX's.

Two methods of operation are used to handle calls which require line link pulsing facilities. When the PBX extensions are not indentified in groups of one hundred or one thousand numbers, the completing marker uses the number group frame twice. However, when the PBX extensions are identified in groups of one hundred and one thousand numbers, the completing marker uses the numbers group frame only once.

8.10 CALLS WHICH REQUIRE THE NUMBER GROUP FRAME TO BE USED TWICE

The transmission path for these calls is between the incoming trunk (intraoffice or intermarker group trunks may also be used) and a line link pulsing line through the trunk link, line link, and junctor group frame.

This path is established the same as the paths for calls to regular customer lines. However, additional signaling paths are required to pass the digits of the called PBX extension to the PBX.

When the completing marker receives the digits of the dialed number it proceeds to obtain a translation of it from the number group frame the same as if the call were to complete to a regular customer line.

The number group frame, however, determines that the called number terminates at a PBX and requires the use of the LLP facilities. It then passes to the completing marker the proper route to the PBX and the number of digits that are to be outpulsed.

The completing marker with the aid of its LLP frame generates a four-digit number that represents a group of line link pulsing lines which connect to the PBX and passes it to the number group frame.

The number group frame, upon receipt of this number selects an idle LLP line in the group and passes its line frame location, along with an identification of its associated LLP sender group, back to the completing marker.

The completing marker connects to an idle LLP sender within the sender group through the outgoing sender connector frame and passes to it both the last four-digits of the called number and the number of digits to be outpulsed to the PBX. If the four-digit number is an LDN number, the number group frame signals the completing marker that no digits are to be outpulsed. The completing marker generates a digit "0" and passes it to the LLP sender with instructions to outpulse it instead of the four-digits which were previously passed.

The completing marker also establishes the transmission path between the incoming trunk and the LLP line and connects the LLP sender at the LLP sender link frame. The completing marker then releases from the call.

When the PBX signals the LLP sender that it is ready, the LLP sender outpulses the proper number of digits to it. (The LLP sender will outpulse the full four-digits or the last one-, two-, or three-digits.)

8.11 CALLS WHICH REQUIRE THE NUMBER GROUP FRAME TO BE USED ONCE

These calls are handled the same as calls to PBX's which place restrictions on terminating service with the exception that the completing marker uses the number group frame only once.

Instead of passing the called number to the number group frame, the completing marker determines, from the called number that the call requires LLP facilities. It also determines from the called number the proper route to the PBX and the number of digits to be outpulsed to the PBX.

The completing marker, with the aid of its LLP frame, generates the four-digit number which represents the group of LLP lines to the PBX and passes it to the number group frame.

The remainder of the call is handled the same as a call which requires the number group frame to be used twice.

8.12 NO. 5 CROSSBAR SYSTEM - FOUR-WIRE NETWORK

The four-wire network shown in Figure 8-22 is primarily a private switching network which enables calls to be handled over high-quality four-wire transmission paths through the No. 5 Crossbar equipment. It may be used to handle normal voice, encrypted voice, and high speed data traffic and, when used for special instructions, can be arranged to handle calls on either a camp-on or preemption basis.

The traffic handling capacity of an individual four-wire or a combined two-wire four-wire marker group is essentially the same as the capacity of a two-wire marker group. Although the total equipment capacity of a combined marker group is the same as a two-wire marker group, the capacity of an individual four-wire marker group is smaller.

A. TRANSMISSION FACILITIES

Two grades of transmission are available in the four-wire network. Voice-grade transmission is used for the basic types of calls while special-grade transmission is required for encrypted voice and data machine calls and may also be used for the basic types. Voice-grade trunk groups connect to conventional carrier and repeater facilities while special-grade groups connect to more sensitively balanced and equalized facilities.

B. METHOD OF OPERATION

Both the four-wire and two-wire networks handle the basic types of call essentially the same. The dialing and transmission paths in the four-wire network, however, require four-wire line link, trunk link, and junctor grouping frames as well as four-wire originating and incoming registers, trunks and outgoing senders instead of the corresponding two-wire frames and units. The other frames and units are used in both networks.

In addition to the basic types of calls, the four-wire network can be arranged to handle encrypted voice and data machine calls for all customers and can be arranged to handle calls on a camp-on or preemption basis for special customers.

An encrypted voice or a data machine call requires the use of a trunk assigned to a special grade trunk group for access to the proper carrier and repeater facilities. The originator may or may not dial a control digit before he dials the directory number when he desires to place these types of calls.

The control digit indicates to the marker that a trunk to the connecting office is to be selected from the special grade trunk group. The originator may or may not also dial a control digit if he desires preemption or camp-on treatment of this call.

If this digit indicates that the call required preemption treatment and the marker finds that all trunks are busy it will disconnect an existing call between the two offices and seize the idled trunk to establish the required transmission path.

If this digit, however, indicates that the call requires camp-on treatment, the marker will attempt to select an idle trunk to the connecting office. If it finds that all trunks are busy, it will return the call to the originating register and establish a connection at the register priority link frame between the originating register and all trunks in the group. The register monitors the trunks and, when one becomes idle, seizes a completing marker and again requests a transmission path. The marker will attempt to select the idle trunk and if successful will proceed to establish the transmission path. If however, the

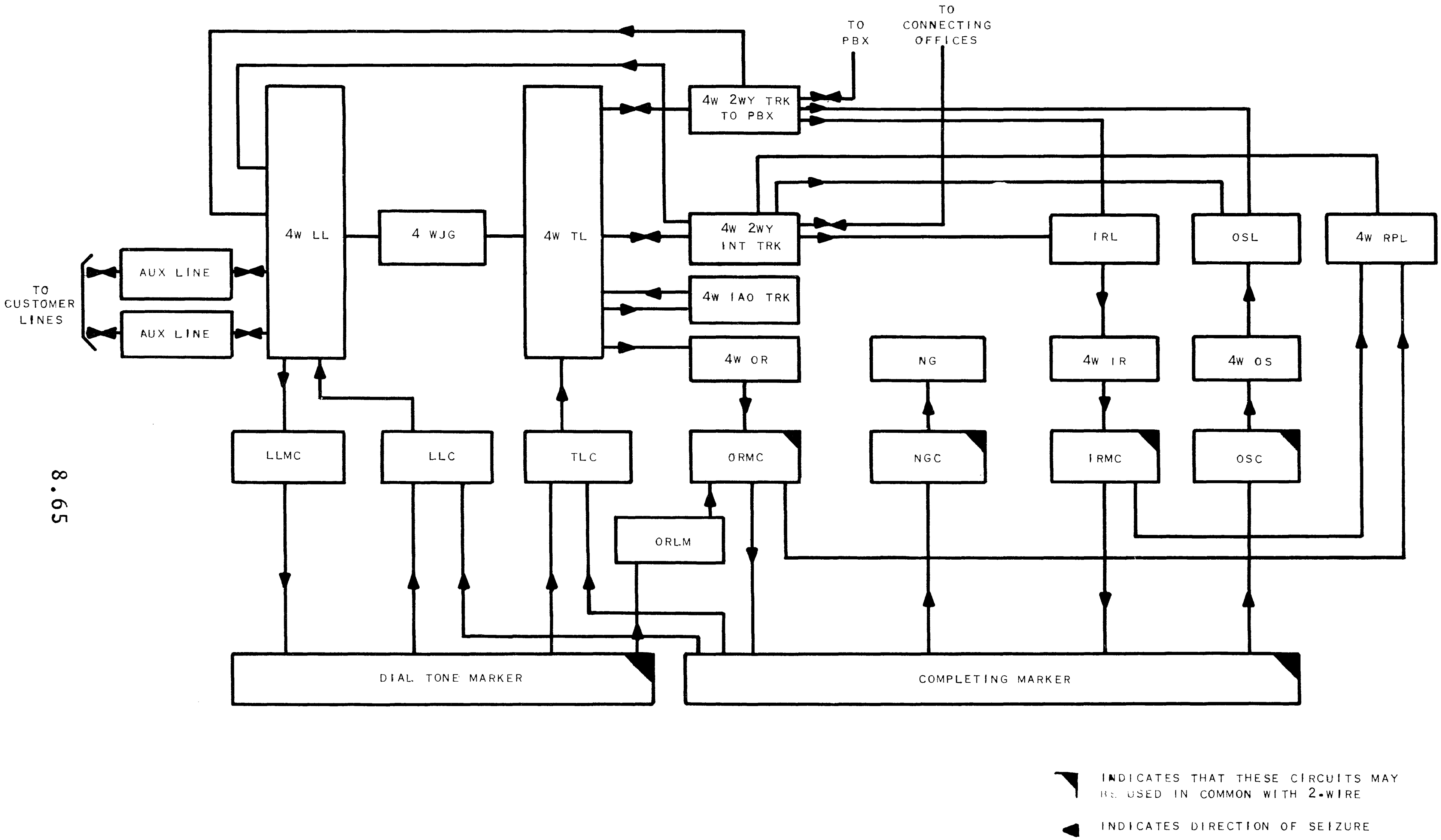


Figure 8.22 Additional Customer Service 4-wire

marker finds that all trunks are still busy it will again return the call to the register and reestablish the connection at the register priority link frame. This process will be repeated until the marker successfully selects a trunk.

The same basic operation is used for calls from a connecting office which are to be switched through a four-wire office. In this type of call, however, the marker returns the call to the incoming register and establishes the connection at the register priority link frame between the incoming register and the trunks of the group to the connecting office.

When an idle trunk is finally selected the marker establishes the transmission path between the line link frame appearance of the incoming trunk and the trunk to the connecting office.

C. FOUR-WIRE FRAME DESCRIPTIONS

The four-wire frames are divided into the same groups as the frames used for basic customer services in the two-wire network (two-wire frames).

This section describes briefly only the equipment used specifically in the four-wire network.

Connectors, dial tone and completing markers, and various test and maintenance frames are used in both networks. Variations in this equipment for operation in the four-wire network are optional features in the equipment specifications.

D. FRAMES IN THE TRANSMISSION PATH

1. Four-Wire Line Links

The function of the four-wire line link frames is the same as the function of the two-wire line link frames. The four-wire line link frame, however, uses two pairs of leads in the transmission path instead of a single pair. Each pair is used for transmission in only one direction.

The lines or trunks, with line link frame appearances, terminate on verticals of line switches and the junctors terminate on verticals of junctor switches. The horizontals of line and junctor switches are connected in a standard crossbar link pattern which gives the lines full access to junctors.

Both basic 190 line (two-bay) and basic 190 line (one-bay) four-wire line link frames are available.

The basic 190 (two-bay) four-wire line link frame is a double bay frame which contains crossbar switches and surface wired units of general purpose and line relays. This frame gives 190 lines access to its own 100 junctors and an additional 90 lines access to the 100 junctors on the basic 190 line (one-bay) frame.

The basic 190 line (one-bay) four-wire line link frame is a single bay frame which also contains crossbar switches and surface wired units of general purpose and line relays. This frame gives 100 lines access to 100 junctors.

Although the two-bay frame may be used by itself when an odd number of line link frames is required, the one-bay frame must be associated with a two-bay frame to attain its full capacity of 190 lines.

2. Four-Wire Trunk Links

The function of the four-wire trunk link frames is the same as the function of the two-wire trunk link frames. The four-wire frames, however, use two pairs of leads in the transmission path instead of a single pair. Each pair is used for transmission in only one direction.

The trunks and originating registers terminate on the horizontals of trunk switches and the junctors terminate on the horizontals of junctor switches. The verticals of the trunk and junctor switches are connected in the standard crossbar link pattern which gives all junctors full access to all trunks.

The basic four-wire trunk link frame is a double bay frame which contains crossbar switches, small fields of cross connection terminal strips, units of multicontact relays, and surface wired units of general purpose relays. This frame gives 100 four-wire trunks access to 200 junctors.

The four-wire supplementary trunk link frame is a single bay frame which contains crossbar switches, units of multicontact relays, and surface wired units of general purpose relays. This frame gives an additional 100 trunks access to the 200 junctors of the basic frame.

The four-wire extension trunk link frame is a single bay frame which contains primarily crossbar switches. This frame gives the trunks assigned to the basic and supplementary frames access to an additional 200 junctors.

3. Four-Wire Junctor Grouping Frames

The four-wire Junctor grouping frames consist of pairs of two-wire junctor grouping frames. The frames in the pair used for single trunk link frame operation are designated four-wire junctor grouping frames and four-wire extension junctor grouping frame. The frames in the pair used for paired trunk link frame operation are designated four-wire supplementary junctor grouping frame and four-wire supplementary extension junctor grouping frame. The four-wire junctor grouping and four-wire supplementary junctor grouping frames terminate the T, R and S leads of the junctors and the four-wire extension junctor grouping and four-wire supplementary extension junctor grouping frames terminate the T1 and R1 leads.

These frames are single bay frames which contain terminal strips and jumper rings for retaining the wire used for running the jumpers.

4. Four-Wire Trunks

Various four-wire trunks are available for use specifically with the four-wire switching network. These trunks include four-wire intraoffice trunks and four-wire two-way intertoll trunks.

Four-wire trunks are surface wired units consisting of from one to eight mounting plates of general purpose relay equipment.

E. FRAMES IN THE CONTROL PATH

1. Completing Marker Four-Wire

The function of the four-wire frame is to provide the additional control and translation facilities which enable the completing marker to perform its functions in the four-wire switching network.

The frame is a single bay frame which contains fields of cross-connection terminal strips and surface wired units of general purpose relays.

2. Four-Wire Originating Register

The basic function of the four-wire originating register is the same as the two-wire originating register. The four-wire originating register, in addition, can be arranged to signal the marker and to perform additional tasks when the call requires camp-on or preemption treatment. Like the two-wire originating register, the four-wire originating register can accept either dial pulses from a rotary dial set or TOUCH-TONE pulses from a TOUCH-TONE set.

The four-wire originating register consists of surface wired units of general purpose relays.

The four-wire originating register frame contains a maximum of eight originating registers and associated multicontact relay assemblies for assigning each register to one of a possible three originating register marker connectors.

3. Four-Wire Incoming Register

The basic function of the four-wire incoming register is the same as the function of the two-wire incoming register. The four-wire incoming register, in addition, can be arranged to signal the marker and to perform additional tasks when an incoming call requires camp-on or preemption treatment.

Only four-wire incoming registers arranged to accept multifrequency pulses are available.

The four-wire incoming register consists of surface wired units of general purpose relays.

4. Auxiliary Originating Register - Incoming Register Marker Connector

The function of the auxiliary originating register - incoming register marker connector frame is to provide connections between the completing markers and the four-wire originating and four-wire incoming registers in addition to those provided by the basic originating register and incoming register marker connector frames. This frame is a single bay frame which contains multicontact relay assemblies.

5. Four-Wire Outgoing Sender

The basic function of the four-wire outgoing sender is the same as the function of the two-wire outgoing sender. The four-wire outgoing senders, however, can handle calls which originate in the four-wire switching network and complete to a two-wire network, in the same marker group, in addition to calls which both originate and complete in the four-wire network. Calls which complete to the two-wire network in the same marker group may either complete to a local customer or may be switched through the two-wire network on a tandem basis.

Only a four-wire outgoing multifrequency sender is used for basic operation in the four-wire switching network.

The four-wire outgoing sender consists of surface wired units of general purpose relays.

6. Register Priority Links

The function of the register priority link frame is to give four-wire originating and incoming registers access to the group busy leads of the various four-wire trunk groups when a call requires camp-on treatment. The registers monitor the appropriate trunk groups and signal the completing marker, when a trunk becomes idle, to make another attempt to establish a transmission path.

F. FOUR-WIRE MAINTENANCE AND TEST FACILITIES

The same facilities which are used in the two-wire switching network are used in the four-wire switching network. However, four-wire register and senders are tested only with the manual test set facilities. The variations which are required to permit operation with the four-wire switching network are covered in the individual equipment specifications.

G. ADDITIONAL CUSTOMER SERVICE - FOUR-WIRE DIRECT-INWARD-DIALING

Four-wire direct-inward-dialing (DID) enables a four-wire marker group to provide direct-inward-dialing to a step-by-step PBX extension and permits direct outward dialing from a PBX extension to the four-wire marker group, also shown in Figure 8-22.

The PBX in addition to being arranged for DID, must also be arranged to convert the two pairs of wires in the normal four-wire transmission path to the single pair available at the PBX.

The capacity of a marker group arranged for four-wire direct-inward-dialing is the same as the capacity of a marker group arranged for four-wire switching without direct-inward-dialing.

H. METHOD OF OPERATION

The transmission path for a call which completes directly to a PBX extension is through a four-wire line link frame appearance of a four-wire two-way intertoll trunk and the four-wire trunk link frame appearance of a four-wire two-way trunk to a PBX.

If the call to a PBX is originated by a customer whose line terminates on a four-wire line link frame in the same marker group, the transmission path is between the four-wire line link frame appearance of the line and the four-wire trunk link frame appearance of the four-wire two-way trunk to a PBX.

The four-wire two-way trunk to a PBX has both a four-wire line link frame and a four-wire trunk link frame appearance. The four-wire line link frame appearance enables the PBX extension to originate calls to the four-wire marker group and the four-wire trunk link frame appearance enables a call from a four-wire marker group to be direct-inward-dialed to the PBX extension.

The transmission path for calls which are originated by a customer line in the four-wire marker group is established the same as the path for outgoing calls. The path for calls which originate in a connecting marker group is established the same as the path for other calls which are switched through the four-wire marker group on a toll switching basis.

For this transmission path, however, the completing marker selects a four-wire outgoing dial pulse sender instead of a four-wire outgoing multifrequency sender to match the pulsing requirements of the PBX.

CHAPTER 10

4A TOLL SWITCHING SYSTEM

10.1 INTRODUCTION

The growth of toll traffic within the Bell System during the past thirty years has been amazing. In an attempt to keep abreast of this growth, provide new and better facilities, and at the same time obtain maximum use of existing facilities, the No. 4 Toll Switching System was designed.

The No. 4 Toll Switching System, of which the 4A is the latest model, is a four wire system, using one pair of wires for transmitting and one pair for receiving. All switching is done mechanically. The No. 4A Toll Switching System was designed to serve as a Control Switching Point (CSP) in the switching of intertoll traffic on a nation-wide basis. However, until the ultimate goal in FACD, or Foreign Area Customer Dialing is attained, operator assistance will be necessary at some points.

The No. 4A Toll Switching System is capable of handling switching between points using either a 3-digit central office code, or a 6-digit code including both the Numbering Plan Area (NPA) and the local area office codes. It has provisions for translating the full 6-digit code for selection of the correct route where more than one route exists to another NPA. It has features capable of varying the number of digits sent to the distant office and in some cases substituting other code digits when passing all or part of the full 6-digit code to a distant point. Another feature is the alternate routing of traffic when the first choice high usage group is busy. Under certain circumstances as many as seven different routes from one CSP can be tested in a search for an idle path.

From the old method of calling "Long Distance" to leave the name of the called party and waiting from 15 minutes to several hours to get the connection to the present method of dialing directly to the called party covers many years of research and development in the field of telephone system communications.

10.2 TOLL SWITCHING SYSTEM

The 4A Toll Switching System is a part of the Nationwide Toll Dialing Plan for operator and customer dialing of toll calls. The plan provides for long-distance operators or customers to dial or key the information for routing a call. The switching equipment then automatically completes the call.

Figure 10-1 shows the relationship of the 4A Toll Switching System to the Toll Switching Plan.

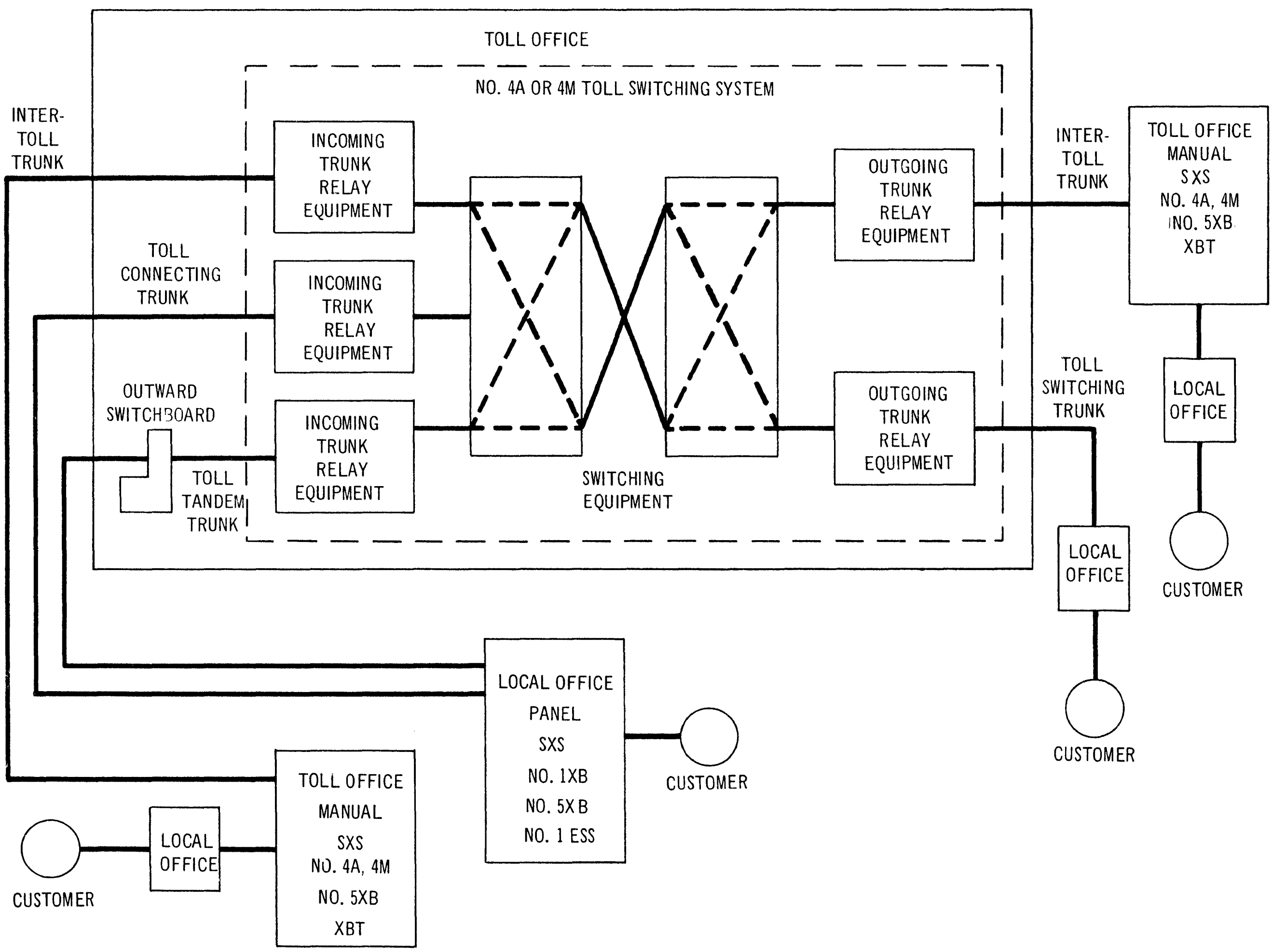


Figure 10-1 - Relationship of 4A Toll Switching Systems to General Toll Switching Plan

A. SWITCHING PLAN

Crossbar switches arranged on incoming and outgoing link frames, and common control equipment provides 4-wire paths for establishing connections mechanically between intertoll trunks, tandem and intertoll trunks, and intertoll and toll switching or miscellaneous terminating trunks. Common control equipment consisting of markers, senders, decoders, card translators, link controllers, and trunk block connectors will set up the switching paths and receive and send, as necessary, the pulsing and signaling information required for completion of a call. The relationship of the link frames and the common control equipment is shown in Figure 10-2.

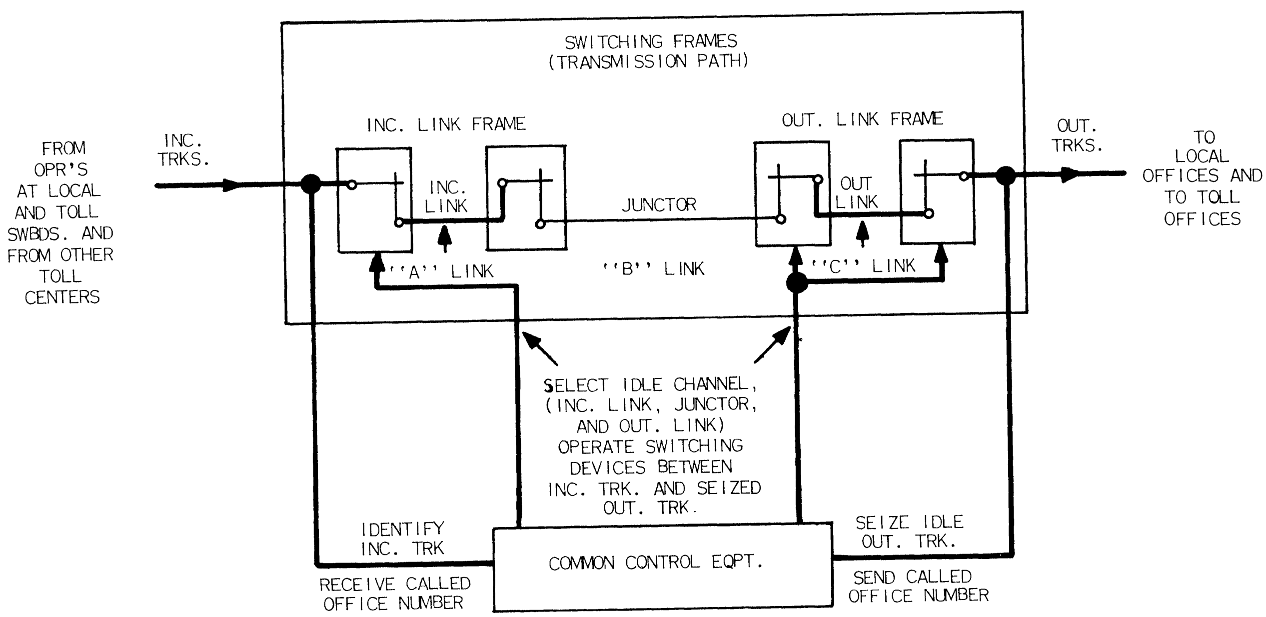


Figure 10-2 - Relationship Between Common Control Equipment and Switching Frames

Common control means that the switches in the talking connections are set up by certain equipment units which are common to many of the switching frames in the office. A common control system has the ability to store and reuse digits. Other common control circuits associated with the CAMA portion of the 4A system are: transverters, billing indexers, recorders, position link controllers, and master timers which are not discussed in this section.

The marker is one of the major control units of the common control equipment. One of its 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. In this manner a few units of complicated equipment are used for short periods of time to set up the switches for a proportionately large number of calls.

1. 4-Wire Talking Path

The 4A system is a 4-wire transmission system. This means that two voice paths per trunk are provided through the switches - one for each direction of transmission.

The 4-wire transmission system eliminates a need to convert 2-wire trunks to 4-wire and back to 2-wire for voice repeaters and also eliminates the undesirable transmission effects caused by these conversions.

A conversion from 4-wires is still required, however, when connecting to a 2-wire office. This would be at the originating and terminating ends, so that the call can be switched through local automatic switching equipment or via a switchboard to the customer.

The 4A system starts with the trunk relay equipment on the incoming intertoll or incoming toll connecting trunks, and ends with the trunk relay equipment on the outgoing intertoll or toll switching trunk.

Calls arriving at the 4A toll office may have been originated by an operator or customer. As there is no incoming class indication used by these systems, the equipment can not differentiate between operator and customer calls. Incoming calls with a few exceptions are routed from the digital information alone.

After the number has been registered, the No. 4A system automatically takes over. A route that can complete to the terminating local office is selected, routing information is transmitted to the distant toll office and the call is then completed.

2. Nationwide Dialing Requirements

Nationwide dialing requires that calls be switched on a destination basis rather than on a trunk route basis. To route calls on a destination basis requires in some cases that the 4A system be able to examine and use (translate) six ditits.

Another requirement of nationwide dialing is automatic alternate routing. 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 the call can be completed. 4A systems have the ability to automatically scan rapidly and select a route from several alternates in its attempts to establish a connection. The 4A system automatically checks the preferred route and as many as five alternate routes in rapid succession, although the actual use of five subsequent choices is not typical.

To complete some calls, it is necessary to delete or to change the area or national office code digits, dialed or keyed by the operator or customer before the number is pulsed 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. With variable spilling, all the code digits can be spilled forward or some of them can be skipped and the remaining digits spilled forward. Three or six digits may be skipped. The code conversion feature makes it possible to change one or as many as three consecutive digits to different numerals before they are spilled forward. In addition, one, two, or three digits can be prefixed as required before spilling.

B. NO. 4A TOLL SWITCHING EQUIPMENT

The equipment used in the No. 4A Toll Swtiching System can be divided into the following groups:

Switching Equipment
Sender Link Frames
Common Control Equipment
Trunk and Traffic Equipment
Maintenance Center Equipment

Two arrangements of equipment are provided for the No. 4A System, one with a single train for smaller offices where the number of incoming or outgoing frames will not exceed forty, and the other with two trains each having this capacity. The single train arrangement handles both intertoll and toll completing traffic with a maximum of ten markers and ten decoders. Such an office is called a "Combined Train Office" and is shown in Figure 10-3. The two train offices operate with a maximum of ten markers for each train and twenty-four common decoders and are called "Separate Train Offices - Combined Operation" to distinguish them from other two train offices used in the earlier No. 4 type toll switching systems. Figure 10-4 illustrates a call through a separate train office. In the 4A two train arrangement each train handles both intertoll and toll completing traffic with multiple appearances of all incoming trunks on the incoming link frames of both trains. The trains involve several arrangements which differ essentially in junctor distribution.

1. Incoming Links

An incoming link (A link) is a five wire interconnection between the primary and secondary switches of the incoming link frame. The incoming link frame is the first frame on which the talking paths terminate in a 4A Toll Switching Office. Ten 200 - point, 5 wire crossbar switches are mounted on a "Primary Bay" of each incoming link frame. 200 - point, 5 wire crossbar switches having split horizontals are mounted on a "Secondary Bay." One hundred incoming trunks, ten per switch, are connected to the horizontals of the primary switches, two hundred junctors, twenty per switch, are connected to the verticals of the secondary switches.

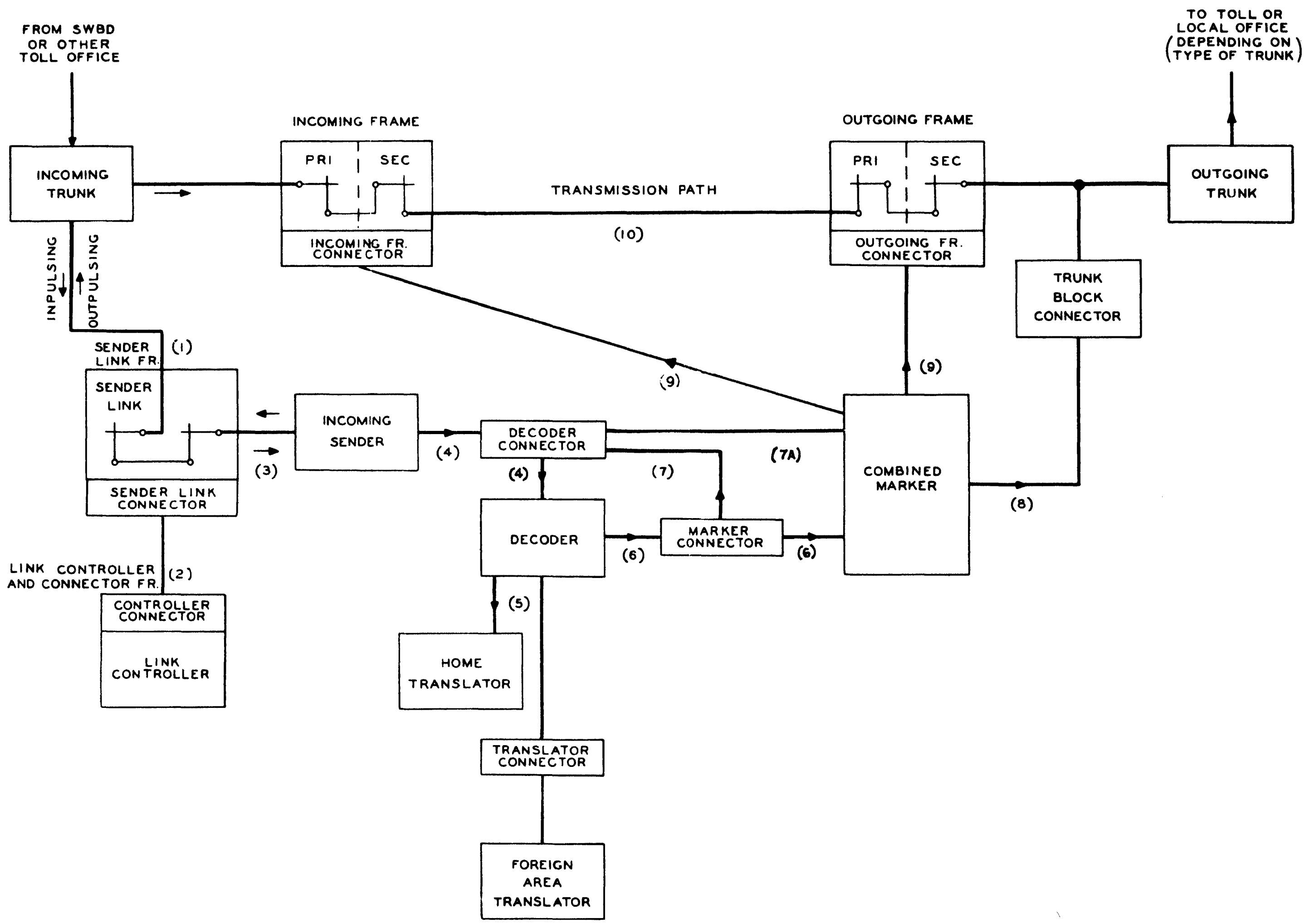


Figure 10-3 - Call Through a Combined Train Office

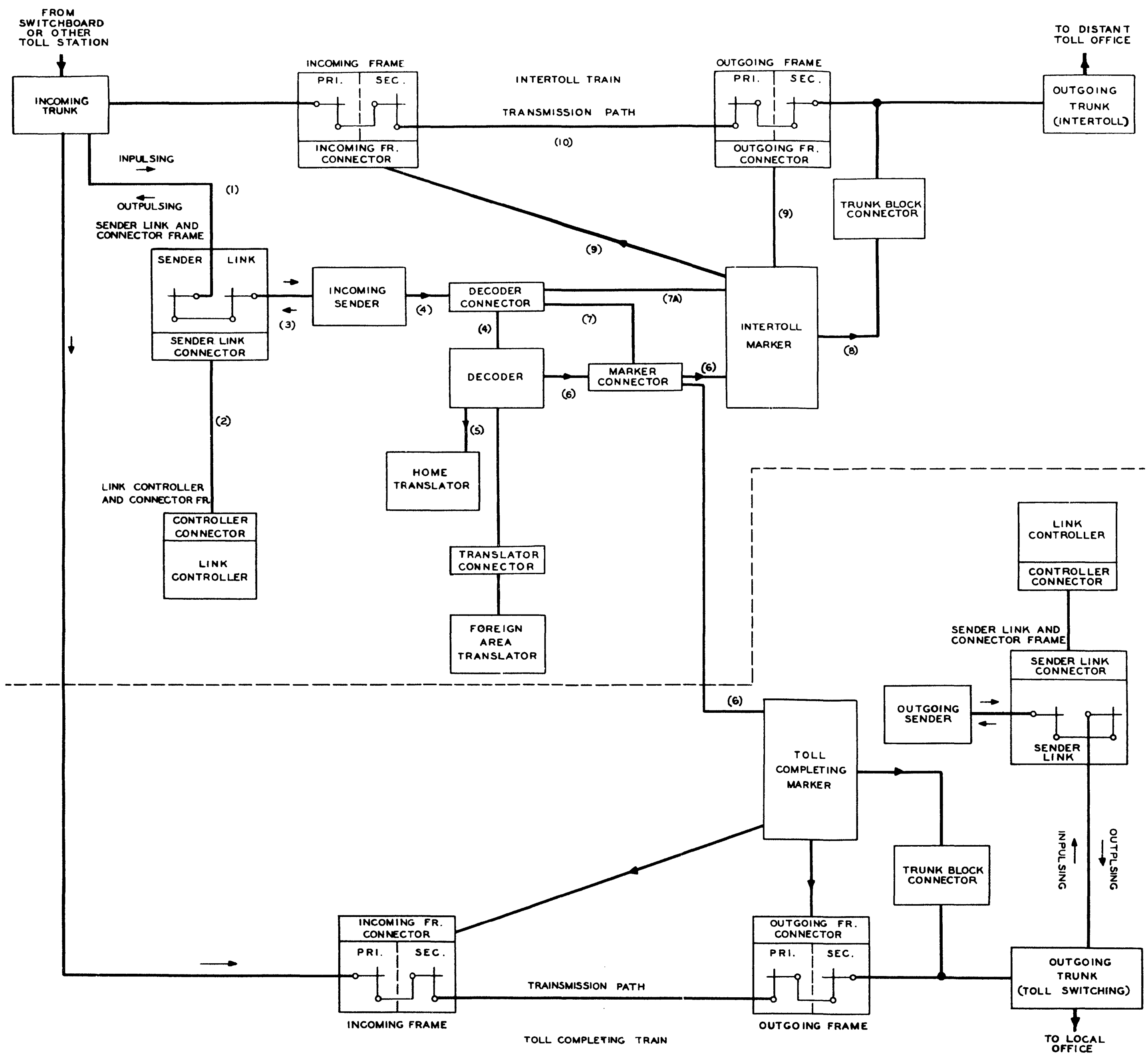


Figure 10-4 - Call Through a Separate Train Office

Two hundred incoming or "A" lines are distributed over the secondary switches in accordance with a fixed pattern, as shown in Figure 10-5. This pattern is such that the twenty links from the verticals of any primary switch are evenly distributed over the ten secondary switches, two per switch. The left verticals of the primary switches always terminate on the left horizontals of the secondary switches and the right verticals of the primary switches always terminate on the right horizontals of the secondary switches. Thus, any of 100 incoming trunks has access to any of the 200 junctors.

Since an incoming link appears on a vertical of a primary half-switch and on a horizontal of a secondary half-switch, and "A" link may be traced in accordance with the following rule: The primary vertical number is the same as the secondary switch number on which it appears, and the primary switch number is the same as the secondary horizontal number. This arrangement of incoming links is known as a vertical-to-horizontal spread and obviates the necessity of providing designation strips for the tracing of incoming links.

2. Junctors

The junctors interconnect the verticals of the secondary switches of the incoming link frames and the verticals of the primary switches of the outgoing link frames. These junctors, which are 5 wire links, are also called "B" links. The respective crossbar switches each have 20 verticals, thereby providing termination for twenty junctors, or 200 junctors per frame.

Since any incoming trunk must have access to any outgoing trunk, the junctors are grouped and interlaced as shown in Figure 10-6. It will be seen that, with this arrangement, the 200 junctors on one incoming link frame must be divided into as many groups as there are outgoing frames. Each group must carry all of the traffic load from the trunks on one incoming link frame to the trunks on one outgoing link frame. Also, it should be observed that the number of junctors on an incoming link frame is equal to the number which appears on the outgoing link frame.

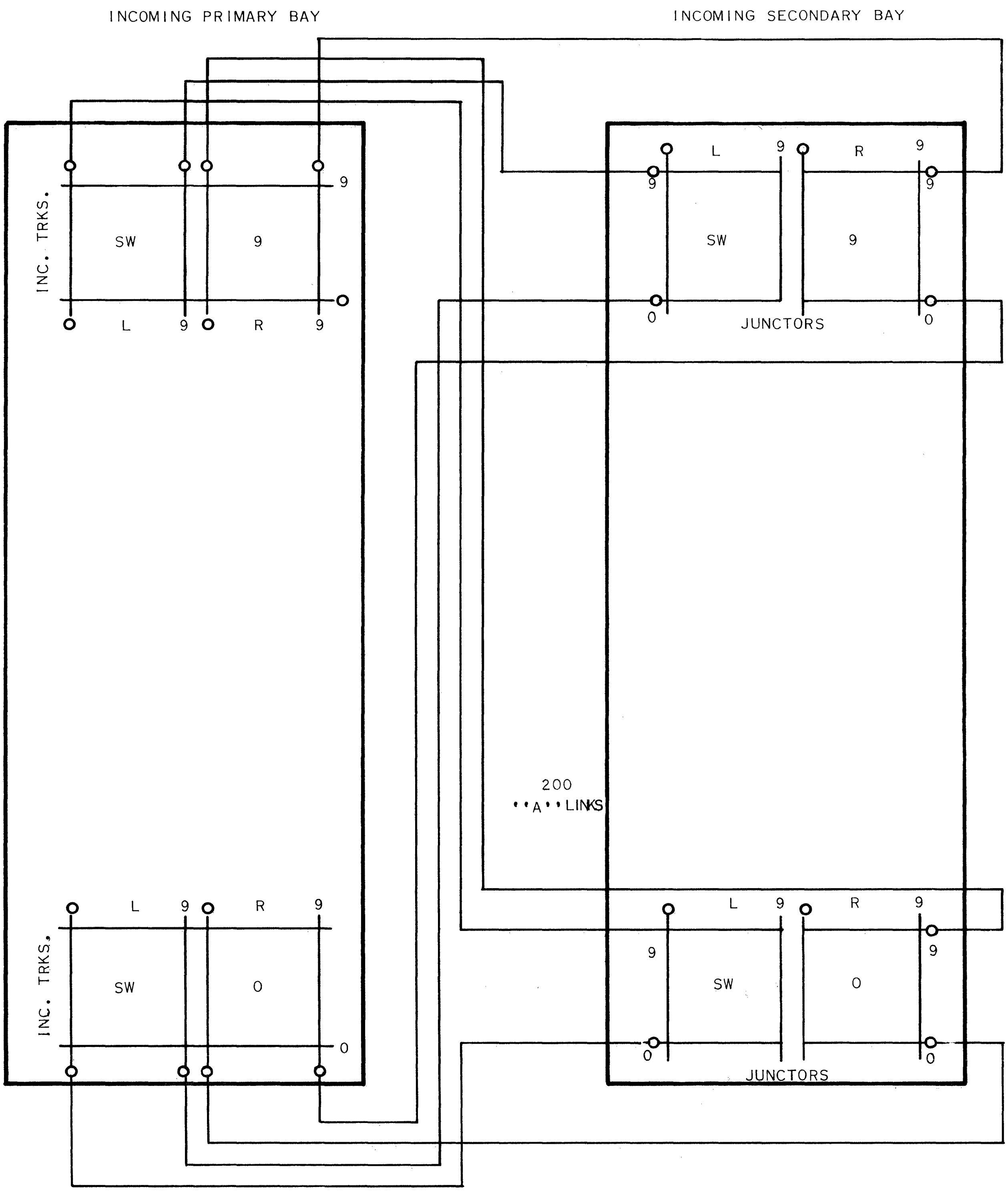


Figure 10-5 - Incoming Link Spread

As the number of incoming and outgoing link frames increases, the possible number of junctors between any two frames must decrease. That is, the size of each junctor group decreases due to the fact the fixed number of junctors on an incoming link frame is divided into as many groups as it has frames to reach. Example: If there are four incoming link frames and four outgoing link frames, then the 200 junctors from any incoming link frame must be divided into four groups consisting of 50 junctors per group; now if the office was increased to eight incoming link frames and eight outgoing link frames, then the 200 junctors from any incoming link frame must be divided into eight groups consisting of 25 junctors per frame.

Design provides that the number of junctors in a group must not be less than ten. This number is reached when the number of incoming link frames in an office reaches 20. For more than 20 frames an arrangement known as "pairing of frames" is employed. The incoming link frame capacity may be increased to 400 junctors by adding a secondary extension bay of ten 200 point 5 wire switches. These additional 200 verticals, thus obtained, together with the 200 verticals of the regular bay of secondary switches, provides terminations for 400 junctors. There are only 200 "A" links serving these 400 junctors, and in order to load them to their full capacity, the same 400 junctors multiple to like numbered verticals on secondary switches of another incoming link frame. The two frames which share the use of these 400 junctors are called an incoming group. The distribution of these 400 junctors of an incoming link frame group is shown in Figure 10-7.

3. <u>Outgoing Link Frame</u>

The <u>outgoing link</u>, or <u>"C" link</u>, is a five wire interconnection between the primary and secondary switches of the outgoing link frames. The outgoing link frame consists of ten 200 point 5 wire switches with split horizontals on the primary bay and ten 200 point 5 wire switches on the secondary bay. There are 200 junctors, with 20 junctors, appearing on the twenty verticals of each primary switch, ten on the left half and ten on the right half. The 200 "C" links are

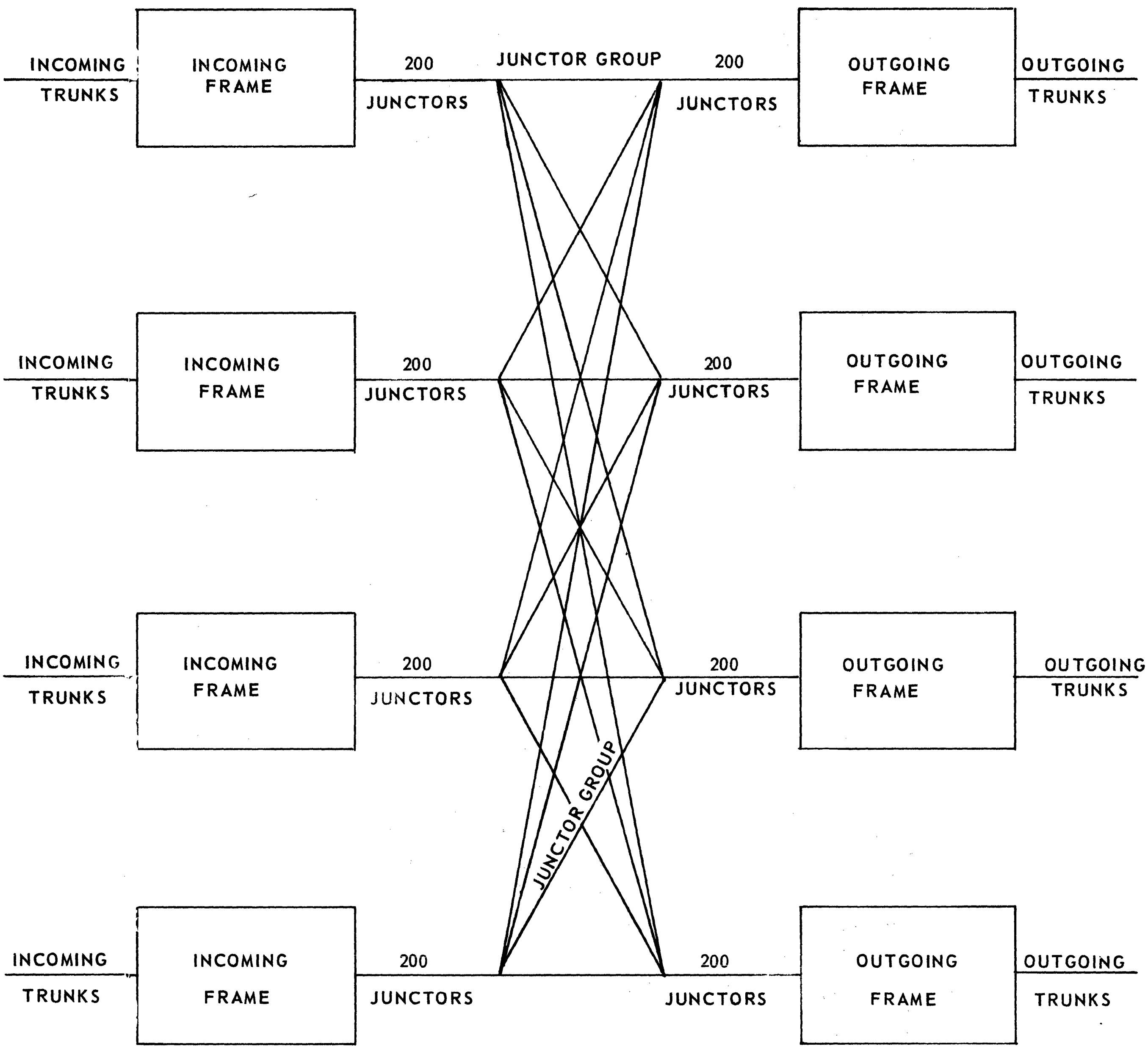


Figure 10-6 - Junctor Spread

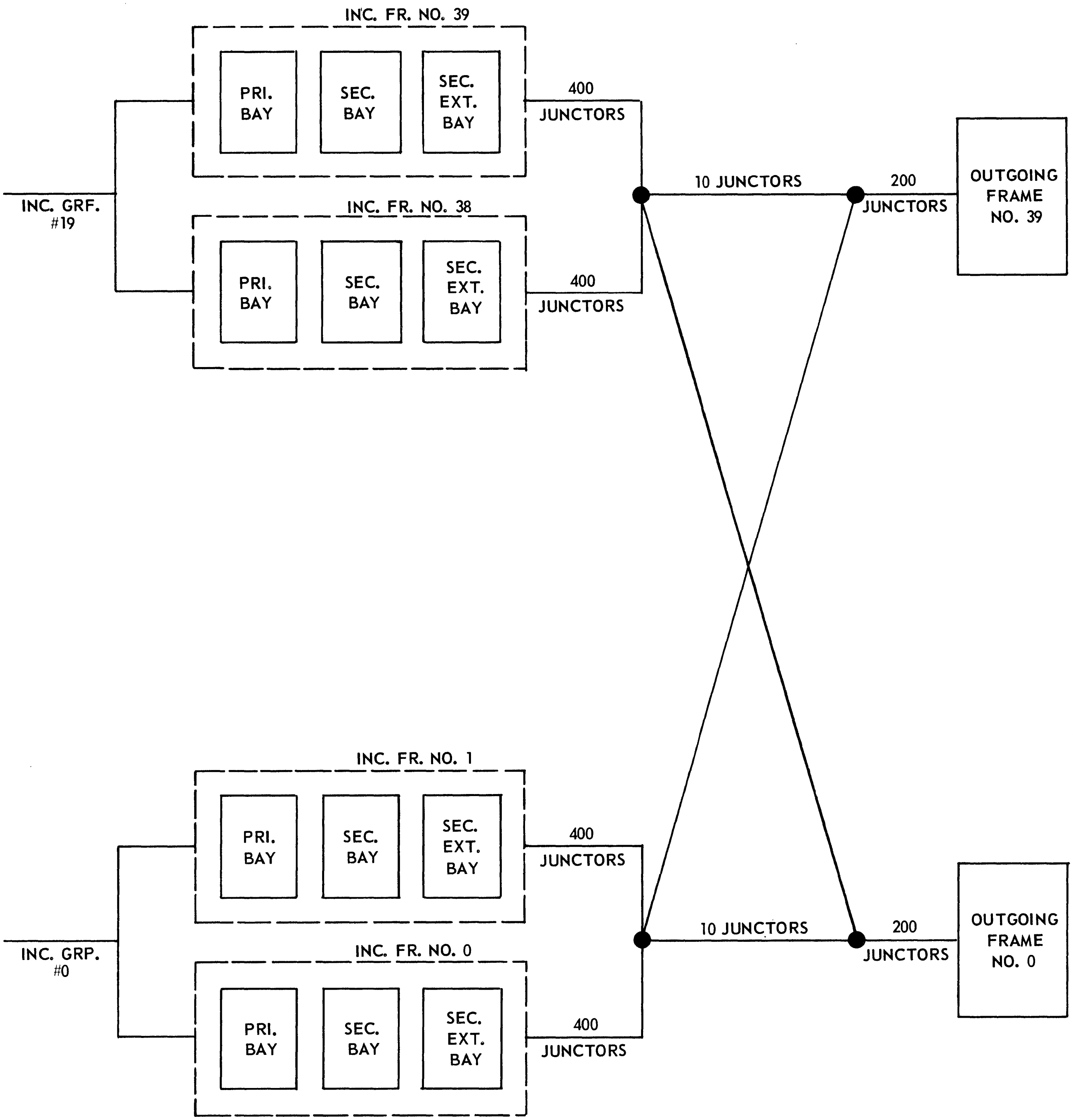


Figure 10-7 - Pairing of Incoming Frames distributed over the secondary switches in a fixed pattern, as shown in Figure 10-8. This pattern is such that the 20 links from the horizontals of any primary switch are evenly distributed over the verticals of all ten secondary switches, two per switch.

One hundred outgoing trunks, ten per switch, appear on the horizontals of the secondary switches. Thus, any one of the 200 junctors has access to any one of the hundred outgoing trunks.

Since an outgoing link appears on a horizontal of a primary half-switch and on a vertical of a secondary half-switch, any "C" link may be traced in accordance with the following rule: The <u>primary horizontal</u> number will be the same as the <u>secondary switch</u> number on which it appears, and the <u>primary switch</u> number is the same as the vertical number on the <u>secondary switch</u>. This method of link distribution is known as a <u>horizontal-to-vertical</u> link spread. In addition, a horizontal on the left half of a primary switch is always connected to a vertical on the left half of a secondary switch, and a horizontal on the right half of a primary switch is always connected to a vertical on the right half of a secondary switch.

The outgoing link frames provide a means for terminating the talking paths of all outgoing trunks in a 4A office, whether to outgoing inter-toll trunks or to toll completing trunks. Through the office control equipment it can be assured that every outgoing trunk in the office is accessible to every incoming trunk.

4. <u>Channels</u>

A <u>channel</u> is a combination of an incoming or "A" link, a junctor or "B" link, and an outgoing or "C" link. This combination of links forms a chain, by means of crosspoint closures, that will connect an incoming trunk with an outgoing trunk. Each group of ten or more junctors connecting an incoming frame with an outgoing frame is spread at both ends over the ten junctor switches, the left and right halves and switch numbers being the same at both ends for each junctor. Considering a particular incoming trunk on an

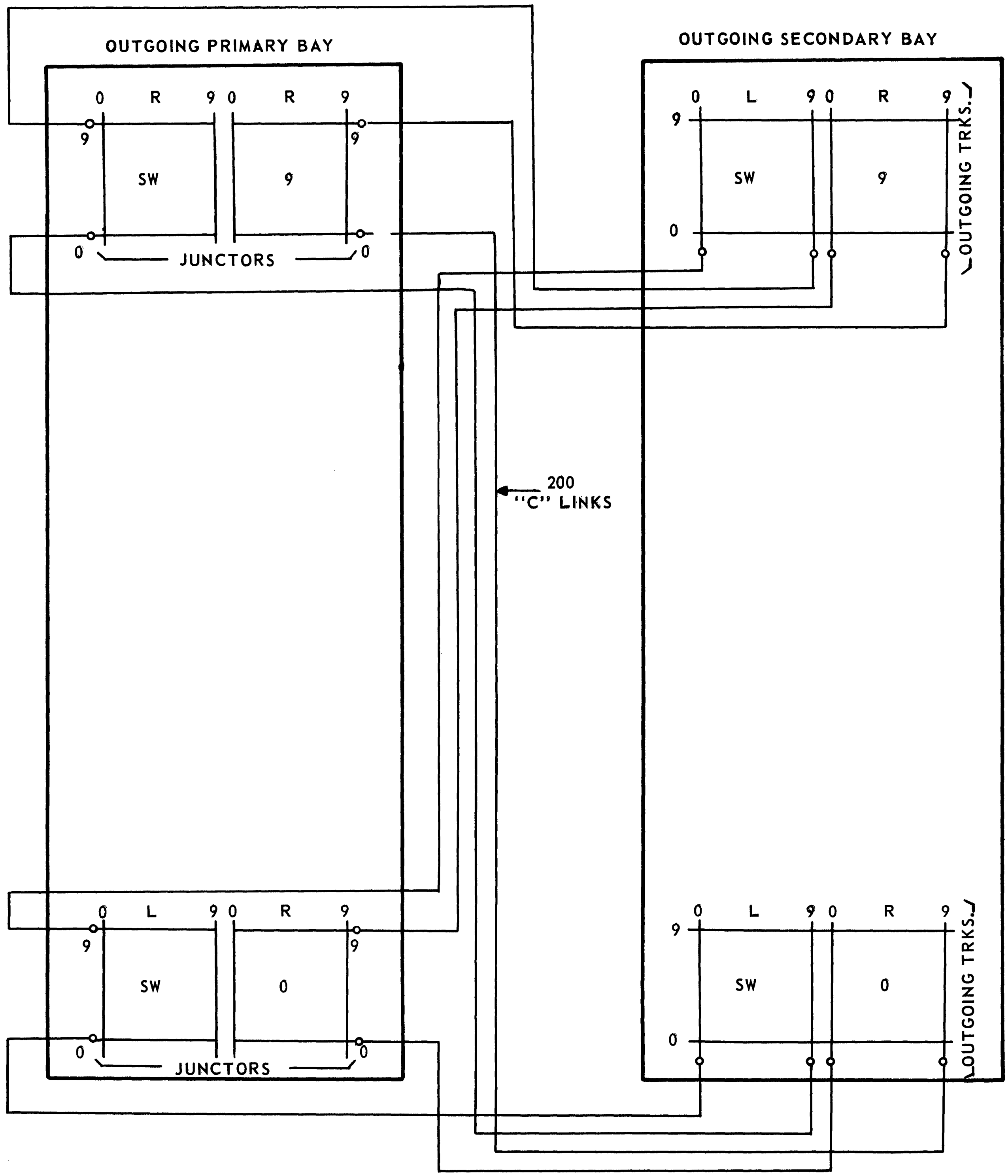


Figure 10-8 - "C" Link Distribution

incoming frame, there are twenty incoming or "A" links (10 left and 10 right) serving it. These are spread over the ten secondary switches of the incoming frame. Considering a particular outgoing trunk on an outgoing frame, there are twenty outgoing or "C" links (10 left and 10 right) serving it. These are also spread over the ten primary switches of the outgoing link frame. Thus between a particular incoming trunk and a particular outgoing trunk, there are ten or more channels available for connection. A diagram for channels is shown in Figure 10-9.

The channel number corresponds to the incoming primary vertical number on which the "A" link appears, to the incoming secondary switch number, to the outgoing primary switch number on which the "B" link appears, and to the outgoing secondary switch vertical number on which the "C" link appears. The channel number is thus an important association of equipment, for it facilitates tracing a connection from an incoming to an outgoing trunk.

5. Increasing Frame Capacity

Previously, only a primary bay which always has a capacity of 100 incoming trunks was mentioned, in order to simplify explanation of the switching principles. As can be seen, it would be uneconomical to provide only 100 trunks to have access to 200 links and 200 junctors. Therefore, a primary extension bay is always provided on incoming frames to increase the capacity to 200 incoming trunks. A second primary extension bay may be furnished where it is desired to increase the capacity to 300 incoming trunks. And similarly a third primary extension bay where it is desired to increase incoming trunk capacity to 400 trunks. The verticals of the primary bay are multipled to the verticals of each extension bay to share the use of the 200 "A" links, Figure 10-10a.

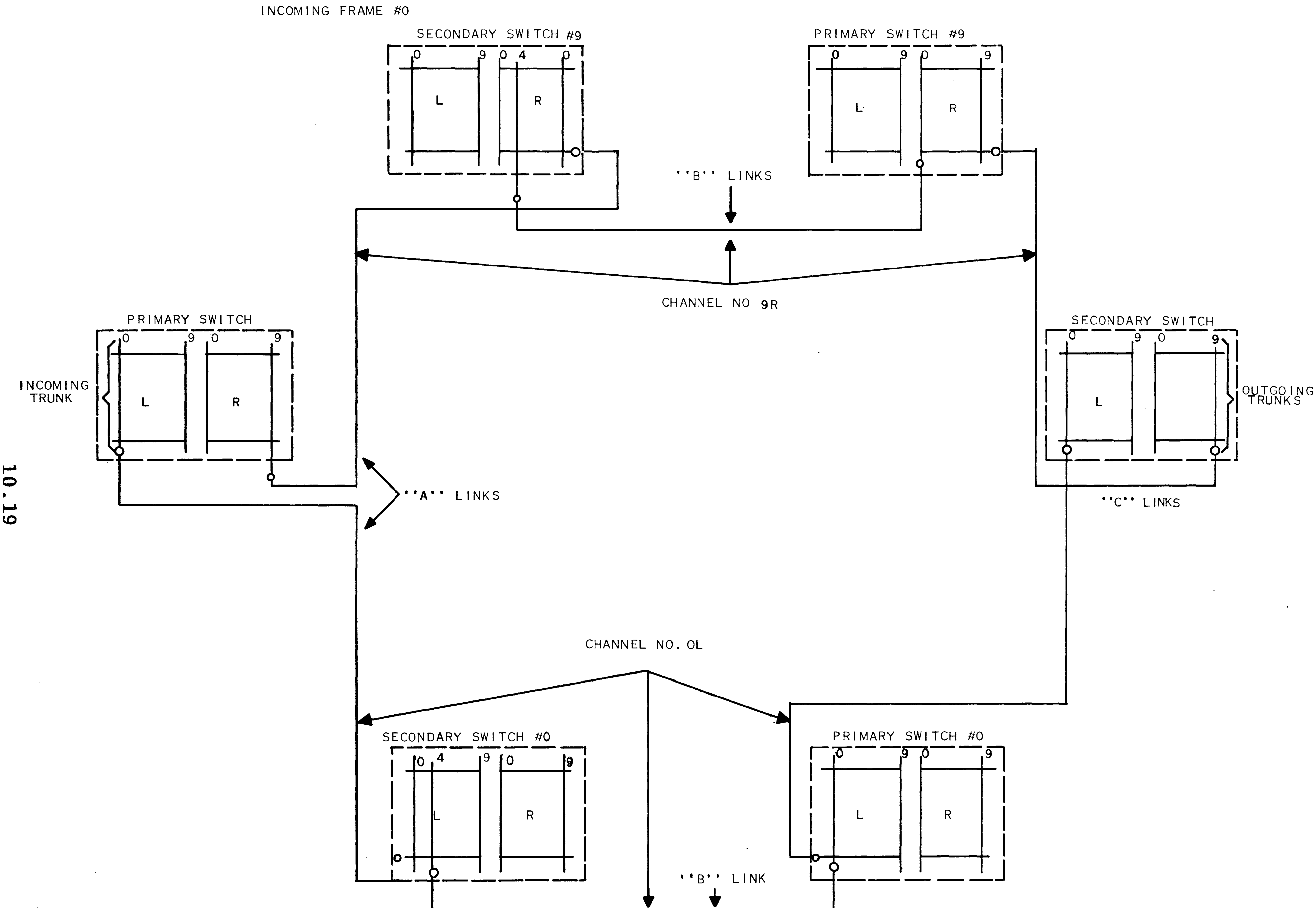


Figure 10-9 - Channels

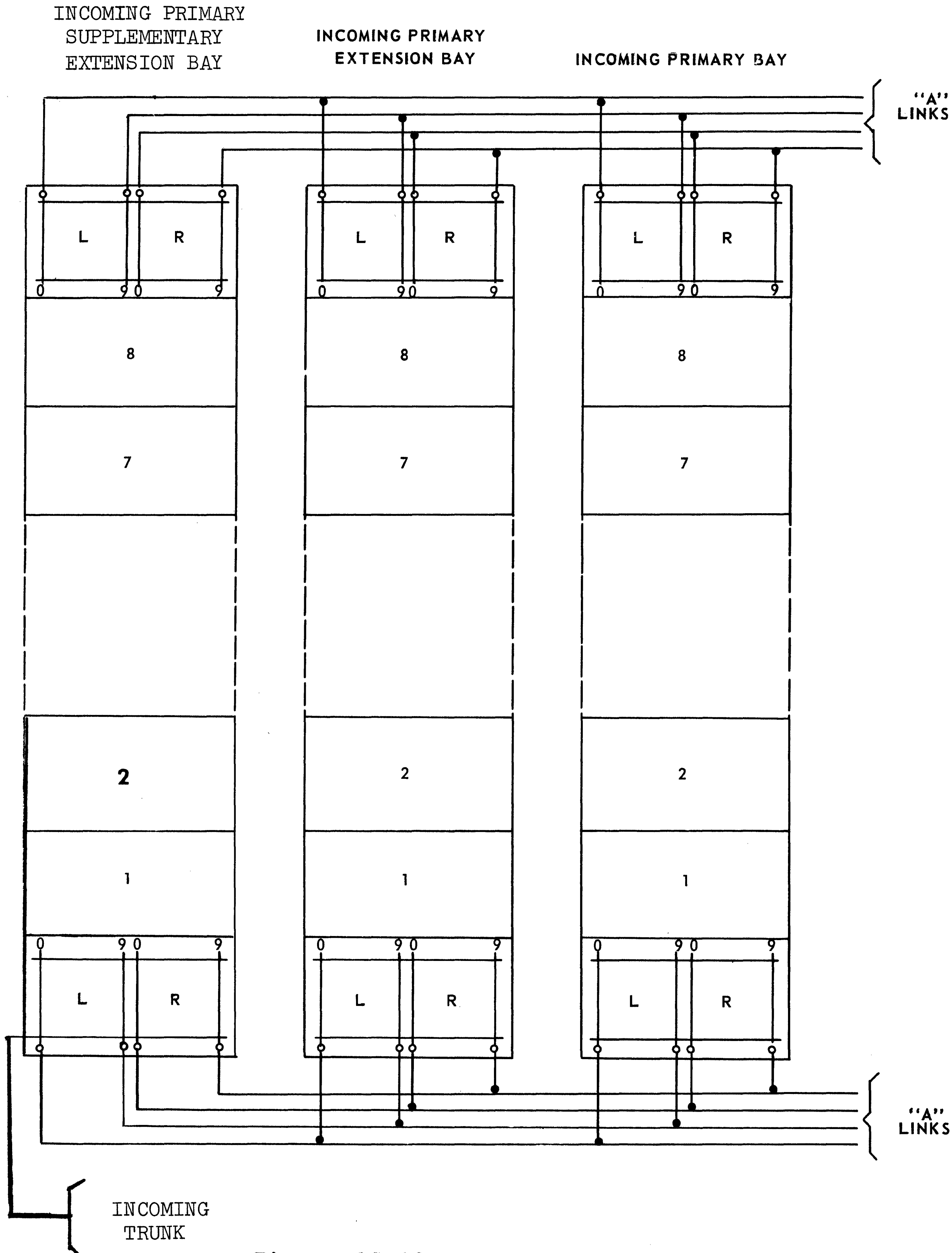


Figure 10-10a - Increasing Incoming Frame Capacity

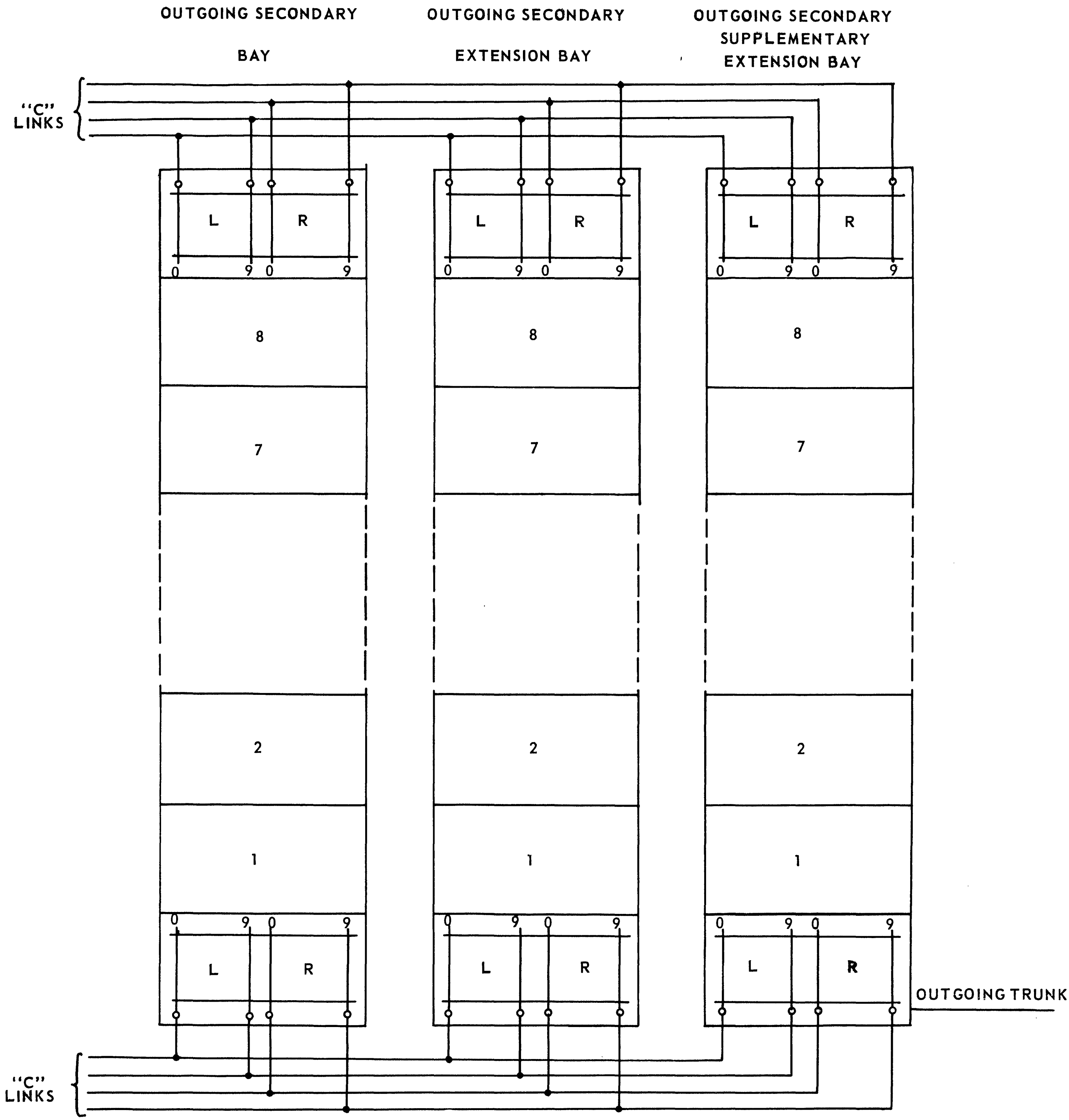


Figure 10-10b - Increasing Outgoing Frame Capacity

Likewise, as referred to in a previous paragraph, the secondary bay of an outgoing frame terminates only 100 outgoing trunks. For the same reason as stated above, a secondary extension bay is always furnished to increase the capacity to 200 outgoing trunks. A second secondary extension bay may be furnished where it is desired to increase the capacity to 300 trunks. The secondary extension, and the second secondary extension bays have the same switch arrangements as the primary bays on an incoming frame, Figure 10-10b.

C. SENDER LINKS

The primary function of a sender link frame is to associate any one of 100 trunks with any one of 40 senders of the proper type. Three types of sender link frames arranged for single class sender access are part of the 4A Toll Switching System. They are:

Incoming MF Sender Link Frames
Incoming Dial Pulse Sender Link Frames
Outgoing revertive and PCI Sender Link Frames

The sender link frame terminates ten trunk groups each on the horizontals of the primary switches and 40 senders on the horizontals of the secondary switches. Each frame includes sixteen 100-point, 6-wire switches mounted in two bays. Eight switches are primary and eight are secondary. The switches are divided into two groups, "A" and "B" units, permitting independent operation of either unit.

Figure 10-11 indicates provisions for terminating 12 leads from each trunk circuit on the horizontals of the "A" primary switch. (Note: This is increased to 18 leads when used for CAMA and overseas calls.) These leads are multipled to the horizontals of the "B" primary switches. The 12 leads from each sender terminate on the horizontals of two secondary switches.

The primary switch verticals are strapped horizontally in pairs, two such pairs being required to carry the leads comprising two links. Each group of ten trunks has access to two links through an "A" primary switch and to two links through a "B" primary switch. The leads from ten trunks are therefore connected to the horizontals across two pairs of "A" switch verticals and a multiple is provided to the corresponding horizontals on the "B" primary switches. The links between the primary switch verticals and the secondary switch verticals find their outlet at the secondary switch horizontals which provide access to the senders.

Each group of ten trunks is served by four links, each link having access to a maximum of ten senders. Any trunk, therefore, may have access to each one of four groups of ten senders or less on the frame.

The vertical number of the primary switch is the same as the secondary switch number on which it terminates. The vertical number on the secondary switch is the same as the incoming trunk group number on the primary switch on which it terminates. This is known as vertical to vertical spread. Connections between trunks and senders are set up by controllers which are reached by the sender link frame through controller connectors. Senders of a type can be connected to a sender link frame in groups of 80 maximum on a "key" frame basis. The latest arrangement for connecting senders to sender link frames, known as "Simplified Sender Grouping" involves the assignment of no more than 40 senders to each sender link frame group. The "key" frames are the first four sender link frames of a group, and are interconnected with a slip multiple which is arranged so that when there are 40 or less senders, all senders appear on all link frames. When the number of senders exceed 40, the additional senders, up to 80, are introduced into the slip multiple in such a way that each sender has appearances on two key frames. Thus, each sender link frame has access to 40 senders, but not always the same combination of 40.

D. DIVISION OF COMMON CONTROL FUNCTIONS

The arrangement of crossbar switches used for the talking connections between an incoming trunk and an outgoing trunk has been discussed in the preceding chapters. With the exception of the sender link frames, the crosspoints on all switches used for a call remain closed for its duration. The problems of controlling the switches may be understood by considering the operations required to set up these connections. The problems, in appropriate order, are as follows:

a. The calling trunk must be identified.

b. An idle sender with an idle link available to it must be selected.

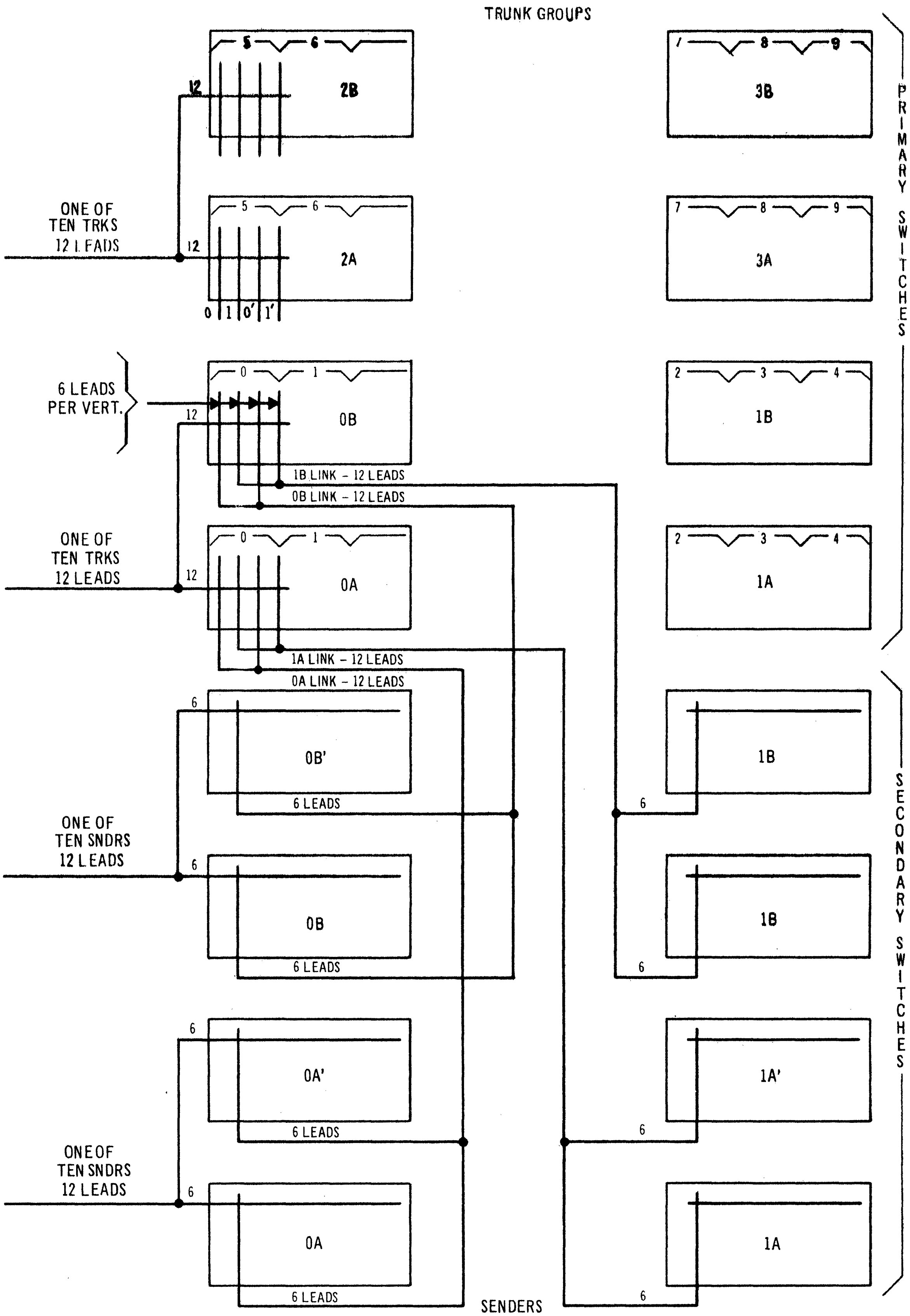


Figure 10-11 - Sender Link Frame - Sender Link Spread

c. The various select and hold magnets in this chain must be operated to set up the connection between the trunk and the sender.

d. The number pulsed over the incoming trunk must be recorded in the sender.

e. The route, in general, must be determined from the first three digits of the number or translating a six digit code for selection of correct route when more than one route exists to another NPA.

f. An outgoing trunk for this route must be selected.

g. An idle channel between the incoming and outgoing trunks must be found and marked.

h. The various select and hold magnets in this chain must be operated to set up the connections between the two trunks.

i. The required number of digits, recorded in the sender, must be passed on through the outgoing trunk to control the circuits which establish the connection to the called line.

j. The sender link crosspoints must be released.

k. The incoming and outgoing trunk must be cut through for talking with supervision.

It is obvious that to provide so much "built-in intelligence" in a large number of circuits would be very costly. Therefore, every effort was considered in the design of the 4A Toll Switching System to concentrate the control operations in as few circuits as possible. Since these few circuits which have the necessary intelligence are used in common for establishing all the connections, the 4A Toll Switching System is known as a "common control system."

In the above list of operations necessary to set up a connection, it is evident that items "d" and "i" stand apart from the other items in that they necessarily require much longer periods of time. The time required to record the number dialed, the time required to transmit pulses to the connecting office, and, in some cases, the readiness of the connecting circuits to receive the pulses all contribute to this extended time period. Therefore, items "d" and "i" and also "j" and "k" are handled by one group of common control equipment known as senders.

On the other hand, the remaining operations are such as may be completed with very rapid actions. Therefore, items "a", "b", and "c" are performed by a group of common control equipment known as link controllers. Items "e" through "h" are performed by another group of common control equipment known as translators, decoders, and markers. These various groups of common control equipment will be discussed subsequently.

One of the definite advantages of common control operation is that relatively few circuits need be provided to set up connections. Because of the limited number of such circuits, they are equipped with self-checking and service - safeguarding features. In addition, many features, such as second attempts to complete a connection, alternate routing, and automatic recording of trouble, can be economically provided.

The number of switching control elements provided in each installation is dependent upon the number of calls requiring their services and the length of time required to complete their functions. The switching control and associated elements used in a 4A system are as follows:

a. Senders
   - Incoming
     - Multifrequency Pulsing
     - Dial Pulsing
   - Outgoing
     - Panel call indicator pulsing
     - Reverting pulsing

b. Controllers
   - Link controllers and connectors
   - Decoder connectors
   - Marker connectors
   - Truck block connectors
   - Foreign area translator connectors

c. Decoders

d. Translators

e. Markers

1. Incoming Sender

Two types of incoming senders are employed in the 4A Toll Switching System; Incoming Dial Pulse and Incoming Multifrequency Pulse Senders. However, there are three types of MF senders. These are (1) Regular Toll - 11 digits, (2) CAMA - 10 digits and (3) Overseas - 14 digits. 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 to an outgoing sender. The outpulsing capabilities and digit capacities of the two types of incoming senders are identical. They have a maximum capacity of 11 digits, consisting of a three digit toll code, a three digit office code, and five numerals. One of the numerals may be a party letter or ringing code. The 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.

Although they register different kinds of pulses, these senders can out-pulse 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.

The methods by which incoming senders dispose of their information are determined by characteristics of the called trunk circuits. These methods are briefly described as follows:

a. When completing to step-by-step equipment, dial pulsing is employed.

b. When completing to toll and local crossbar equipment, (when local crossbar is arranged to receive MF pulses) multifrequency pulsing is used.

c. When completing to a trunk requiring revertive or panel call indicator pulsing, an outgoing sender is employed. The incoming sender spills forward d-c pulses to the outgoing sender.

The outgoing sender then converts these pulses to revertive or panel call indicator (PCI) pulses and spills them forward to the local office over the outgoing trunk.

d. When completing to manual trunks, no pulsing is required.

The design of the 4A Incoming Sender incorporates certain spill forward and code conversion features which enable a 4A sender to perform the following functions under control of the decoder and marker.

1. The sender may spill forward all digits received up to a maximum of 11 digits or may generate any 1, 2, or 3 additional digits and outpulse these ahead of the received digits for a maximum of 14.

2. The sender may drop the first three digits and spill forward the remaining digits (maximum 8) or may generate any 1, 2, or 3 digits and outpulse these ahead of the remaining digits (maximum 11).

3. The sender may drop the first six digits and spill forward the remaining digits (maximum 5) or may generate 1, 2 or 3 digits and outpulse these ahead of the remaining digits (maximum 8).

2. <u>Seizure of the Incoming Sender</u>

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 <u>incoming sender</u>. When the incoming sender is attached to the incoming trunk and is ready to receive pulses, it signals to the operator or sender in the distant office to begin outpulsing as shown in the simplified block diagram of Figure 10-12.

<u>Dial Pulse Sender</u>: When an operator receives 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 while to make sure that all the digits are received.

Multifrequency 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.

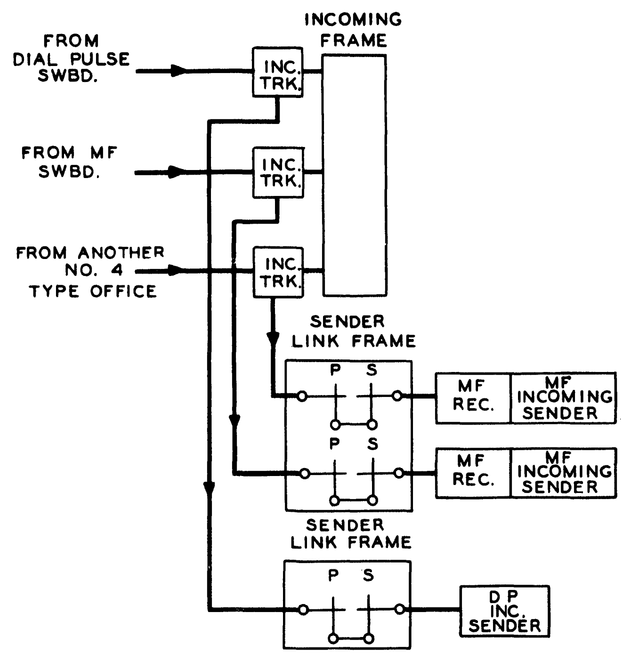


Figure 10-12 - Access to Incoming Senders

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

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

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.)

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 sender waits for a signal from the distant office, or from an outgoing sender in the same office, that it is ready to receive the pulses. Upon receipt of this signal, the incoming sender spills forward the digits, as instructed, via the sender link, incoming trunk circuit, incoming link frame, outgoing link frame, and outgoing trunk circuit to the distant office or outgoing sender.

At the end of outpulsing, the incoming sender and sender link release, leaving the transmission path through the incoming and outgoing link frames. In cases where 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. Outgoing Senders

Outgoing senders may be seized only by a trunk appearing on an outgoing frame by means of an outgoing sender link frame. The trunk must be of a type that requires outpulsing on a revertive or panel call indicator basis.

The outgoing sender receives and stores d-c key pulses from an incoming sender, and disposes of the digit information via the called trunk.

When a sender, either incoming or outgoing, has disposed of digit information it disengages from the connection and is available for the handling of other calls.

4. Link Controllers and Connectors

The link controllers are the equivalent of simple markers and perform the functions of selecting an idle incoming sender of the desired type, securing an idle link on the sender link frame, and operating the crosspoints which connect the sender to the incoming dial or MF trunk as illustrated in the simple block diagram of Figure 10-13.

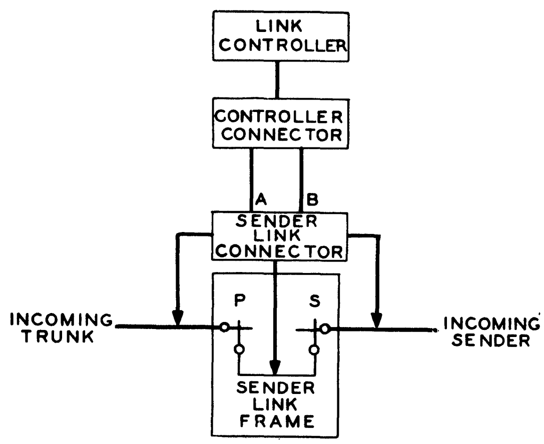


Figure 10-13 - Link Controller Operation

Each sender link connector has access to two controller connectors. 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 the link controller.

Test leads associated with the incoming trunks, the sender links, and the 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.

The sketch in Figure 10-14 shows the sender link access to controller connectors when a group of six controllers is used. Under the Simplified Sender Grouping arrangement, only 4 controllers are used in a sender link group.

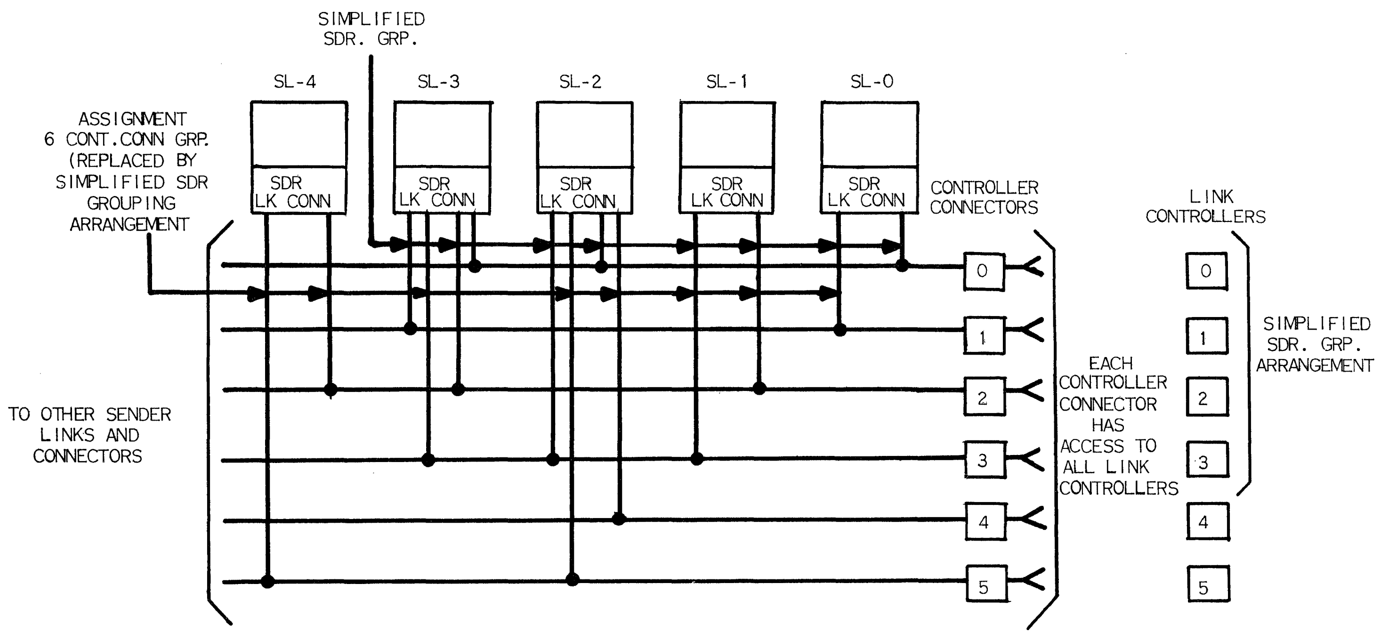


Figure 10-14 - Sender Link Access to Link Controllers

5. Decoder Connector

Decoder Connectors which are made up of a group of multicontact relays are 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. All senders have access through these connectors to all decoders and all markers in an office.

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 the marker connector then signals the decoder connector to operate the multicontact relay associated with marker. 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.

6. Marker Connector

   The marker connectors provide facilities for cutting through a large number of leads between the 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.

   When a decoder signals a marker connector to seize an idle marker, the chain, or preference circuit, selects any idle marker (in a combined train office) 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.

   In a two train office, the marker connectors are equipped with two chain or preference circuits. One chain for the intertoll markers and the other 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. The other functions of the connector are the same as those described for the combined train.

7. Trunk Block Connector

   An outgoing trunk group is spread over at least two outgoing link 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 link 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 and seizes an idle outgoing trunk.

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. A trunk block connector consists of an "even" half connector and an "odd" half connector. Each half connector is an exact duplicate of the other and is designed in this manner so as to increase marker access and service protection. This arrangement is shown in Figure 10-15.

The 400 trunks appearing on each half 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.

Another marker, however, can seize group 1 in the odd half connector. 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.

A trunk block relay cuts in the leads for the 40 trunks connected to its terminals but the "group start" and "group end" data on the translator cards confine the marker trunk test to the particular span of terminals containing the called group of trunks. All trunks of a group or subgroup, including spares and recorded announcement trunks, if any, are assigned to one trunk block relay if there are 40 or less terminals involved. Trunk groups which require more than 40 terminals are assigned in multiples of 40 trunks to other trunk block relays. However, more than one trunk group may be assigned to the same trunk block relay provided the total trunks do not exceed the 40 terminal capacity.

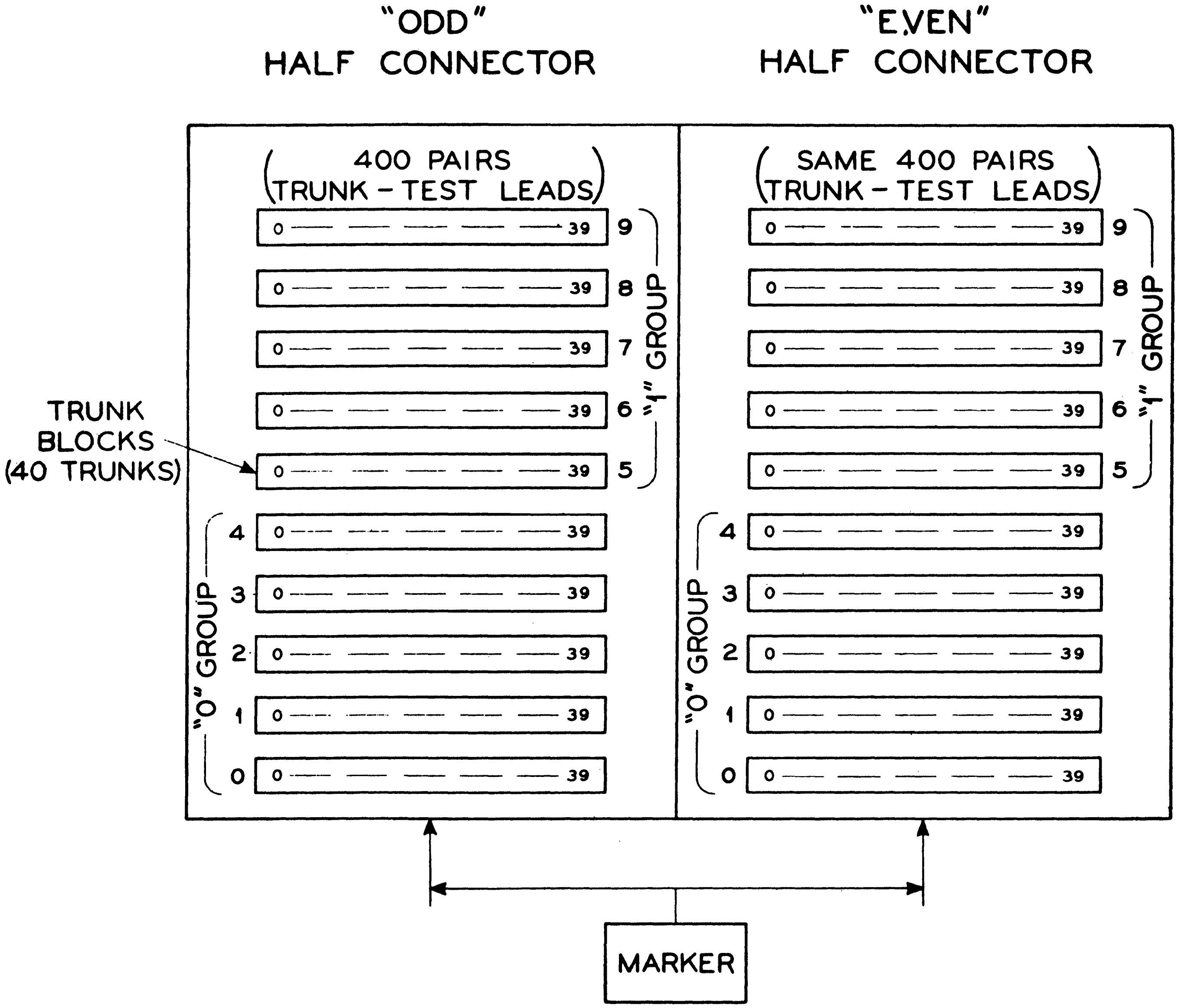


Figure 10-15 - Trunk Block Connector

8. <u>Foreign Area Translator Connectors</u>

One translator connector per "foreign area translator" is provided to cut through approximately 180 leads between a decoder and a translator. One <u>translator connector</u> frame will accommodate two translator connectors. However, as odd and even numbered connectors are located on separate frames two translator connector frames are required when exactly two foreign area translators are provided.

9. Decoders

The decoder, in conjunction with the card translator, performs the function of decoding the digits registered in the incoming sender into information on outgoing trunk selection, alternate routing, code conversion, variable spilling of digits, and outpulsing class and transmits this information to the marker.

In an office not using the "increased-capacity" features, a maximum of 18 decoders may be provided. With "increased-capacity," as many as 24 decoders may be provided.

When a decoder is seized by an incoming sender for the first time, the decoder always sends the first three digits registered in the sender to the home translator. The sender may or may not have additional digits registered, at this time, beyond the initial three sent. 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 the first card as follows:

a. 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.

b. 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. If pretranslation option is not used or if the sender has enough additional digits registered, the decoder will not release. If this is not the case and more digits are required, the decoder restores the card, signals the incoming sender that more digits are required, releases from the sender, and is available for servicing other calls.

c. Six 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 the marker. The marker then completes the call.

Other important items 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 location of a maximum of 40 trunks can be obtained from one card. If there are more than 40 trunks for a particular routing, then two or more cards are necessary. When there are two or more cards available, a decoder can operate in one of three different modes:

a. Card to Card: The decoder advances from one subgroup of 40 trunks to another subgroup of trunks by presenting the appropriate information from a series of cards to a marker which then tests for idle trunks in these subgroups.

b. Relay to Relay: The decoder does not present the information from a series of cards to the marker for finding an idle trunk. The decoder first checks for availability of trunks in both direct and alternate route trunk groups by means of group busy relays. If none of the trunks associated with the first card are idle, a second card will not be dropped unless a group busy indication indicates that the second card will be associated with an idle trunk.

c. Card to Relay: This is a combination of the above two types.

10. Decoder Route Relays

One decoder route relay is provided for each intertoll trunk group to a primary center, sectional center, or regional center, which is to be used as an alternate route. A route relay is also provided for each trunk group to a crossbar tandem office which is to be used as an alternate route. The number of route relays per decoder to be provided will vary from a minimum of 30 to a maximum of 100.

11. Card Translator

There are two types of translators commonly used in the 4A Toll Office, Home Translators and Foreign Area Translators. Each of these translators has a capacity of 1,176 working cards.

The card translator is literally the "seeing eye" of the 4A common control equipment. It 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 its name from the fact that metal cards are used in the translation process instead of the relay type translator used in all other common control systems.

Card translators are equipped with metal cards, coded, to provide the switching information for all calls arriving at a No. 4A Toll Office. As shown in Figure 10-16 each card has 40 tabs and 118 holes. The tabs are used to code the card to correspond to a called code. This is accomplished by removing some of the tabs so that the remaining tabs are arranged in a definite pattern which is unique for that card. This tab coding is called the input information. The holes in

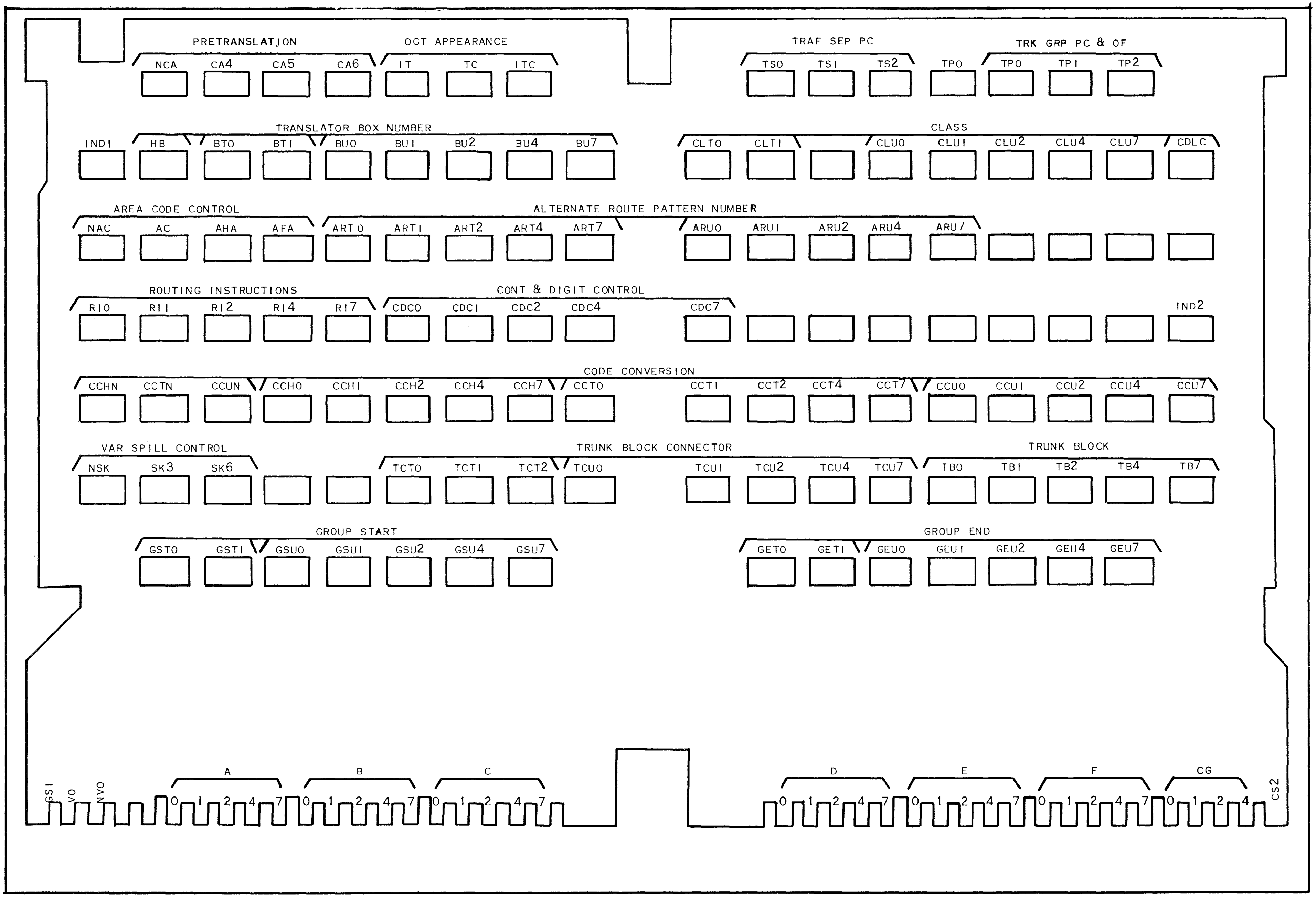


Figure 10-16 - Translator Card

the card are also coded to correspond to the switching information needed for the called code represented by the card. The switching intelligence is applied to the card by enlarging the pertinent holes, and is called the output information.

The basic elements of the translator consists of a light source modulated at 400 cycles, a bank of light sensitive photo transistors and a stack of perforated cards. The cards are stacked between the light source and the photo transistors, of which there is one for each hole in the card. When the cards are in their normal positions the holes in the cards form 118 continuous tunnels or light channels between the light and the transistors. When the translator is operated, that is when a card is dropped about 1/8 inch, all of the light channels are blocked except for those holes which have been enlarged. Figure 10-17 shows a schematic of the translator, and Figure 10-18 indicates the effect of a dropped card on the light channels.

The selection and dropping of a card is accomplished by means of the card tabs and a group of code bars. The tabs correspond in position to, and rest directly on, 40 rectangular bars located at right angles to the cards. As mentioned before, a unique group of tabs are left on the card to agree with the code represented. Figure 10-19 shows a card resting on the code bars when the translator is unoperated.

When the decoder connects to the translator, it depresses certain code bars by means of solenoids. The one card, whose tabs correspond to the depressed bars, is thus permitted to drop as shown in Figure 10-20.

The card drops a distance slightly greater than the height of uncoded (nonelongated) hole. Thus, the dropped card produces a shutter-effect on all light channels except those for which the card holes were enlarged. The open channels energize their photo-transistors and associated detector amplifiers. These circuits read the beams of light and transmit the information to the decoder.

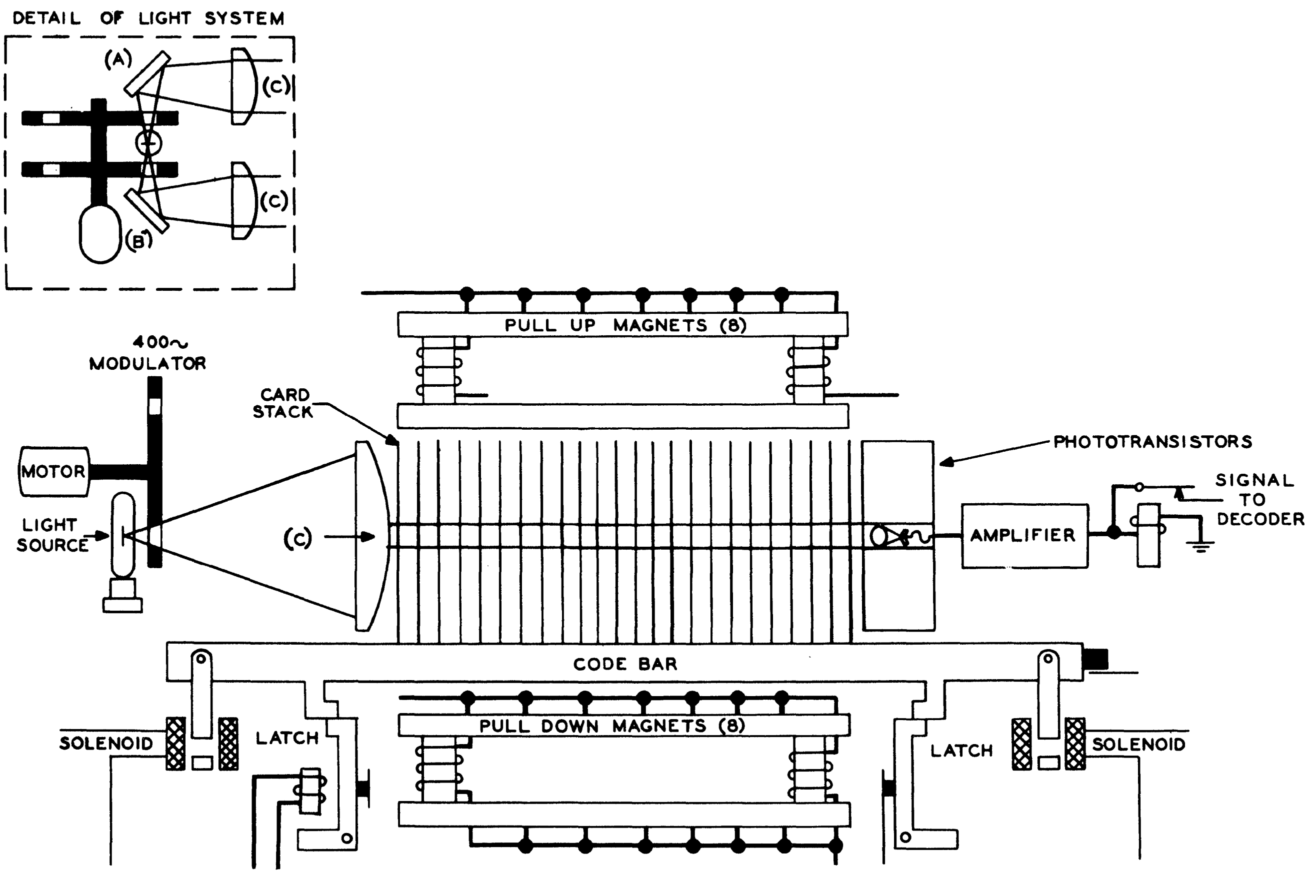


Figure 10-17 - Elements of the Card Translator

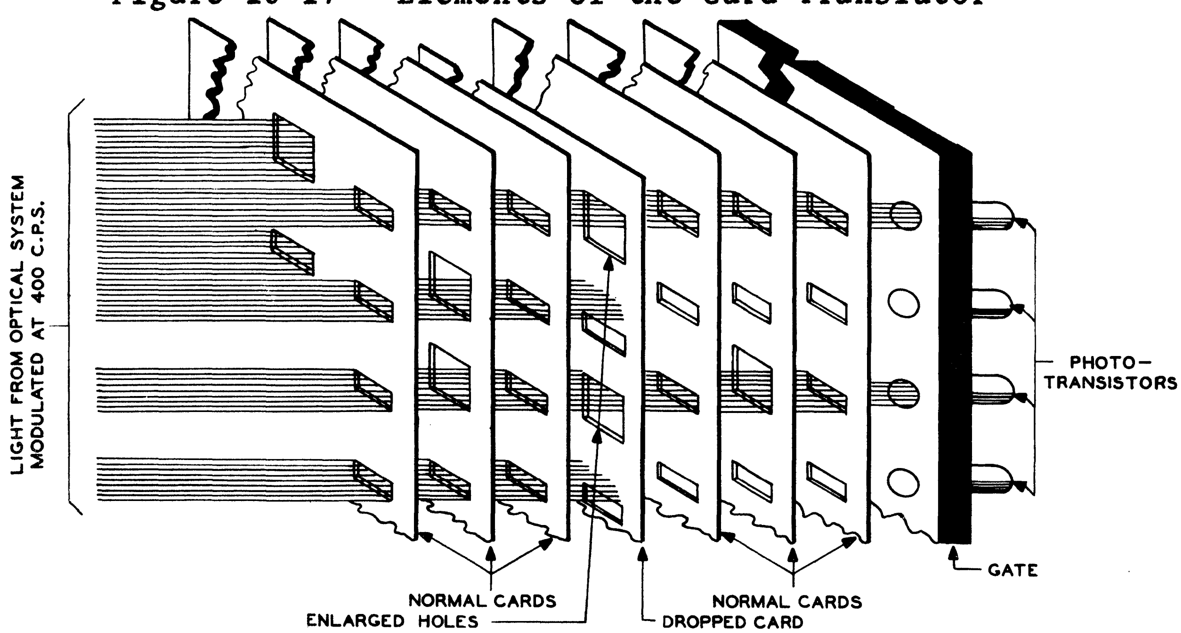


Figure 10-18 - Effect of Dropped Card on Light Channels

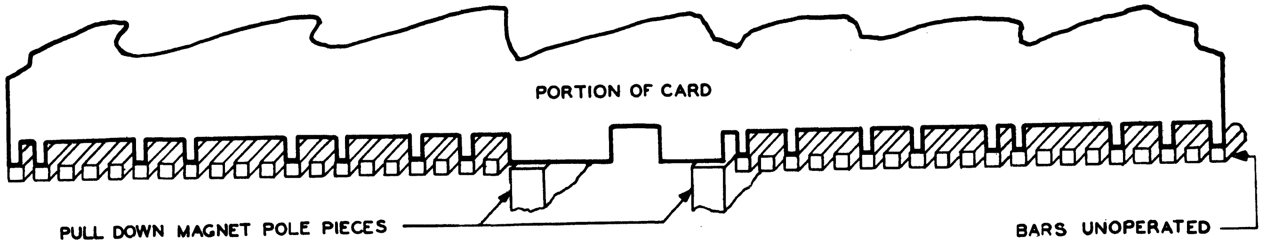


Figure 10-19 - Card Support and Code Bars Normal

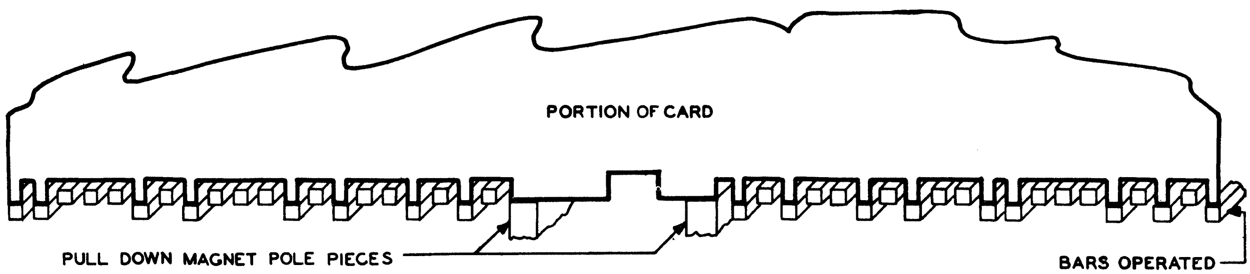


Figure 10-20 - Card Support and Code Bars Operated (Corresponding Card Drops)

Home Translator: One home translator is directly associated with each decoder in the office. On every call, once a decoder is seized, it drops a three digit card in its own home translator. Any decoder can handle any call, therefore all the home translators in the office contain identical sets of cards. If a three digit card fails to drop, the decoder releases and gives a second trial indication to the decoder connector. The connector would then select another decoder and a second attempt is made to drop an identical card. If the 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. The home translator does two things:

a. provides switching information for calls requiring 3 digit translation.

b. directs decoder to foreign area translators for calls requiring 4, 5, or 6 digit translation, if the home translator is not arranged to handle the particular call in question.

Foreign Area Translator: Each foreign area translator contains all of the 6 digit cards required for completion of calls to several particular foreign areas. For example, one translator may contain all of the cards for three foreign areas and another for five foreign areas. Therefore, unlike home translators, a particular foreign area translator must be used on each call. Each foreign area translator is available to all decoders through the foreign area translator connectors. Foreign area translators may be paired or nonpaired.

Paired. If there is no principal city routing for certain calls, the translators may be paired. In this case both translators of the pair would have identical cards.

Nonpaired. Nonpaired translators contain 6-digit cards for calls which, if routing is not obtained at the foreign area translator, can be routed by principal city routing from the home translator without a second trial.

If a 6-digit card fails to drop in a paired translator, the decoder releases and gives the decoder connector a second trial indication.

12. Markers

The marker is one of the major equipment elements in the 4A toll switching system. It locates an idle outgoing trunk and identifies the incoming trunk handling the call. It then marks an idle path between them and establishes the transmission path. Markers in the 4A offices use information furnished by the card translators and decoders in establishing these connections as shown in Figure 10-21. 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.

Seizing an outgoing trunk: In a 4A toll office, all of the outgoing trunks (a trunk group), going to a certain distant office are spread over as many outgoing frames as is practical.

Figure 10-22 shows how 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.

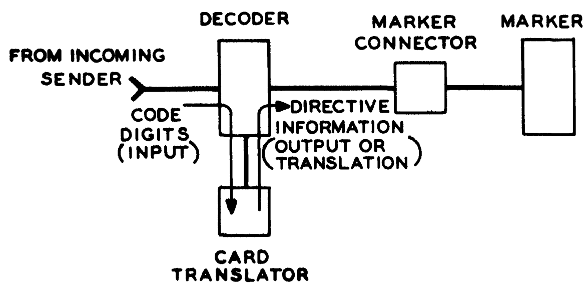


Figure 10-21 - Information to Marker

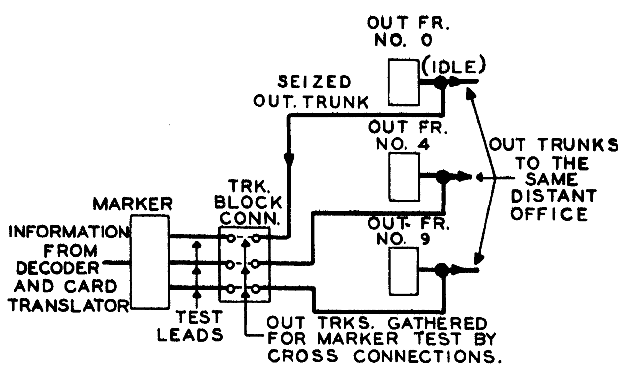


Figure 10-22 - Seizing and Outgoing Trunk

Identifying the outgoing frame: So far the marker knows that 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 a 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, Figure 10-23 connection 2A.

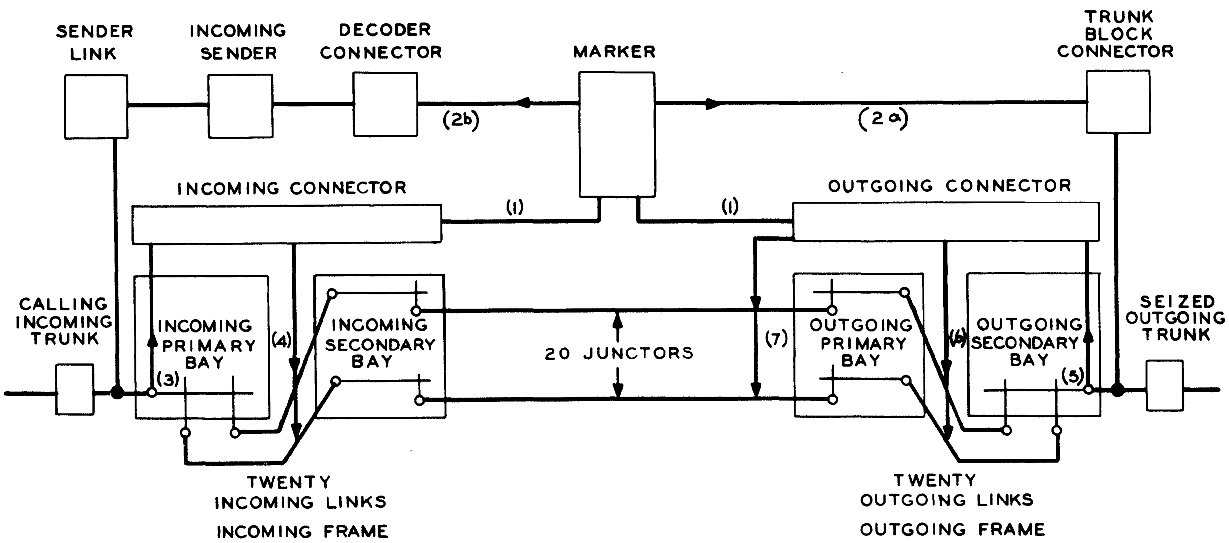


Figure 10-23 - Establishing a Channel

Identifying the Incoming Frame: The marker must also 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, incoming sender, and decoder connector, Figure 10-23 connection 2B.

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 on the marker connector frame. Figure 10-23 connection 1. Through these connector circuits the marker gains access to the incoming links, outgoing links, and junctors.

Information to the Incoming Sender: 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. This 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 the completion of the call. In another case, such as to another 4A office, the sender is directed to spill forward multifrequency pulses. If the call is to a manual office, the sender does not spill forward any digits.

Second Trial Feature: The marker has a second trial feature for making a second attempt to complete a call. Second trials are made if the marker encounters trouble, if the marker cannot match a channel, or if the marker is given a second trial routing instruction.

10.3 TRUNK EQUIPMENT AND TRAFFIC IN THE 4A SYSTEM

A trunk is a communication channel used as a common artery for traffic between switchboards or other switching devices. Trunk circuits consist of line facilities and trunk relay equipment. Trunk relay circuits provide the means by which the line facilities connect to the switching devices. These circuits are of various types, depending upon the types of traffic handled and the equipment to which they connect. Trunk relay circuits in the 4A System are designed for one-way or two-way operation. One-way circuits may be selected from one end only, they may be either incoming or outgoing. The two-way circuits are associated with intertoll trunks only. They may be seized from the distant end on an incoming basis or may be seized by common control equipment within the 4A System on an outgoing basis. Inasmuch as all switching is made on a four-wire basis, it is necessary to convert trunks which employ a two-wire transmission path to a four-wire. This conversion, which in general is required for all toll tandem and toll completing trunks, is obtained with hybrid coils. These coils are part of the associated trunk relay circuit. Trunk relay circuits associated with four-wire intertoll trunks do not, of course, require hybrid coils.

The 4A Toll Switching system provides switching facilities for toll traffic. The incoming traffic to a particular 4A installation originates either within its toll center area or from other toll center areas. This traffic is switched for local completion or for completion in other toll center areas.

Types of Trunks: The trunks of the No. 4A System may be classified as intertoll and toll connecting.

Toll connecting types include:

a. Toll Tandem: completing and thru; C.A.M.A. trunks

b. Toll Completing
LW trunks (Leave-Word formerly TX trunks)
121 (inward assistance) trunks
Information trunks
Rate and Route
Delayed through position trunks

Miscellaneous type trunks include:

a. Overflow

b. Combined NC-operator

c. Reorder

d. Digit absorbing

e. Test trunks

Intertoll Trunks: An intertoll trunk is an incoming, outgoing, or two-way trunk connecting the 4A System with other toll switching systems. The line facilities may be either two-wire or four-wire.

Toll Tandem Trunks: The toll tandem trunk is an incoming trunk connecting outgoing or DSA switchboards with the 4A System. These switchboards may be No. 1, 3, 3CL, 5 toll switchboards or any type of DSA switchboard. These switchboards, regardless of the type, are located within the toll center area. The various types of tandem trunks employ either dial or multifrequency pulsing. The 3-wire trunks transmit supervisory signals over the third wire. The 2-wire trunk employs the talking path for the transmission of pulses and supervisory signals. The 4-wire toll tandem trunk uses multifrequency pulsing and a sleeve path fifth wire for the transmission of supervisory signals.

Toll Completing Trunks: A toll completing trunk is an outgoing trunk from a toll switching unit to a local office, operator, or testboard in the toll center area. The term "toll completing" does not apply to a particular type of trunk, but does apply to various types of trunks that handle toll completing traffic. These are described briefly.

Toll switching trunks are provided for calls which are completed to subscribers served by various types of local and community dial offices. In general, toll switching trunks are arranged for dial pulsing to step-by-step offices, multifrequency or revertive pulsing to crossbar offices, revertive pulsing to panel offices, and panel call indicator pulsing to manual offices.

LW trunks are trunks to outward positions handling delayed traffic LW trunks for the purpose of reaching particular outward positions from other toll centers. These trunks employ direct current signaling, and usually require no pulsing on the part of the sender for completion.

Service trunks, such as 141 route operator, 131 information, 121 inward, 151 delay operator, 101 testboard, 102 milliwatt supply and others are considered toll completing trunks.

A. ASSOCIATED FRAMES

1. Alternate Route Traffic Control

The successful dialing of nationwide long distance traffic, by both operators and customers, depends on a high speed intertoll network so that "all trunks busy" conditions will infrequently occur, even during the average busy season. Alternate routing is one of the techniques that makes this possible. Actually, alternate routing is a method of advancing a call at a switching point by diverting it to a trunk group, other than the first choice group, when the first choice group is busy. Multialternate routing, a provision for more than one alternate route, is a feature of the alternate routing pattern in the 4A toll switching system.

The alternate route traffic control frame provides centralized facilities for interconnecting the alternate route relays of each decoder in accordance with the basic switching plan. Associated with each decoder route relay is a route transfer relay which can be used to prevent the alternate routing of traffic over a trunk group to a Central Switching Point that has been congested. The route transfer relays are controlled by the operation of traffic control keys located with their associated guard lamps on the traffic supervisory cabinet.

2. Frame Identification Frequency Supply

This frame mounts the oscillators, amplifiers, and mixing resistors for the frame identification frequencies used in the marker operation. The signal received from the oscillators is amplified, mixed with a three frequency alternating current signal, and distributed to the incoming and outgoing link frame and to the trunk block connector circuit associated with the jump hunt trunk routes. By means of these signals, the marker is enabled to identify any incoming or outgoing link frame or trunk group. Each frame identification signal consists of a combination of three different frequencies, each of which is supplied from a separate oscillator and amplifier and through separate mixer resistors. The frequency output from amplifier A is 425 cycles, from B 595 cycles, and so on up to the H amplifier, 1615 cycles, in steps of 170 cycles. These frequencies are combined through mixer resistors in such a manner as to provide 40 different signals each of which represents a certain incoming of outgoing link or trunk group. All of this equipment is furnished in duplicate and mounted on separate supply panels which for safety reasons, are located some distance apart.

3. Multifrequency Current Supply Frame

This frame mounts the oscillator units which generate the MF current for MF pulsing. The circuit generates the six frequencies, 700, 900, 1100, 1300, 1500, and 1700 cycles used for MF key pulsing from switchboards and testboards and for multifrequency outpulsing from senders. A minimum of two supply frames are furnished in each office to assure continuity of service.

Multifrequency Receiver Frame - The multifrequency pulsing receiving circuit receives and amplifies MF pulsing signals and converts these signals into dc pulses to operate various code combinations of relays in the associated sender. The MF pulsing signals consist of an alternating current of six different frequencies which are combined to provide key pulsing and start signals, and digit codes as shown in Table 10-1.

TABLE 10-1

Frequency & Designation	0	1	2	3	4	5	6	7	8	9	KP	ST
1700-10											X	X
1500-7	X							X	X	X		X
1300-4	X				X	X	X					
1100-2			X	X			X			X	X	
900-1		X		X		X			X			
700-0		X	X		X			X				

4. Office Interrupter Frame

This frame is arranged to mount reciprocating bar-type interrupters which function to supply interrupted battery or ground to the various circuits in the toll switching office. A minimum of two frames is provided for each office so as to divide the load approximately evenly and minimize service reaction in event of the temporary failure of the motor or drive mechanism of a frame.

5. Circuit Busy Announcement Trunk

The CBA frame performs the following functions in the 4A Toll Switching System:

1. Provides indications directly to the decoders as to the lowest numbered subgroups in which there are idle trunks available on groups which are used for alternate routes.

2. Aids in disposing of certain types of calls when all intertoll trunks of a group are busy, and in these cases, provides the originating operator with information as to the availability of trunks.

3. Provides idle indications to toll operators in the same building for all outgoing intertoll trunk groups and groups to crossbar tandem.

4. Provides trunk group-busy indications at the traffic supervisory rack.

6. <u>Traffic Measuring and Administrarive Facilities Traffic Register Racks</u>

The traffic register rack provides miscellaneous registers for recording for traffic purposes:

1. Overflow conditions on link frames, outgoing trunks, common reorder, no circuit, blank code, and system overload announcement trunks.

2. Group busy conditions on incoming trunks other than intertoll.

3. Peg count of calls served by incoming and outgoing link frames, marker peg count, trunk block connector peg count, marker through traffic peg count, marker traffic separation per count, marker card read peg count, clock circuit pulses, reorder system overload announcement, local call intercept, blank code, no circuit trunk, group peg count, reorder trunk time alarms, marker trunk group peg count, sender peg count, decoder through traffic peg count, decoder separation peg count, decoder peg count, decoder pretranslation peg count, outgoing trunk group peg count, ringdown trunk peg count, card translator peg count, and various CAMA peg counts.

4. Sender link delay registration: Time alarm if two delay registrations are received within 28 to 56 seconds.

5. Group busy time duration registration: for common trunks, terminal trunks and via trunks one-way incoming, one-way outgoing, and two-way trunks, and for senders.

6. Usage registers: Group cycle and detector usage registrations associated with the traffic usage recorder circuit.

7. Load measurement: This circuit is arranged to record the traffic load on the individual incoming and outgoing link frames, the total traffic load on incoming link groups, and the traffic load on the sender groups.

8. Multiple plant registers: A multiple appearance of the first and second trial marker and decoder registers and the stuck sender registers from the maintenance center.

7. Traffic Supervisory Rack

The traffic supervisory rack is used in the operating room to assist the chief operator in estimating the delay that will be encountered in handling calls on any trunk group during heavy traffic periods; to provide a means to put that trunk group on a specific "delay quotation" basis of operating procedure; and to provide means of denying access to trunk groups for alternate route traffic. The traffic supervisory rack includes the following equipment: Sender Group Busy Lamps; Overflow Lamps; Delay Quotation Jacks for Overflow Trunks; Delay Quotation Trunk Patching Jacks; Alternate Route Traffic Control Keys and Lamps.

8. Traffic Usage Recorder

The traffic usage recorder is used by the traffic department for measuring the usage of the numerous circuits in the 4A Toll Office. This information is necessary for initial planning, for engineering quantity and arrangement of specific components, and for assignment of lines and trunks for a balanced system.

The traffic usage recorder is designed to measure usage directly in units of CCS (100 call seconds). At the end of any period of time the average traffic load carried by a group of circuits can be determined by taking account of the number of scans made and the total number of busies encountered. If the scan rate is set at 36 per hour, the accumulated number of busies at the end of an hour will indicate the group traffic load directly in terms of CCS per hour. Therefore the traffic usage recorder has a scan rate of 36 per hour with a corresponding scan interval of 100 seconds.

B. MAINTENANCE EQUIPMENT

1. Automatically Directed Outgoing Intertoll Trunk Test Frame

Automatic testing of intertoll trunks is performed by the Automatically Directed Outgoing Intertoll Trunk Test Frame (ADOIT) which utilizes the Automatic Transmission Measuring System (ATMS) Director to provide more accurate measurements. In addition to the testing, recording, and transmission measuring circuitry, the ADOIT is associated with an IBM control unit, card punch, and electric typewriter. This latter equipment permits the test frame to function over a wide selection of transmission testing sequences in addition to recording the tests on page printouts and punched cards. Flexibility is obtained through rearrangement of input control cards. Operational tests may be performed on trunk circuits by a wired-in sequence or by external selection under control of the input card deck.

The ADOIT test circuit starts every test by selecting the trunk to be tested and establishing a connection through the office. The test circuit functions as a incoming trunk with an appearance on the incoming link frame and appears to the common control equipment as a sender. The test connector frame (ITC) is utilized for the purpose of obtaining trunk class information and for gaining access to the trunk circuit. After class registration, a busy test is made; if idle, the trunk is made busy to prevent siezure by a service call. The common control equipment is engaged and the test circuit connects the SM lead of the trunk block to the SM lead of the trunk for outgoing frame identification. A connection is then established to the trunk over the incoming and outgoing link frames; the common control equipment and test connector are released for use by other equipment. After receiving a go-ahead from the distance office, the test circuit out-pulses a 3-digit code to reach a test line in that office. On operational tests, the ADOIT performs the entire test by itself. When a transmission test line is reached the ATMS-Director is called in to perform a transmission test. In the course of setting up the connection for a transmission test, the ADOIT performs some operational-type tests. Therefore, some operational test results can be recorded when transmission tests are performed. Transmission tests are directed by information read from input cards and operational tests can be either sequential or card controlled. Test results are recorded on printouts or cards.

2. Automatic Outgoing Toll Connecting Trunk Test Frames

   a. Automatic Outgoing Toll Connecting Trunk Operational Test Frame

      The Automatic Outgoing Toll Connecting Trunk Operational Test Frame (AOOT) is used to make over-all circuit tests on toll switching trunks to local offices, trunks to TX Operators, and miscellaneous trunks. Automatic tests are made on all trunks that have access to local central offices test lines and by means of a tone detector on other none-operator type trunks. The selected trunks can be tested manually via a remote transfer feature to a remote position manual testing frame.

      The AOOT circuits for operational and transmission testing appear on the incoming link frame as incoming trunks, and by means of a test connector, directs the marker to establish a connection through the incoming and outgoing links to the trunks to be tested. The test circuits utilize a common set of test connectors with a preference arrangement. As a connection is made, the test circuit pulses forwarded the proper test line code to reach the desired terminating line at the local office to make the tests on the trunk. Trunk class information is obtained from wired cross connections at the connectors. An external programming arrangement utilizes a send-receive teletypewriter set to make automatic transmission and noise tests. Transmission data is fed into the teletypewriter set by means of an 8-channel tape containing pertinent trunk information. The teletypewriter then proceeds to print out the test results. When a busy trunk or an operational trouble is encountered, a two or three letter functional printout is made to identify the condition.

b. Automatic Outgoing Toll Connecting Trunk Transmission Test Frame

The Automatic Outgoing Toll Connecting Trunk Transmission Test Frame (AOTT) is used to make automatic transmission and noise measurement tests on all trunks having access to code 104 and 105 automatic far-end measuring equipment. One-way transmission tests are made on trunks having access only to code 102 milliwatt supply terminations. The frame also has all the operational and manual testing capabilities of the automatic outgoing toll connecting trunk operational test frame.

3. Incoming Sender and Register Test

The incoming sender and register test frame provides a means for the routine testing of all incoming sender (CAMA and NONCAMA), and CAMA transverters on an automatic basis. Also, individual equipments may be tested on a single or repeat test basis. 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.

On automatic routine tests, the test frame automatically progresses from one sender to another until all of the incoming senders in the office have been tested, or, on certain tests, until all of the senders of a class, that is, dial, multifrequency, or CAMA have been tested. If trouble is encountered, the test frame stops and an alarm is operated. Various combinations of input and output conditions are checked, many on a marginal basis. The frame is equipped with a full keyset and a number of lever type keys for establishing the various test conditions.

4. Manual Outgoing Trunk Test Frame

This test frame (MTCT) provides a means of testing the toll completing trunks in the 4A toll office. The trunk test jacks are arranged so that this test circuit tests directly into the tip and ring leads of the cable to the distant office. It does not test the outgoing trunk relay equipment except to determine whether the trunk is idle. Provisions are made for directing a call over various types of trunks to a test line in the distant office, using a straightforward operation, revertive panel call indicator, multifrequency dial, and step-by-step pulsing. In conjunction with the test line at the distant end this circuit tests that the trunk is capable of reaching a particular destination code or number and that the ringing or signaling circuit as well as the supervision is functioning satisfactorily. This circuit is also used to facilitate transmission testing of the trunk by providing rapid means of directing the trunk to a transmission test line in the distant office.

5. Test and Make Busy Frame

This test frame includes the test and make busy jacks of the outgoing trunks to be tested. Common jacks associated with the MTCT test circuit are also provided in this test frame. These common jacks are so located that they can be readily patched by means of cords to any one of the test and make busy jack circuits. In the 4A toll office, the test and make busy jacks are always cabled to the distributing frame for cross-connection to the associated outgoing trunk.

6. Outgoing Sender Test Frame

This frame has the same general functions as the incoming sender and register test frame, that is, automatic progression over the outgoing senders, or individual circuit testing, comparision of input with output information, indicating lamps, etc.

7. Sender Make Busy Frame

This frame provides for a central location for the maintenance of senders and incoming registers (used in CAMA application). This frame through the use of make busy jacks permits the removal of any defective sender from service. Associated with each jack is a stuck sender lamp and a priming jack. When a sender becomes stuck, its corresponding SS lamp will light and a minor audible and visual alarm will be brought in. The release of the stuck sender is made by the insertion of a make busy plug into its associated priming jack. A plug inserted into the MB jack of a stuck incoming or CAMA sender will cause the sender to be connected to the trouble recorder to record the number of the incoming trunk, whereas the insertion of a plug into the MB jack of a stuck outgoing sender will light a lamp indicating the sender link frame through which the sender is connected.

Associated with each incoming register is a priming jack and a stuck incoming register lamp. When an incoming register becomes stuck, its corresponding SP lamp will light. An incoming register is made busy by inserting an MB plug into the priming jack. The release of an incoming register is made by the insertion of a plug into the priming jack.

8. Trouble Recorder

The trouble recorder frame consists of a trouble recorder, a decoder marker test circuit, a link controller test circuit, and a translator conditioning circuit all of which function more or less independently. The trouble recorder is called in by the link controller, decoder, or marker to make a punched card record of the information set up in the common control circuits at the time a call encounters trouble. The two test circuits are used to set up test calls on their respective common control circuits. A remote control feature permits the start and release of the test call at the location of the common control frame. The translator conditioning circuit is used to prepare any of the translators for addition or removal of cards or for the removal of the selector unit of the translator. Make busy jacks are provided for busying translators, decoders, decoder connectors, markers, link controllers, and controller connectors. In addition, traffic condition lamps are provided for the above frames and for the incoming, outgoing, and block relay frames. Jacks are also provided for putting the emergency translator in service in place of any other translator.

Card records may be originated by various circuits in the office, each of which has access to the trouble recorder circuit with preference in the following order: Decoders; Intertoll Markers; Toll Completing Markers; Link Controllers; Decoder Marker Test Circuit; Link Controller Test Circuit; Position Link and Controller Circuit; Register Link Alarm Circuit; Master Timer; AMA Recorders and Transverters.

When either of the two test circuits finds a trouble recorder busy on a service call, it will wait until the trouble recorder becomes available. The common control circuits, however, will not wait if they find the trouble recorder busy, but will lock in a lost record lamp in the trouble recorder frame and then release.

Tests of decoders, markers, and certain associated circuits, such as card translators and trunk class translators (CAMA) may be made from the trouble recorder frame. In all cases, a decoder is selected for use in the test and the test circuit primes this decoder with test call information similar to that which it would normally receive through a sender. Arrangements are provided for forcing the decoder to select a particular marker in a test call or allowing it to select a marker on a service basis.

Tests of link controllers may be made from the trouble recorder frame using the first link controller connector of each group to cut through test leads. The test circuit furnishes all of the information that the controller would receive through the sender link. The controller goes through all of its functions, including the selection of a simulated sender in the test circuit.

In-use lamps and alternate route lamps are concentrated in one portion of the trouble recorder frame and make busy jacks are concentrated in another part of the frame.

9. <u>Trouble Tracing Selector</u>

In the 4A toll office there are incoming tandem trunks which have access, through the crossbar switching equipment, to any one of a number of outgoing intertoll trunks. When a trouble is reported on one of these connections only the identity of the incoming tandem trunk is known to the reporting operator. Since, for trouble location, it is also essential to know the identity of the particular outgoing toll trunk involved in the connection, some means must be provided to enable the test board attendant to identify this particular circuit. This is done by the provision of step-by-step trouble tracing equipment. This equipment permits the test board attendant to connect, by dialing, to the reported incoming tandem trunk which is already connected through the toll crossbar equipment to the particular outgoing trunk involved. Once this connection from the test board is established, testing potential is applied over it to the outgoing toll trunk and the resulting operation of a lockout relay in that trunk lights an associated lamp in front of the test board attendant. Having thus identified the outgoing toll trunk, the trouble tracing selector equipment is released and the operator disconnects.

10. Auxiliary and Service Equipment
Intertoll Trunk or CAMA Service Observing Frame

This circuit is used with service observing desks No. 7 or No. 12. It provides for observing on No. 4 type intertoll or incoming tandem trunk circuits in a No. 4A toll office with CAMA. The association of the particular trunk with the service observing trunk is effected by patching between the fifty connector sockets and the loop sockets for the associated trunks.

11. Emergency Alarm

The majority of 4A installations maintain an emergency alarm frame which includes the equipment associated with the automatic fire detection feature. This equipment functions with fusible fire detection wire to sound alarms when any break occurs in this series circuit setup.

12. Floor Alarm

Alarm features in addition to the trouble recorder previously described are provided in a manner similar to other crossbar systems. These alarms consist of fuse alarms, time alarms for the sender link and control circuits, markers, marker connectors, 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.

C. RECORDED ANNOUNCEMENT

The function of this equipment is to provide recorded announcements in the No. 4 Toll Switching System by means of magnetic tape recordings. The heart of the system is a recorder reproducer which consists of a motor driven drum surrounded by a magnetic band with six pairs of heads arranged to form six separate paths around the band. One of each pair of heads is arranged to record or to reproduce and the other to erase a message on the particular channel.

An announcement trunk circuit is provided in conjunction with each of the channels and is arranged to function with the particular switchboard or modified 601 type telephone set used to make the check recordings or to make emergency announcements should the recorder reproducer fail. The output end of the announcing trunk connects to several jacks at the traffic supervisory rack where each channel may be patched to groups of announcement connecting trunks for providing announcements.

Recording may be made on any channel of the system from the end positions of the toll dial (assistance) switchboard or where no switchboard is used, from a 619A type telephone set.

10.4 TYPICAL CALLS

Call through a No. 4A System - The following call is a single one requiring 3 digit translation and is switched to a system requiring MF pulsing.

The call arrives at the No. 4A office over an incoming trunk and leaves over an outgoing intertoll 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 No. 4A office is the same in either case.

As shown in Figure 10-24, each incoming trunk has two major appearances in a No. 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.

As soon as the incoming trunk is seized it signals a sender link, (conn. 1) to connect it to an incoming sender for registering the incoming pulses. In order to make this connection the sender link frame through its 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 cross-points 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 and they release from the connection to serve other calls.

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 (using the pretranslation option) 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). Now the three code digits in the sender are transmitted through the decoder to the home translator and a card coded to correspond to these digits drops. This card contains information for switching the call with 3 digit translation.

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.

The marker obtains the locations of the outgoing trunks suitable of 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.

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, some digits skipped or converted. When the marker has received all this information it signals the decoder to release.

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. 9a). (The incoming trunk has already registered its incoming frame appearance to the marker over connections 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).

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

The connections in the transmission path remain until a disconnect signal is received. Then all the connections are released and the equipment returns to normal.

The time it takes the common control equipment to switch a call through a No. 4A office is so short that the operating time of each piece of apparatus is measured in milli-seconds. A typical marker operation, for example, with the high speed marker arrangements is about 375 ms.

1. Calls Requiring Outgoing Senders

    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.

    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.

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

When an outgoing trunk to an office requiring revertive or PCI pulsing is seized at the 4A office, it signals the outgoing sender link (conn. 11) that an outgoing sender is needed. The sender link seizes a link controller through a controller connector (conn. 12). The link controller tests for an idle sender and attaches it to the outgoing trunk (conn. 13); the link controller and connector then release and are free to serve other calls.

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 dc 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.

Figure 10-25 diagrams a typical intertoll connection through a crossbar toll office showing jack, signaling and switching equipment interconnections.

10.5 ELECTRONIC TRANSLATOR SYSTEM

A. INTRODUCTION

With the volume of traffic switched through 4A/4M toll machines reaching higher levels each year, two aspects of the route translation - cost and flexibility - have become increasingly important. Continued use of the electromechanical card translator would exact major penalties in both of these respects. In addition, future network management arrangements would be seriously hampered. Of the choices available for replacement of the card translator, a system using solid state switching devices under stored program control has been chosen and designated the Electronic Translator System (ETS).

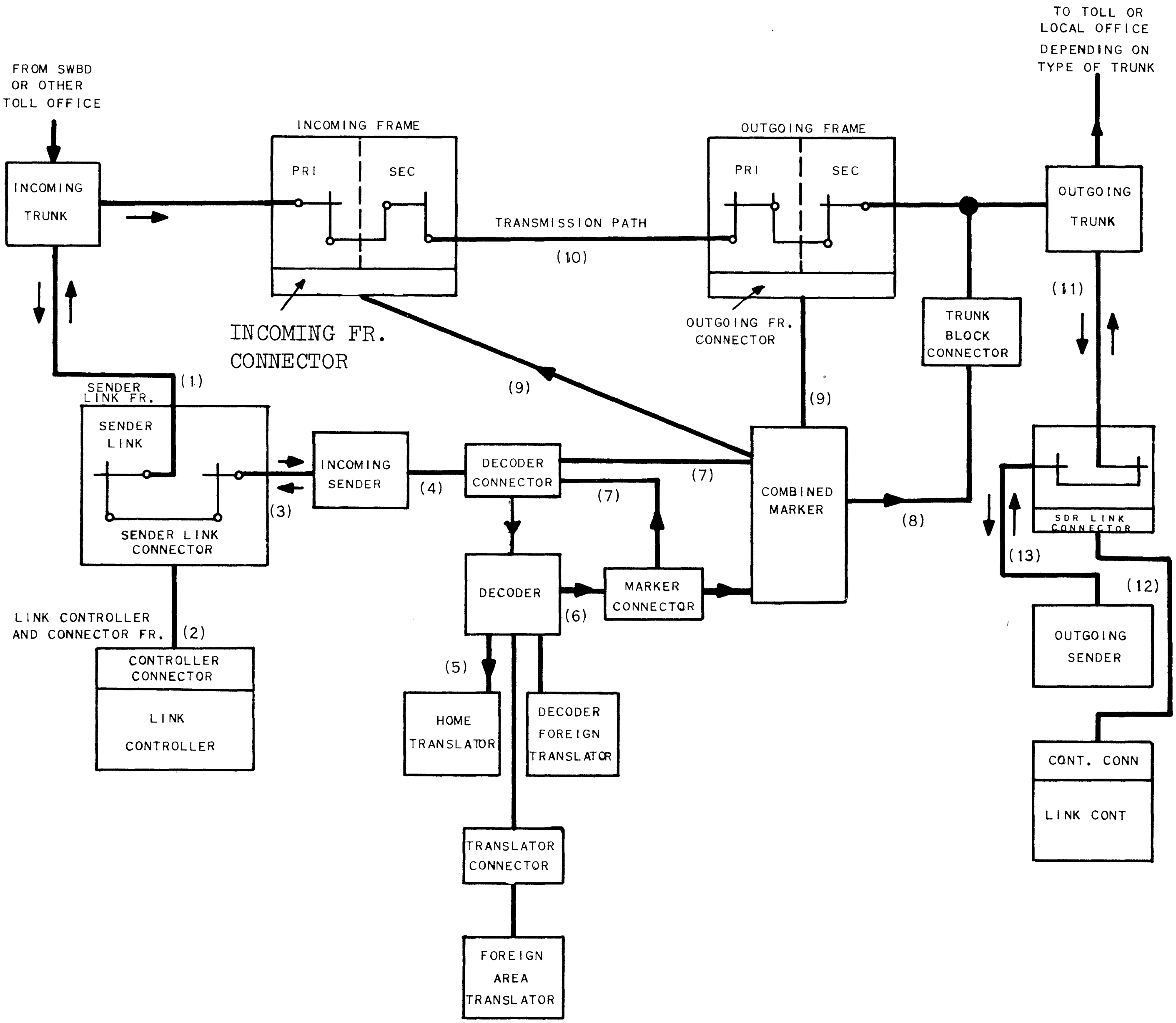


Figure 10-24 - Call Through A Combined Train Office

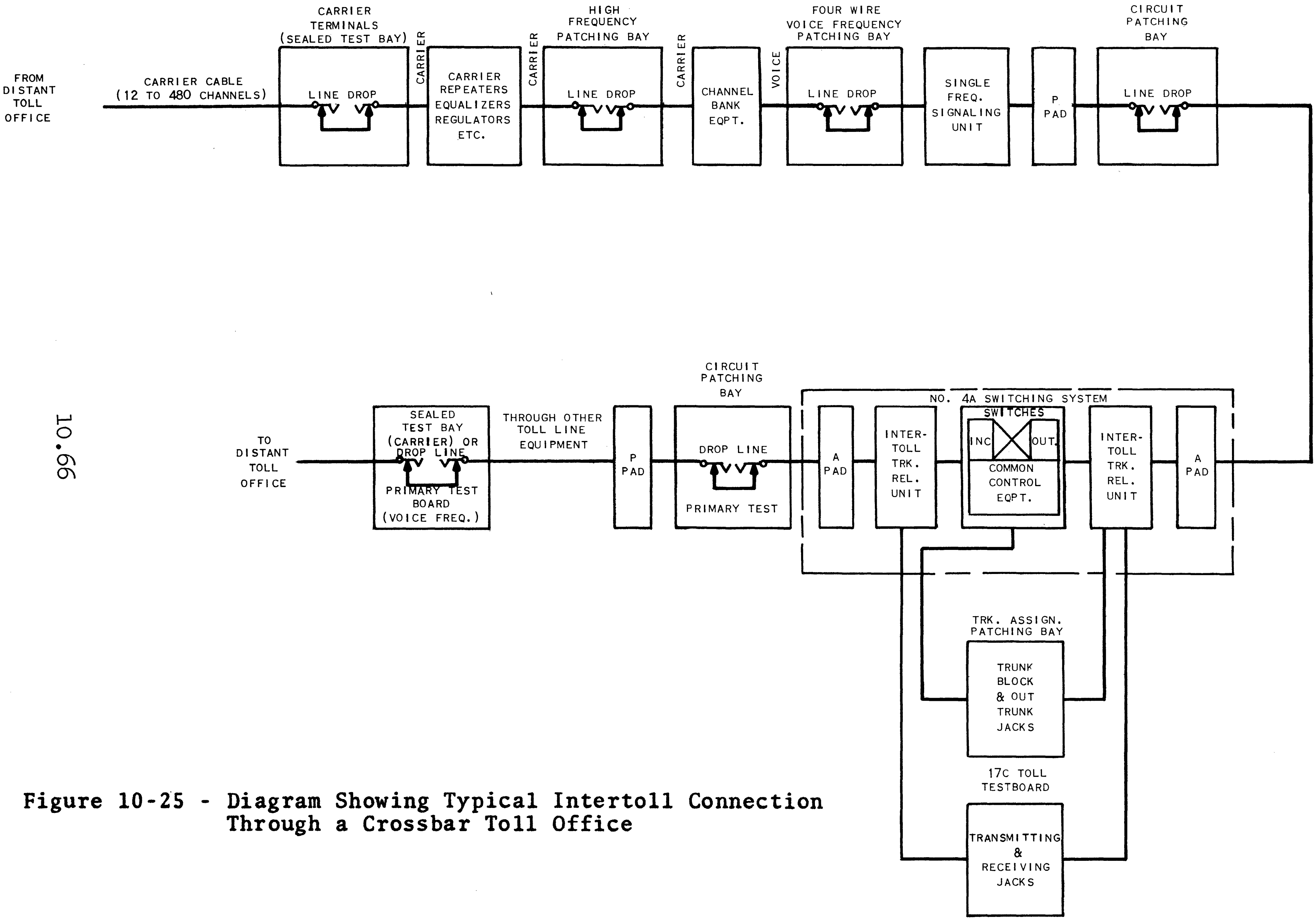


Figure 10-25 - Diagram Showing Typical Intertoll Connection Through a Crossbar Toll Office

The new system will be capable of meeting, increased translation requirements resulting from growth of toll traffic and the introduction of new or changed services, such as overseas transit dialing, private network arrangements, and the new numbering plan. Electronic translation provides a greatly expanded supply of incoming trunk class marks for use in conjunction with address digits and other control inputs, and allows electrical alterability of route translation, to expedite emergency changes and facilitate network management procedures.

B. PRINCIPLES OF SYSTEM OPERATION

The basic component of the ETS arrangement is a Common Systems Stored Program Control (SPC) No. 1A which has been developed concurrently with the Traffic Service Position System (TSPS) No. 1A that will employ the 100B T.S.P. with electronic switching to improve operator assistance facilities.

The solid-state SPC is a fully-duplicated, stored program, digital control system as is the Central Control with associated Program and Call Stores used in the No. 1 ESS. The SPC differs from the ESS Central Control in that it employs a single-type of bulk memory using the new Piggy-back Twister (PBT) module for both program and data storage.

The SPC operates under control of a program of instructions (the soft-ware) which is a set of 40 bit words stored in the memory (Store). The software for each SPC application will include common programs for operating and maintaining the SPC itself. The SPC Processor fetches instructions sequentially from the Store and executes them one at a time. In normal operation, the two Processors will operate in parallel to execute identical instructions fetched independently from the duplicated Stores. One of the Processors assumesactive control of input or output and of system activities. High speed matching of information between the two Processors will provide the major means of trouble detection within the SPC.

General input to the SPC is through adapted No. 1 ESS Master Scanners (MS) which are duplicated and contain unduplicated ferror sensors as scan points to monitor the presence of current in connecting circuits and convert information from electromechanical to electronic form.

General output of the SPC is through adapted No. 1 ESS Signal Distributors (SD) and Central Pulse Distributors (CPD) which are duplicated. The SD responds to high-speed signals from the Processor to operate or release magnetically latching wire spring relays. The CPD responds by providing pulses to control solid-state flip-flops for its major function of performing address decoding for units such as the MS and SD.

A Master Control Center provides controls, alarms displays, and associated Program Tape (PT) and Teletypewriter (TTY) units which are necessary to maintain the SPC and peripheral electronic equipment. TTY is also used by the SPC to supplement alarm and status information for maintenance personnel and may be duplicated at a remote location for extended control purposes.

The interface between the SPC and the 4A/4M Crossbar equipment requires several peripheral circuits of both electromechanical and electronic types as shown in the 4A/4M Electronic Translator System diagram of Figure 10-26.

The Decoder Channel Circuit (DCH), consisting of wire-spring relays, provides sender access from Decoder Connectors to the SPC for the dialed code digits and controls selection of an Intertoll or Toll Completing Marker through Marker Connectors by instructions from the SPC. The Decoder Channel also verifies the sender-marker connection and the registration of routing information which the marker receives from the SPC through the marker connector and two peripheral electronic circuits: The Distributor Register (DR) and the Peripheral Function Translator (PFT).

The Peripheral Scanner (PSC) uses ferrod sensors to monitor status, detect bids, and to read input information required by the SPC for call handling. The major circuits scanned by the SPC are the Decoder Channel, Sender Link Controller and Group Busy Relays.

A new Power Distributing Frame (PD) supplied by a 111A Power Plant provides power for all peripheral and SPC circuits.

C. MODIFICATION OF EXISTING 4A/4M SYSTEMS

The major 4A/4M circuits requiring modification are: Decoder-Marker Test and Trouble Recorder, Marker and Decoder Connectors, Sender Link and Connector, Sender Link

Controller, Controller Connector, Incoming Sender and Register Test, Group Busy Relays, and the Marker. The Marker modification is relatively minor and consists mainly of the removal of relays. The Incoming Senders and Trunks do not require any modification.

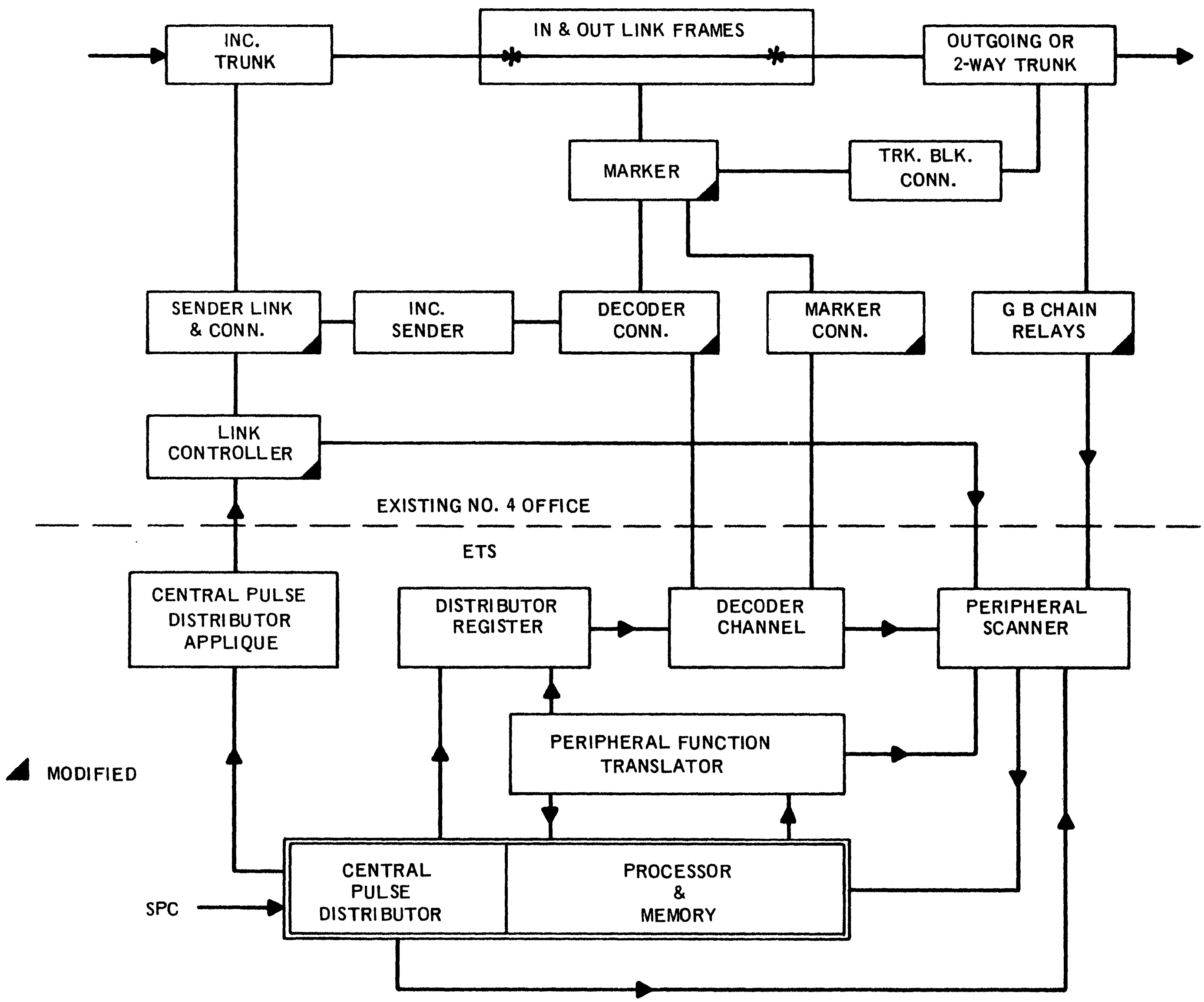


Figure 10-26 - 4A/4M Electronic Translator System

D. BASIC PROGRAMMING CONCEPTS OF THE SPC

The functions to be performed by the SPC and the peripheral units are specified by programs which are stored in the PBT memory. The memory stores both programmed instructions and data. All instructions, and some data, are stored on a relatively permanent basis and are changed as dictated by changes in procedures or service. Some of the data is relatively temporary in nature, since it may be entered into memory, modified, and erased during the processing of a call. The programmed instructions provide the intelligence necessary to instruct the Processor in the many functions required of it under any of the many call situations the SPC may encounter. Instructions can also be referred to as orders or commands.

Data differs from instructions in that it consists of information such as results computation, records of dialed digits, and information as may be required at some time for processing.

The Processor, according to the instructions in the Store, either directly or indirectly controls the operation of every circuit in the system. All commands specifying an operation in peripheral circuits originate within the Processor and all answers signifying the state of circuit points within the system are returned to SPC. Certain instructions result in actions which are entirely confined to the SPC. For example, an instruction or series of instructions may command the Processor to perform logical or arithmetic operations on data currently contained within the SPC. Other instructions may cause the SPC to command a peripheral circuit to perform an operation which results in an answer being transmitted back to the SPC by way of a scanner.

The SPC instructions or orders are of three main classifications:

1. Input - Output Orders: There is one type of input order which calls for scanning a set of as many as 20 input connections and one output order which commands distribution to the peripheral units.

2. General Purpose Orders: There are twelve basic orders that provide the necessary arithmetic and logic operations of the Processor. The arithmetic operations include: subtraction, comparison, shifting, and rotation; and the logic operations are: And, Or, Exclusive Or, and Complement.

3. Maintenance and Miscellaneous Orders: Special orders are provided to implement the necessary fault recognition, diagnostic, and routine test programs.

Application Programming

The application of the SPC for use with ETS requires a program of approximately 7300 words.

The stages of this ETS program consist of control and administration, Sender Link Controller, Decoder Channel, and maintenance programs.

This program will be in common to every ETS installation and is adapted to the local conditions by the data provided by the operating company.

Input and Output Message Manuals are provided to allow communication with SPC from the Master Control Center Teletypewriter.

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