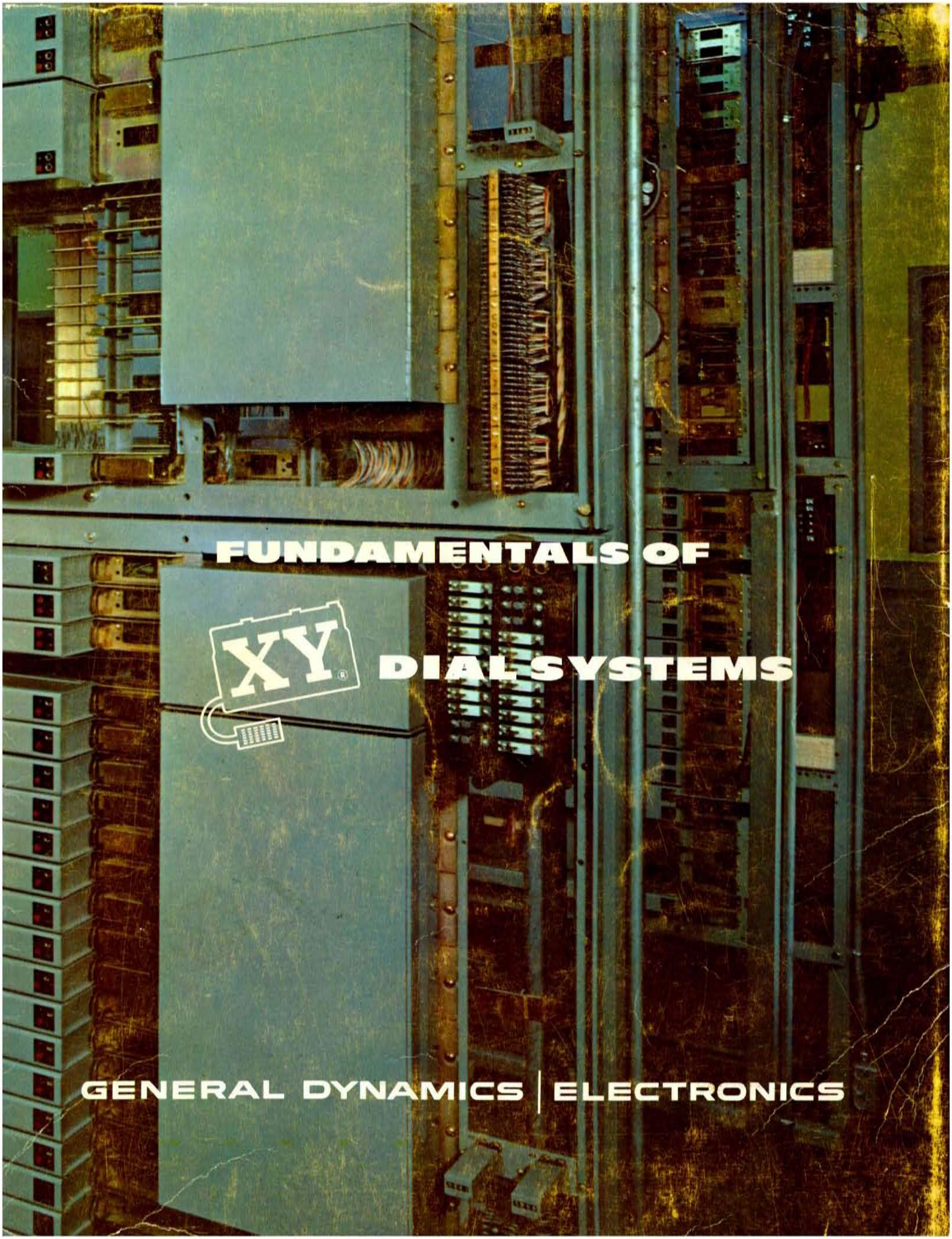


FUNDAMENTALS OF XY® DIAL SYSTEMS

GENERAL DYNAMICS | ELECTRONICS

FUNDAMENTALS OF XY® DIAL SYSTEMS

INTRODUCTION

PURPOSE AND CONTENT

This text has been prepared to describe the simple principles of XY* Dial switching. The subjects discussed include appropriate historical data, the principles of step-by-step switching, a description of the major components used, office layout information, and operating features and ranges of the XY Dial System.

Although this literature is largely descriptive in nature, and is primarily concerned with a discussion of the circuits and mechanical layout of the XY Dial System, some effort has been made to bring to the attention of the reader the principles underlying the development of specific circuits in the section entitled CIRCUIT PRINCIPLES, which has been included to enable one to extract the essential parts from the more involved circuits, and to make apparent the similarity between the principal parts of different circuits. In this sense, these circuit principles are the foundation upon which the XY Dial System is built.

Basic information concerned with the general aspects of office trunking and grading has been included in the section entitled TRAFFIC AND TRUNKING PRINCIPLES.

TERMS

The terms used are those employed and accepted as standard by General Dynamics|Electronics, the manufacturer of the XY Dial System, and in the majority of cases are standard throughout the telephone industry.

APPLICATION

Any telephone exchange must take into consideration the particular needs of the local community. For this reason all XY Dial Exchanges engineered by General Dynamics|Electronics are not identical. This makes necessary the development of many circuits which are fundamentally the same and differ only in details of operation. Since these variations exist, it has been found convenient to select circuits for discussion which are considered typical in an XY Dial System.

*"XY" is a registered United States trade mark of General Dynamics Corporation.

CONTENTS

HISTORY

Stromberg-Carlson® Telephone Equipment has been manufactured since 1894. For a number of years, telephone instruments and manual switchboards were the only products; dial telephones and dial switchboards, so much a part of our life today, were only in the planning stages. During this time Stromberg-Carlson engineers kept abreast of dial telephone system developments and in 1934 placed on the market their first commercial system.

Here, in 1894, Alfred Stromberg and Androv Carlson produced their first telephone.

RELAYDIAL SYSTEM

An all-relay marking type system, developed by Stromberg-Carlson engineers in the 1930's, was produced commercially under the registered trademark "RELAYDIAL." This equipment was similar in many respects to that made by other manufacturers of like equipment and subject to the same limitations regarding size and inconvenience in making additions.

To meet an increasing demand for speedy, dependable dial service, Stromberg-Carlson engineers selected the XY® type equipment, with its inherent flexibility, as best suited to the demands of multi-office exchanges, where its inherent economies are multiplied; yet so simple in its basic design that it is equally practical for the small telephone switchboard.

XY DIAL SYSTEM

The prototype XY Universal Switch used in the XY Dial System was developed in Europe. In 1944 Stromberg-Carlson obtained the exclusive rights to manufacture and sell the XY Dial System to telephone operating companies in the United States and Canada.

Beginning in 1945, a group of Stromberg-Carlson engineers was assigned to the job of fitting the XY Dial System to American manufacturing standards and methods and modifying its design to provide a general purpose step-by-step telephone system. As a result, the XY Dial System is a vastly improved unit of extreme reliability.

The XY Universal Switch used in the XY Dial System is a flat-type switch which occupies considerably less space than other step-by-step switches of the same line capacity. The flat construction allows the switches to be "stacked" one on top of the other, and this in turn allows the use of continuous bare wire multiples which require no soldered joints between switches working into the same multiple.

The main features of the XY Universal Switch are as follows:

a. It is the only truly universal switch manufactured, in the sense that any switch may be used in any circuit without modification or adjustment.
b. It is fundamentally a four wire switch, with two signal carrying wipers (T and R), and two control wipers (S and HS), permitting economical operation of the system.
c. All parts subject to wear are hardened and the wear is negligible after the equivalent of 20 years service.
d. Wipers need not be replaced during the normal life of the switch.
e. To increase reliability of operation, it provides double contacts for the wipers and mechanically operated spring assemblies.
f. Bank multiples are vertical, thus reducing to a minimum the problem of noise caused by dirty banks.
g. In the event of mechanical damage, entire multiples or sections of multiple may be replaced conveniently and at small cost.
h. The percentage make range of operation of the switch exceeds that of other step-by-step switches.
i. The switch is easily removed from service, simple to readjust and easy to clean.
j. The switch may be removed from service and replaced with another one in a matter of seconds—thus routine maintenance may take place without making the relays idle and reducing the grade of service.

Other components used in the XY Dial System were developed or selected from products available. Among these are the Type "A" and "C" Relays, a Stromberg-Carlson development featuring double contacts; the rotary and minor switches, and numerous special meters, relays and other components normally found in telephone systems. The Type "A" and "C" Relays are probably the second most important component of the XY Dial System. They were developed specifically for dial system use and have since found application in manually operated switchboards.

As the components were developed and selected, circuits for controlling the operation of the switch were also designed, and an engineering model of the proposed XY Dial System was produced in the laboratory in 1946.

In 1947 Stromberg-Carlson Company manufactured the first commercial XY Dial System, for installation at Worthington, Pennsylvania. This exchange and its successors have gradually come to be known as "Bay Type" equipment.

Bay Type

The term "Bay Type" has been applied to the original design because of the practice of mounting the Line Circuits, Linefinders, Allotter and 1st Selectors on a bay approximately 4′ wide and 8′ high known as the "Originating Bay," and the Connectors on a bay approximately 6′ wide and 8′ high known as the "Terminating Bay." The relays constituting one circuit are mounted on circuit plates of variable length and width which are "plugged in" to jacks mounted on the bay. The XY Universal Switch is "mounted" in a cell, which carries the multiple on the rear, and is "plugged in" to the associated circuit plate.

Experience proved that the Bay Type equipment was not sufficiently flexible to meet the requirements of larger exchanges. It soon became evident that it would be necessary to separate the various equipments which had been mounted as one unit on the Originating and Terminating Bays and to develop more versatile arrangements for the larger offices. It was with this in mind that an entirely new design of XY equipment was developed to overcome the limitations of the Bay Type, and at the same time to make more successful use of the obvious advantages of the XY Dial System over the older step-by-step systems.

Shelf Type

Shelf Type equipment is designed for exchanges serving 100 to 10,000 lines. It is expected to be the pattern into which 90% of all Stromberg-Carlson dial exchanges manufactured by General Dynamics|Electronics will be fitted. Small XY Dial Systems of less than 100 lines can be self-contained, that is all equipment can be directly mounted on the upright or "bay," similar to the method used for "Bay Type" equipment.

The name "Shelf Type" is derived from the practice of mounting the circuit plates and switches in a shelf of convenient, variable dimensions, and which is in turn mounted on a Bay Frame. For example, four shelves to a 9-foot frame.

The equipment frames are not assembled prior to shipment of the equipment and thus the largest unit which must be handled on the installation is the shelf itself. Circuit plates and switches are not mounted on the shelves until the equipment has been cabled and is ready for testing. Powerboards are shipped assembled.

The text of this book deals exclusively with the "Shelf Type" equipment but the principles of operation set forth herein in most instances are also applicable to the "Bay Type" equipment.

PRINCIPLES OF STEP-BY-STEP SWITCHING

HISTORIC

The idea of making the connection between two subscribers in a telephone network by automatic means is almost as old as the telephone itself. In the three-quarters of a century which has passed since the invention of the telephone, many schemes have been proposed for establishing this connection. So far as the present time is concerned, however, switching systems may be divided into three classifications.

The three general types of dial telephone systems which are in use today are defined by the switching mechanism used and are listed below in the order of development:

Step-by-step
Machine
Relay

The first step-by-step switch was developed by A. B. Strowger in 1889 and he is generally conceded to be the inventor of dial telephony. Shortly after the invention of the first step-by-step switch, the machine and relay systems appeared on the scene.

Electronic switching systems have been referred to repeatedly, especially in recent years, but so far as is known, no system has yet been made available commercially.

A further breakdown of each of the types of switching systems may be made. This sub-classification is concerned with the method of operation, as follows:

Direct or Indirect Response
Hunting or Marking
Linefinding or Line Switching

The term "Direct Response" indicates that the switches are controlled directly from the dial in contrast to the "Indirect Response" type of system where the dial pulses do not directly control the movement of the switch. The XY Dial System is a "Direct Response" system.

"Hunting" operation refers to the methodical selection of one path to a given group of equipment by successively testing all the possible paths and abandoning those which are busy. "Marking" operation involves the preselection of the next path to be used. The XY Dial System is a "Hunting type" system.

"Linefinding" and "Line Switching" refer to two possible means of connecting shared equipment to a calling line. In the case of "Linefinding," the shared equipment is connected to the calling line after a search for the calling line is made. "Line Switching," in effect, connects the calling line to shared equipment. The XY Dial System is a "Linefinding " system.

The step-by-step system, of which the XY Dial System is representative, probably is used for a majority of exchanges.

BASIC PRINCIPLES

The fundamental idea of step-by-step switching involves the methodical selection of successively smaller groups from a large group until the single unit in the smallest group is chosen.

There is no essential difference between the process of selection performed by the XY Universal Switch and that performed by the Post Office in delivering a letter, or the stock room attendant in locating a particular part. For example, there happen to be at least two cities called Rochester—one in New York, another in Minnesota. It first is necessary then, for the Post Office to "select" the "group," in this case New York or Minnesota, if it is to avoid delay and possible non-delivery. Having selected two large groups (the state and city), a smaller group is selected, the postal district. In successive stages, the street, number and sometimes the individual are subsequently selected. Note that this selection must be performed in the proper sequence or it cannot be successfully performed at all—the selection is therefore methodical—always done in the same sequence, and in that sequence which will result in the eventual location of the desired person.

THE BASIC SWITCHING SCHEME

Consider the simple telephone system shown in Figures 1 and 2. The manually operated tap switch enables station 4 to talk to stations 1, 2, or 3 individually and at will. Another way of making this same connection is to have a remotely located stepping switch under the control of a "dial" which will enable station 4 to select stations 1, 2, or 3 by closing the circuit to the stepping switch magnet a corresponding number of times.

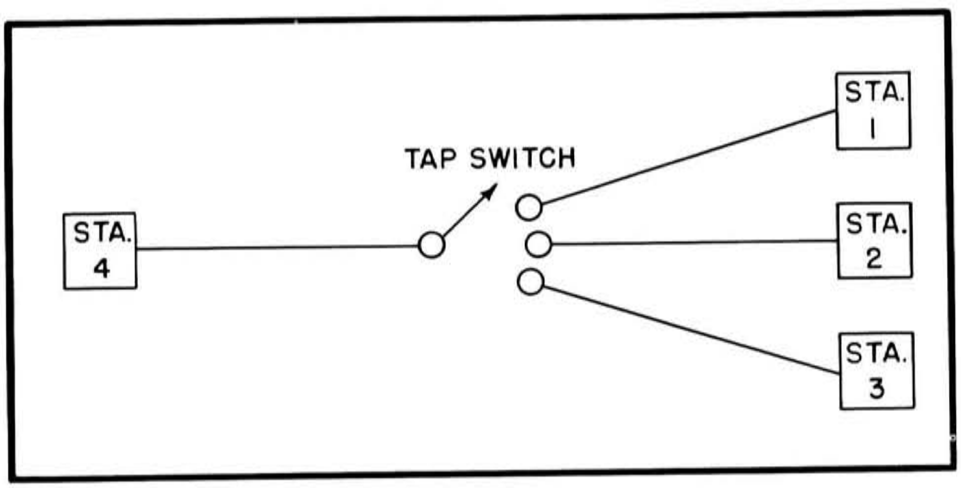


Figure 1. Manually Operated Tap Switch

The major difference in the operation of the two schemes is that in the first illustration station 4 has chosen the proper remote station by manual operation of the tap switch. While in the second illustration station 4 has chosen the proper remote station by mechanical-electrical control through the medium of a mechanical device known as a "dial" which delivers constant closures or "pulses." The introduction of this device makes it possible to design a stepping switch which is operated from known conditions, resulting in extreme reliability. Figure 2 has decided advantages over Figure 1 as the number of stations increases. Figure 1 requires that wires from every station be run into the tap switch which is operated by station 4. Figure 2, on the other hand, requires that only two circuits (one for controlling the switch and one for talking) be run to the immediate location of station 4, no matter how many stations there are in the network. That these two circuits may actually be one will be illustrated in the CIRCUIT PRINCIPLES section.

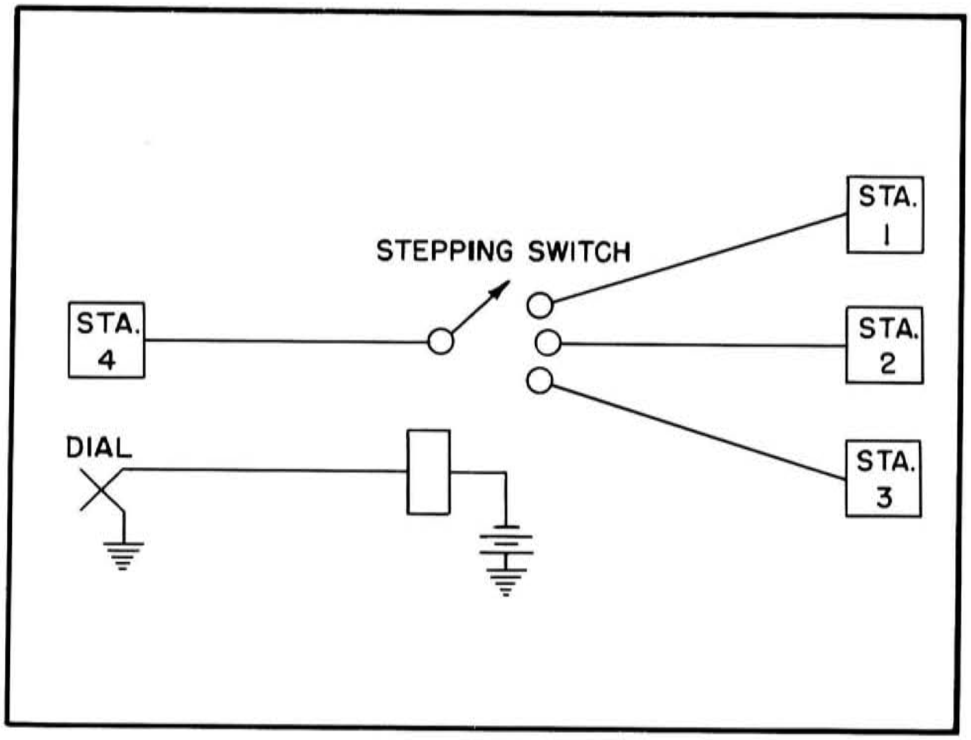


Figure 2. Electrically Operated Stepping Switch

DECIMAL SWITCHING

Let us suppose, for the moment, that a dial and stepping switch capable of selecting any one of 100 points (in one direction) are available. Using the normal pulsing rate of 10 pulses per second, it would require 10 seconds to make the connection to station 100. Another, probably quicker, way to select any one of 100 points is illustrated in Figure 3. Using a dial capable of transmitting a maximum of 10 pulses at the rate of 10 per second, and operating the dial twice, the same selection may be performed in 2 seconds (plus the interdigit time), instead of 10 seconds required by a switch stepping only in one direction.

This example illustrates the decimal system of numbers used in step-by-step switching systems. Any integer may be made up of the digits 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. Since there are 10 and only 10 different digits, a methodical arrangement of them is necessary in order to make up numbers larger than 10. It appears most logical, therefore, to select the digit 1 to indicate that group of 10 numbers which is the first group of 10 numbers greater than the group formed from the original 10, and also to use the 10 digits to identify individual numbers in that group, thus obtaining the numbers from 10 through 19. We know that the digit 1 in 19 means something different than the same digit in 21 because it is in a different *position*. The same reasoning may be applied through number 99 which indicates the ninth group of numbers greater than the group formed from the original 10, and also the ninth unit in that group. At this point, however, the possibilities of using two digits have been completely exhausted, and it is necessary that the tenth group be indicated by three digits. For example, 102 is in the tenth group of

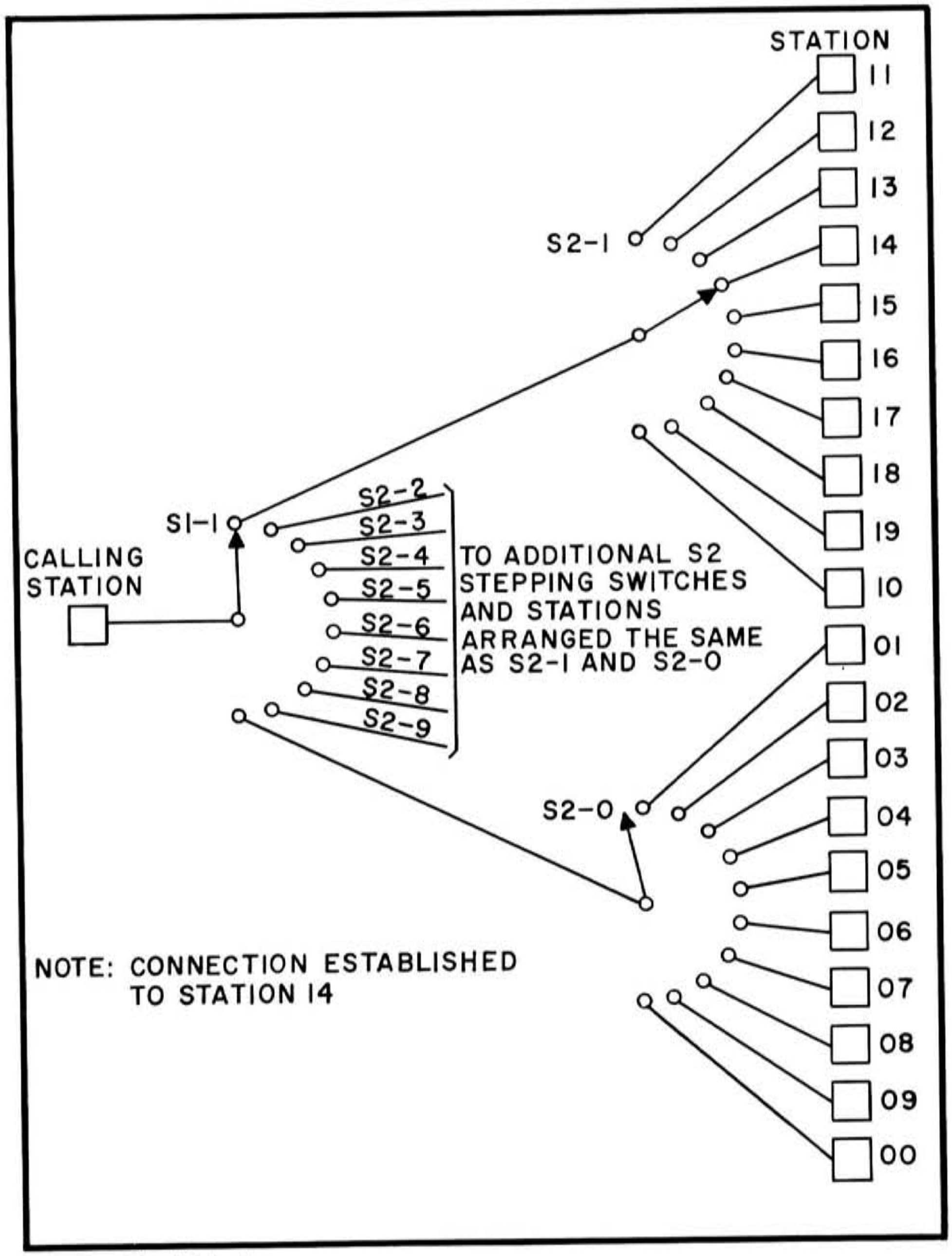


Figure 3. Decimal Selection

numbers greater than the original 10 and is furthermore the second unit. As this process is continued up to 999 it will be noticed that the final two digits repeat at regular intervals, and further investigation reveals that the final digit repeats at smaller intervals than the second. The intervals in this case have been designated as "hundreds" and "tens" respectively, and cause the numbers to fall into groups. There are two distinct types of groups in this illustration, 10 large groups each containing 10 smaller groups which in turn contain 10 units each. This line of thought may be continued upward as far as desired, but its general characteristic is such as to cause the continual formation of 10 larger and larger groups each time the supply of available numbers is exhausted and a new digit added in order to distinguish it from the rest. Although the added digit may be the same as the others, we interpret it to mean something different by virtue of its position.

Figure 4 illustrates a five digit number which has the final four digits hidden from sight.

Figure 4. 7[redacted]

Upon seeing this digit only, and having been told that the number contains five digits, one can immediately classify it as belonging to that group of numbers between 70,000 and 79,999, and a selection has been performed which narrows down the possibilities from 100,000 in number to 10,000 in number. If the next digit is revealed, (Fig. 5) the number can be classified

Figure 5. 75[redacted]

further as belonging to the fifth thousand in the group from 70,000 to 79,999. As each additional digit is revealed a more and more complete classification is available. Note that in doing this we have each time limited the possibilities to one group out of 10 of the same "kind" (number of digits), and at the same time excluded all the others of the same kind.

To give this discussion practical application, imagine that the numbers are telephones. The same type of a selection of one out of a larger group of telephones may be accomplished by mechanical switches which perform the same selection "step-by-step" under the control of a dial.

GROUPING

This discussion leads to the subject of "grouping". Note the similarity between the numbers served from any stepping switch in Figure 3. The first or tens digit is the same in all cases, the individual difference occuring because of the presence of the final or units digit. Note also that the units digits repeat on each switch, but that the thing which distinguishes each units digit from all the others is the fact that it is associated with a particular tens digit. There are thus 100 unique points. The stations are "grouped" depending upon their tens digit. Except for the fact that the number of switches used would be very large, it would be possible to design a satisfactory, highly expandable switching system around these single motion stepping switches.

A 100 point, two motion switch can perform the functions of the S1-1 and S2-1 stepping switches illustrated in Figure 3. If we mentally remove the switch mechanism from all the stepping switches, rearrange the banks as shown in Figure 6 and then arrange a two motion switch in front of those banks, it is possible to make the same electrical connection using only one switch. The first or "X" motion of the switch locates the wipers which will eventually establish the electrical connection to the bank terminal in front of the proper section of the bank, called the "level"; and the second or "Y" motion moves the wipers into the bank to establish the connection at the proper point, the "step". The "X" motion corresponds to the selection of the S2 switch shown in Figure 3, and the "Y" motion to the section of the bank terminal on the S2 switch.

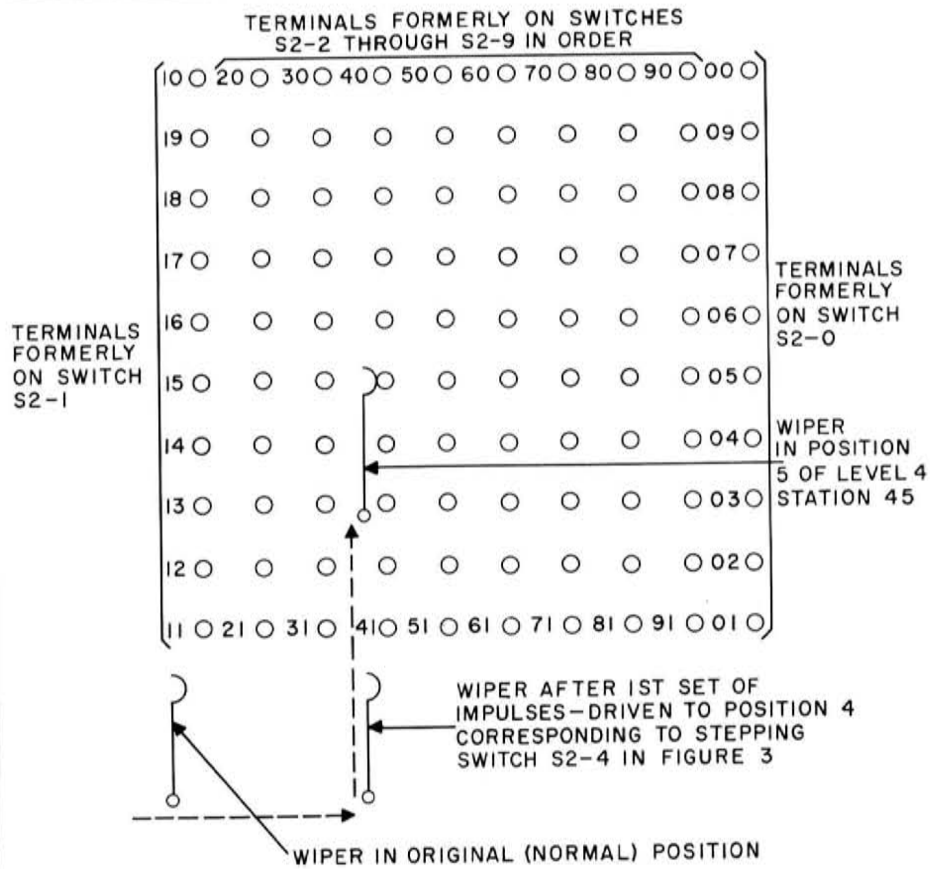


Figure 6. XY Universal Switch Bank Principles

In the preceding discussion, it has been assumed that one wire may carry the pulses and also provide a talking path when pulsing is completed. Modern telephone circuits require at least two wires external to the exchange and four within the exchange. It is necessary, therefore, that each of the stepping switches illustrated in Figure 3 be equipped with more than one bank and wiper and this is also true of the XY Universal Switch. When one wiper is in a certain numerical position in the bank, the associated wipers are also in the same *numerical* position (Fig. 7).

In some operations of the XY Universal Switch, it is necessary that the X position of the carriage be indicated electrically. In order to provide for this indication an extra set of banks and wipers, known as the XX-X bank and XX-X wipers respectively, are used. As the Switch moves in the X direction, the XX-X wipers move into the XX-X bank.

In order to clarify the meaning of the succeeding drawings, conventions will be adopted as shown below:

○ = An individual bank terminal T, R, S or HS.
● = An individual numerical position. (T, R, S and HS)
⊗ = A level (T, R, S, HS for 10 steps—40 wires.), or XX-X for 10 steps (20 wires)

The XX-X bank is always labeled.

A larger "group" containing 100 stations has now been established by means of a two motion XY Universal Switch. If more than 100 stations are involved it is necessary that reconsideration be given to the possibilities of Figure 3. By substituting an XY Universal Switch for each of the ten S2 stepping switches, it is possible to expand the system to 1,000 stations. The expansion of this system is practically unlimited, using the principle outlined in Figure 3.

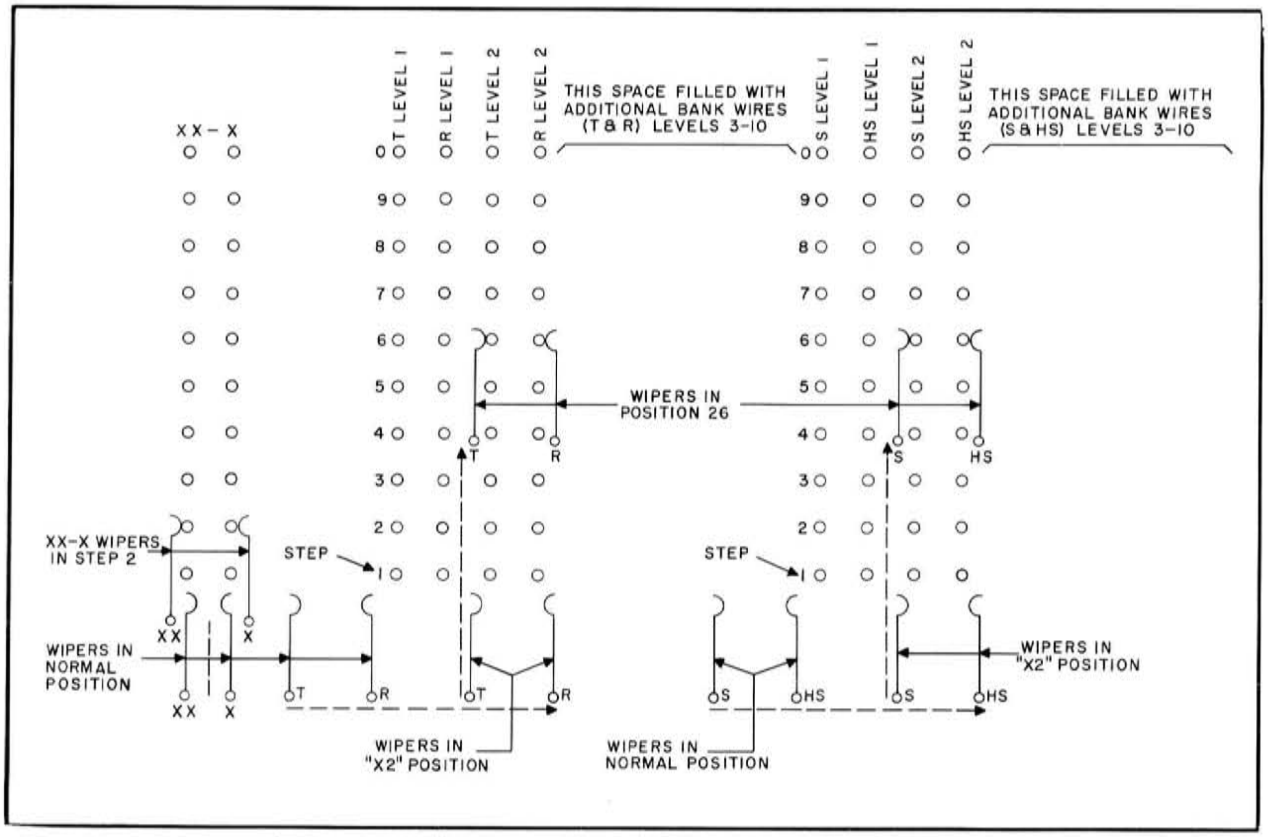


Figure 7. XY Universal Switch Bank

THE CONNECTOR

In the previous discussion a 100 line group has been established as the smallest distinct group in the XY Dial System. By proper circuit design it is possible to control an XY Universal Switch so that it pulses first in the X direction and then in the Y direction, to the proper point and then performs the following operations in sequence.

a. It tests the line to determine if it is busy or idle.

1. If the line is busy, busy tone is transmitted to the calling subscriber and the busy line is not disturbed.

2. If the line is idle, ringing is sent out over the line to signal the called party.

b. When the called party removes the handset from the telephone base the talking path is established. When required, answer supervision is sent back over the calling path.

c. When the calling party replaces his handset the switch releases and returns to the home position.

The switch and relay group which accomplishes the operations just described is known collectively as the "Connector". The operations described are basic to any "Connector". Connectors containing additional "features" (special operations) are used in the majority of XY Dial Systems.

SIMULTANEOUS CALLS

We have so far assumed only one call to be in progress at any one time. When only one call is in progress there is no necessity for more than one switch capable of locating any given point. Figure 8 shows the situation if two calls are to be handled at one time. The equipment must be doubled throughout and the banks of the Connectors connected together point for point or "multipled" so that either of the two Connector switches available may connect to any line in the bank multiple.

The idea of simultaneous calls can be carried to such proportions as to allow each station to have available at all times an XY Universal Switch which will allow him to originate calls to other stations. If there are 100 stations, this would require 100 XY Universal Switches and 100 sets of control relays, i.e.—100 Connectors (Fig. 9)

SHARING

While a 100 line exchange having a 100 point XY Universal Switch per line (illustrated in Figure 9) may be entirely satisfactory from the viewpoint of the subscriber, the cost of such quantities of telephone equipment prohibits this method of operation in a practical exchange. It is therefore necessary that stations "share" equipment. Since all stations will not be in use all of the time it is possible, with safety, to reduce the number of possible simultaneous calls which can be made by having the shared equipment available to all stations during (and only during) the period that they require it.

The success of the sharing idea wherein a small amount of switching equipment is available to a large group of stations results from the fact that the average subscriber uses his telephone only a small portion of the time; and the groups of subscribers (usually divided into groups of 100) are sufficiently large to allow great economies in equipment when treated on a probability basis. While any particular subscriber may take the notion that he wants to make a telephone call at any instant, the probability that great numbers of subscribers will all make calls at this same instant is fairly remote. Obviously, when using shared equipment, there will be times when a particular subscriber will be unable to complete a call if the exchange operates under the sharing system, as do all commercial exchanges.

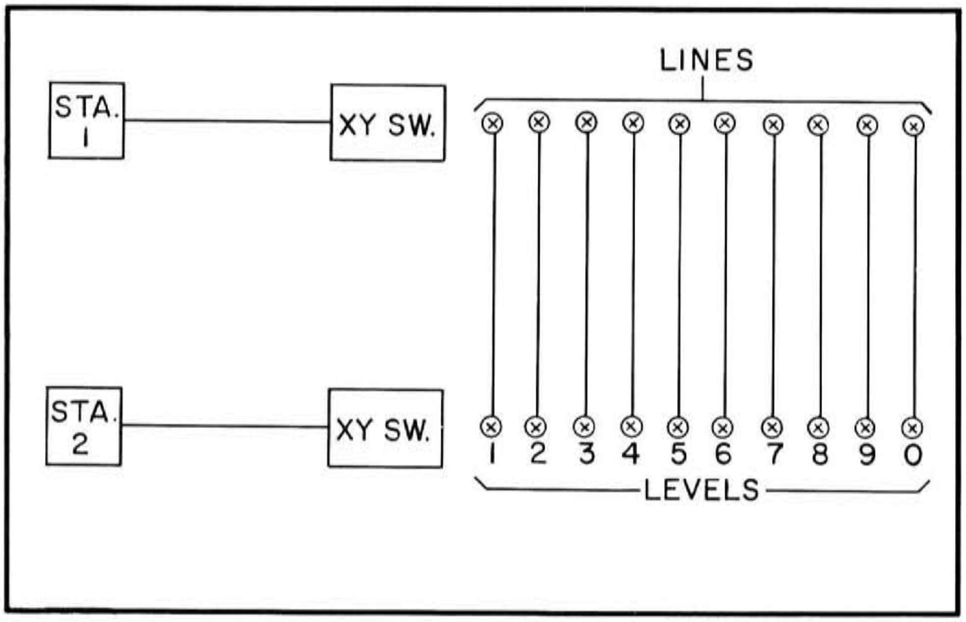


Figure 8. XY Universal Switch Bank

Different groups of subscribers have different group idiosyncrasies which cause the traffic originating in the particular group to rise and fall at regular intervals during the day. The particular hour during which the exchange is busiest is known as the "Busy Hour". While knowing the number of calls originated during the Busy Hour is of some help in determining the amount of shared equipment required, it also is necessary that the average duration of the calls be determined. If these two factors are determined, it is possible to use tables, taken from a probability curve, which will give the amounts of shared equipment required for any convenient percentage of "lost" or incompleted calls. Exchanges in this country are normally engineered to "lose" one call out of 100. This explains why telephone switchboards are "tied up" in case of common disaster.

The sharing principle is not peculiar to dial systems. The same principle has been used for manual operation where the cord circuits are the shared equipment.

The block diagram shown in Figure 9 illustrates the 100 line exchange without shared equipment. In order to share equipment located in a central office it is necessary that:

a. The shared equipment be available to all stations on an equal basis.
b. The amount of shared equipment be sufficient to handle the maximum number of simultaneous calls occurring at any one time during the *normal* busiest period.
c. Some indication be available to inform the subscriber that the shared equipment is ready to accept dial pulses.

THE LINE CIRCUIT

Since the shared equipment is available on an equal basis to all stations and is not normally connected to any one station, it is necessary to supply some method of indicating that a particular station requires switching

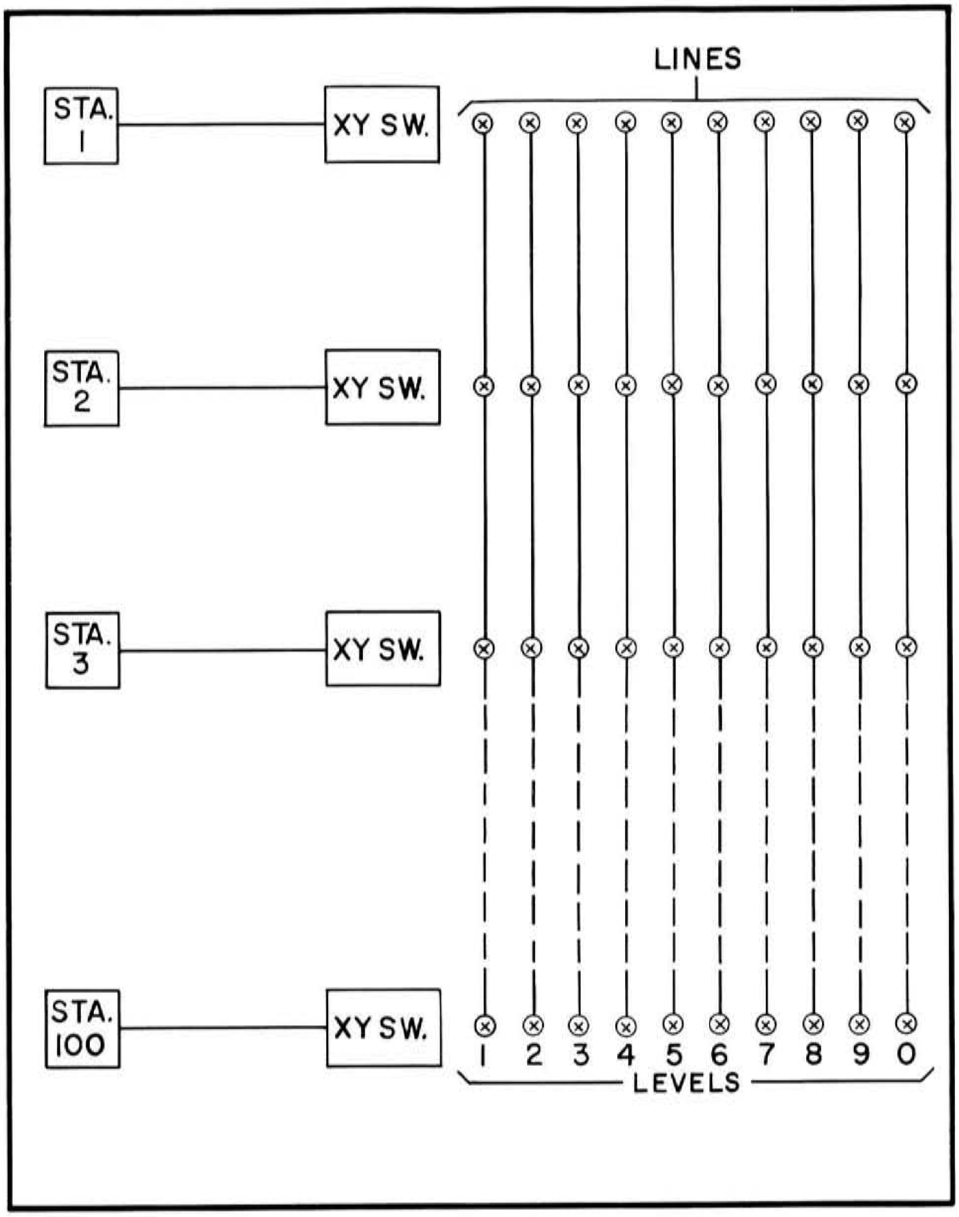


Figure 9. Theoretical 100 Line Exchange Containing 100 XY Universal Switches for Individual Use

equipment. The Line Circuit accomplishes this by sending a signal to the shared equipment when the station originates a call.

The Line Circuit is controlled so that on an incoming call to the station, the shared equipment is not connected with the station since it is not required.

THE LINEFINDER

A means is required for connecting the shared equipment to the line originating a call. This component is known as the Linefinder. The Linefinder, which is part of the shared equipment, is motivated to find the "calling line," after a signal indicates that the equipment is required. This signal comes from the Line Circuit.

"Numerical" switches, which follow the directions of the dial, have been discussed so far. The Linefinder is not under the control of the dial, and merely serves to connect the "numerical" shared switching equipment to the calling line. In this sense the Linefinder is *nonnumerical.*

The Linefinder sets out to find the line requiring shared equipment in a methodical way—selecting first the group of 10 lines containing the line and finally the line itself. The Linefinder is an XY Universal Switch used in a different manner from that previously discussed. Figure 10 illustrates the principle. When the calling party lifts the handset from the hookswitch, the Line Circuit sends a signal to the Linefinder. Upon the receipt of the signal from the control lead, the Linefinder (XY Universal Switch) moves out in the X direction automatically, searching for the level in the bank in which the calling line is located. The XX-X bank and wipers serve to indicate the tens position (level) of the calling line. When it reaches this level, it stops and starts moving into the bank in the Y direction. When the proper line is located, it then stops and sets up the necessary connection so that the station may control the Connector with the dial and thus complete a call. The calling party is advised of the completion of linefinding by the application of Dial Tone to the line. The Linefinder remains connected to the line during the entire call and drops away after the calling station has replaced the handset on the hookswitch. The Linefinder is then available for establishing other calls.

Only one Linefinder has been illustrated in Figure 10. If other calls are to be made simultaneously, it is necessary that additional Linefinders which operate in the same banks be made available. Between 10 and 15 Linefinders will ordinarily be required for each 100 lines.

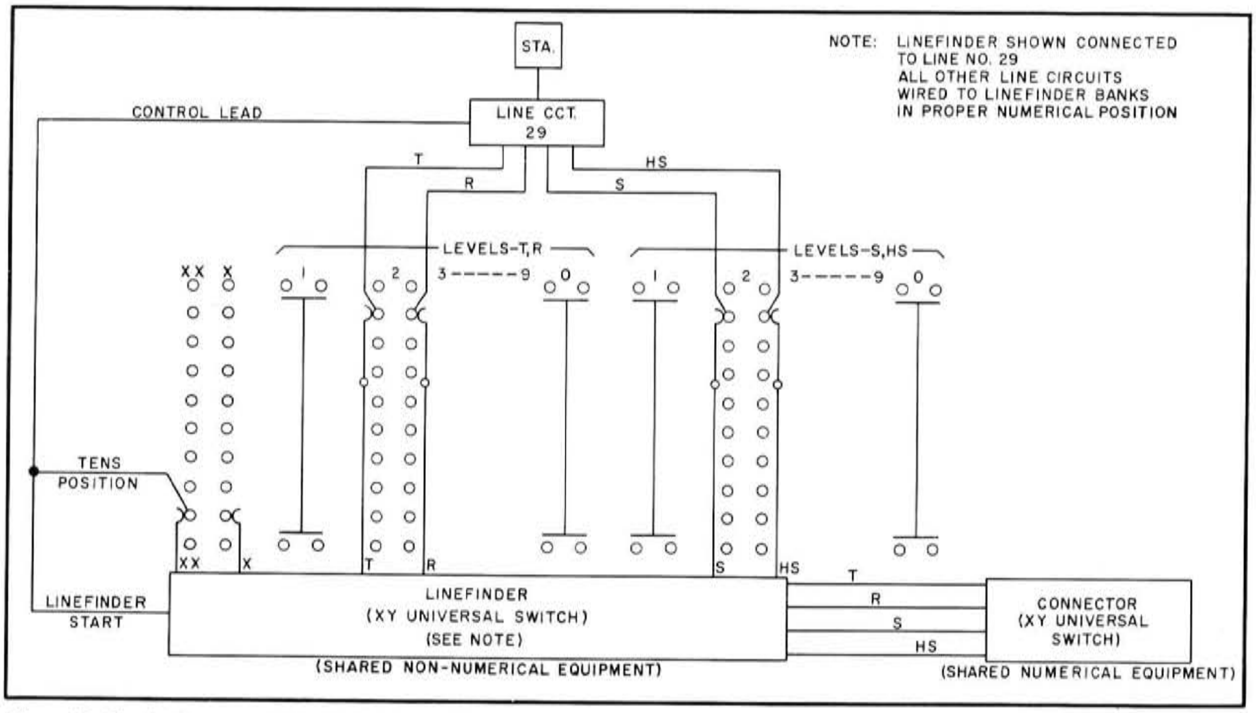


Figure 10. Block Diagram of Linefinder Operation

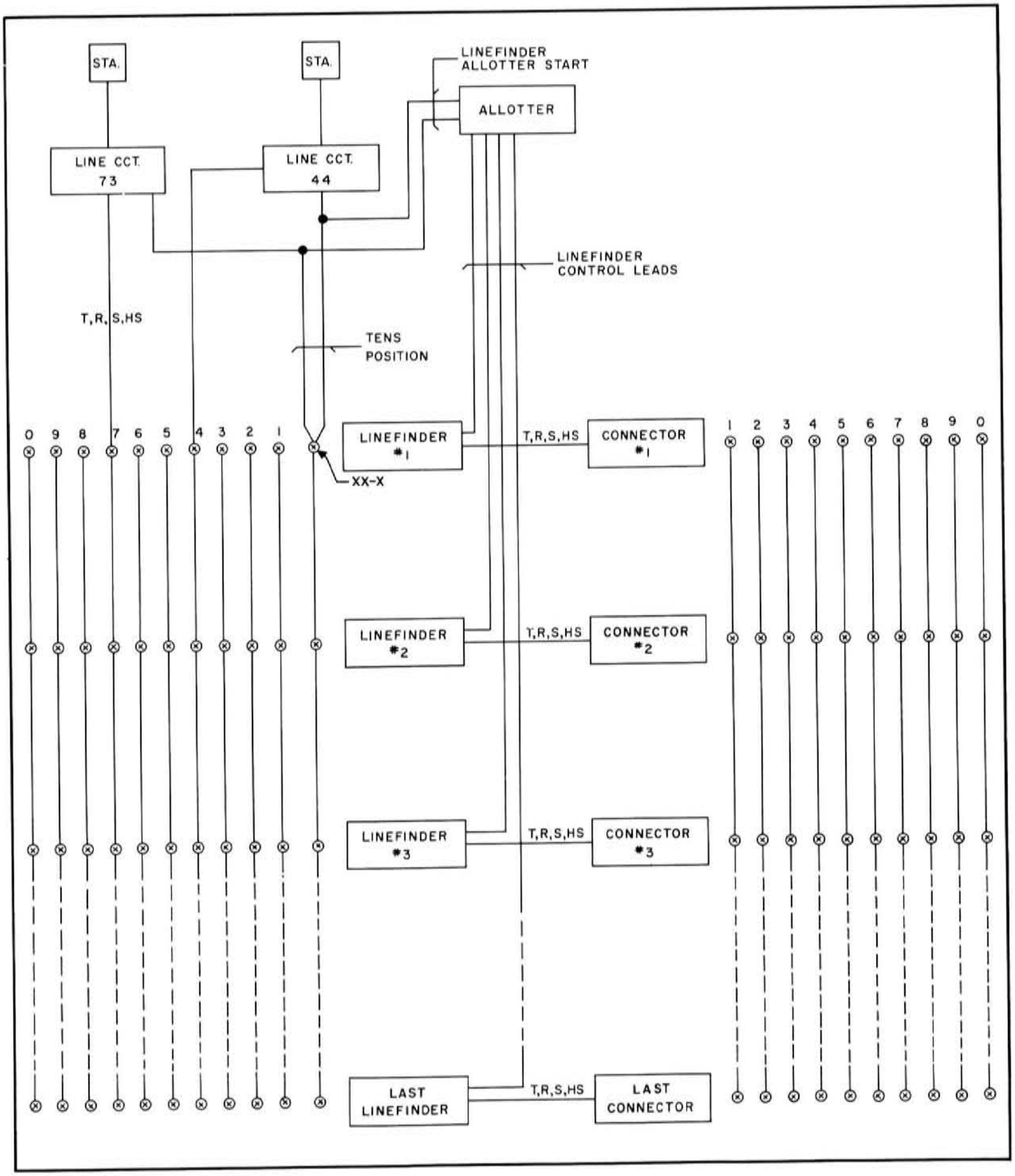


Figure 11. Block Diagram of 100 Line Linefinder Unit

THE ALLOTTER

It is necessary that each Linefinder be available for use by any Line Circuit as required. This is accomplished by a device known as the "Allotter," which distributes the Linefinders, one at a time, as they are required.

The Allotter preselects the Linefinder to be used for the *next* call and, after having directed it in searching for the calling line, preselects the next idle Linefinder and waits for the indication that a Line Circuit requires shared equipment before sending the Linefinder out. Figure 11 is a complete block diagram of switching circuits of a 100 line Linefinder Unit.

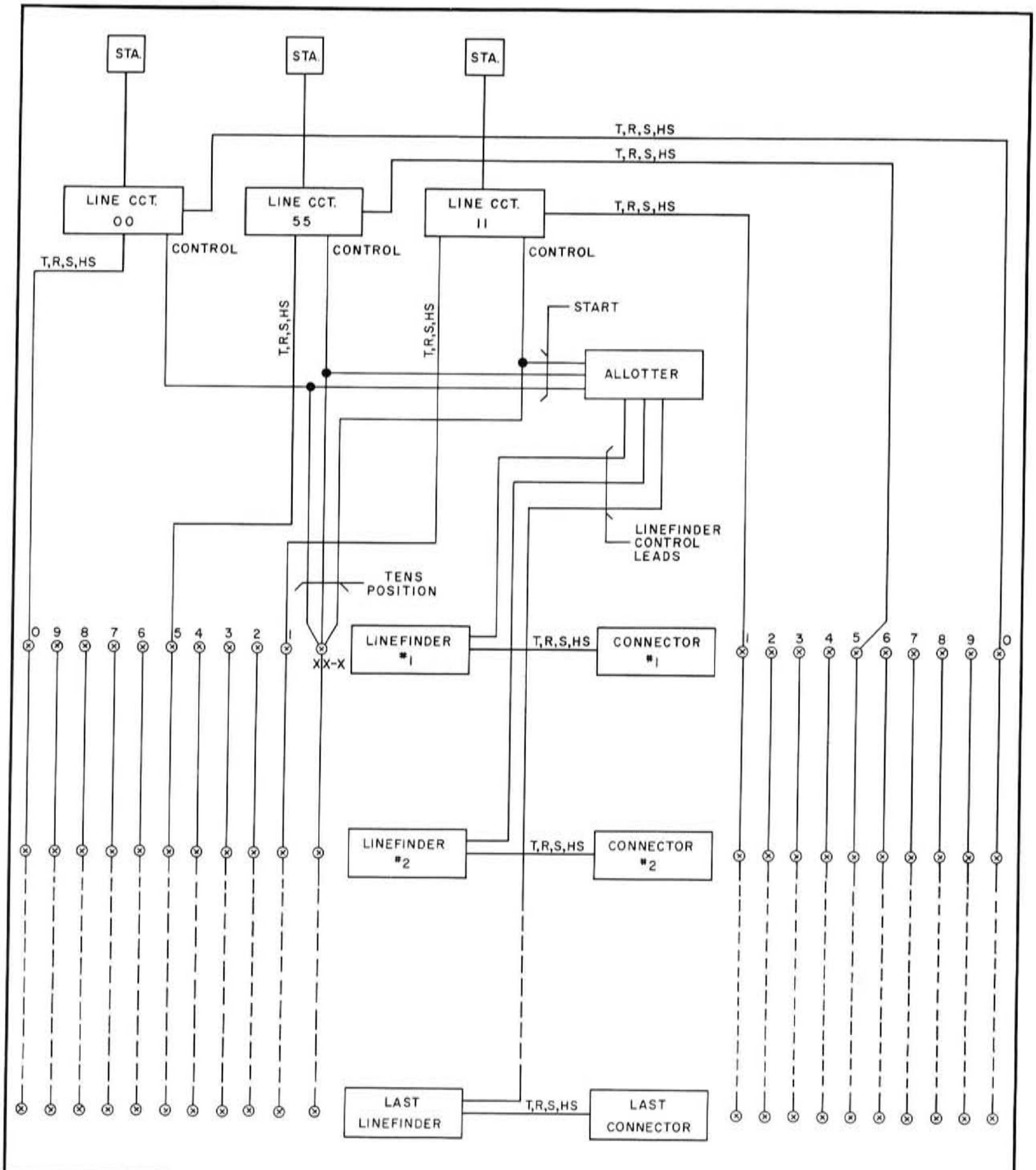


Figure 12. Block Diagram of 100 Line XY System

THE 100 LINE XY DIAL SYSTEM

As discussed previously, the Line Circuit has two functions. It signals the shared equipment when the line requires equipment in order to originate a call, and it prevents seizure of shared equipment when the line is called by another subscriber. Accordingly, the Line Circuit is connected to both the

Linefinder and Connector banks as illustrated in Figure 12. Figure 12 is the block diagram of a complete 100 Line XY Dial System. It should be understood that there are always the same number of Connectors as there are Linefinders.

THE SELECTOR

Figure 12 shows a system serving only 100 lines and, hence, there is no necessity for this 100 lines to be distinguished from any other. It contains a sufficient number of Connectors, all working into the same multiple, so that the traffic requirements of the exchange are satisfied.

Consider the situation, however, if more than 100 lines are required. It will then be necessary that additional groups of lines similar to the first group be added to allow expansion to 200 or more lines, and, also, it will be necessary that a means be available to indicate which 100 group is desired. The device which selects the group desired is the Selector. This unit utilizes an XY Universal Switch for this purpose. Figure 13 illustrates the operation of the basic Selector System.

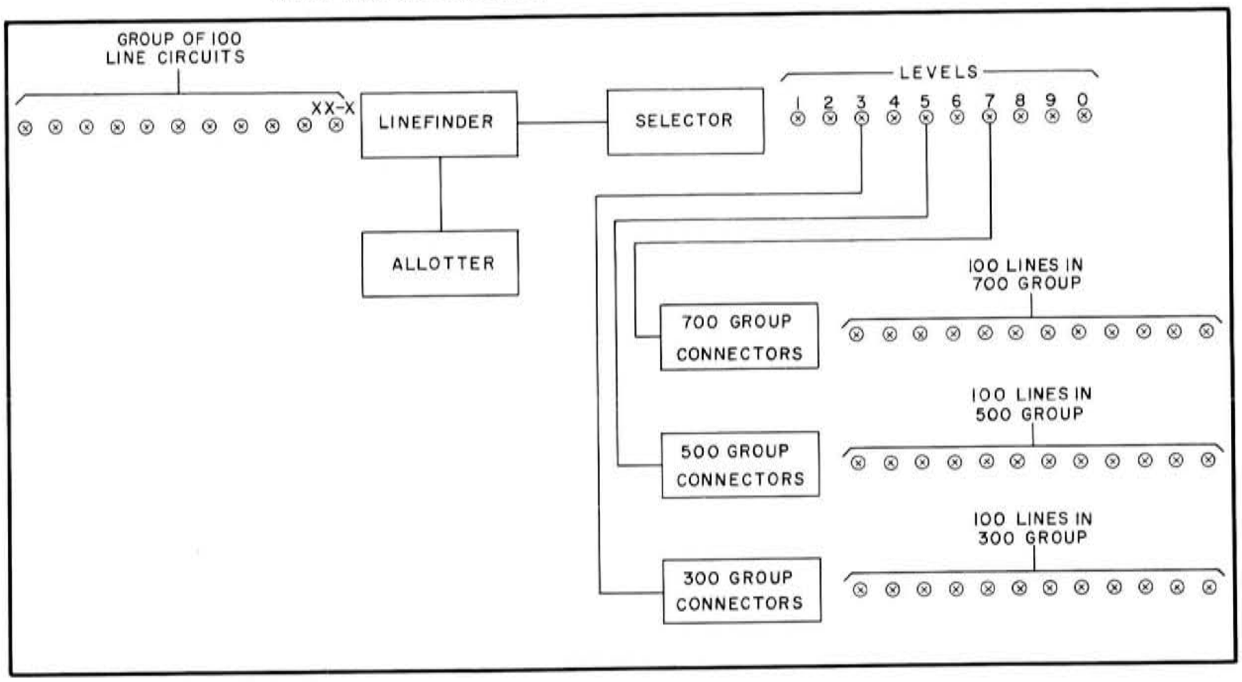


Figure 13. Basic Selector System

The Selector follows dial pulses only in locating the level which leads to the desired group. Having located this level under the control of the dial, it then proceeds automatically to test one by one all available paths to the selected groups. This operation is known as "hunting" or "searching" since the Selector switch is attempting to find a path to the desired group. In step-by step systems, searching takes place during the interdigit time and, therefore, must be extremely rapid. An XY Selector requires approximately 400 milliseconds to search over 10 possible paths, engage the selected switch, and switch the pulsing leads through so that pulsing may be continued in the next switch. A majority of this time is taken up in moving the wipers across the bank wires of the 10 different steps. The hunting speed of the switch itself is approximately 40 steps per second.

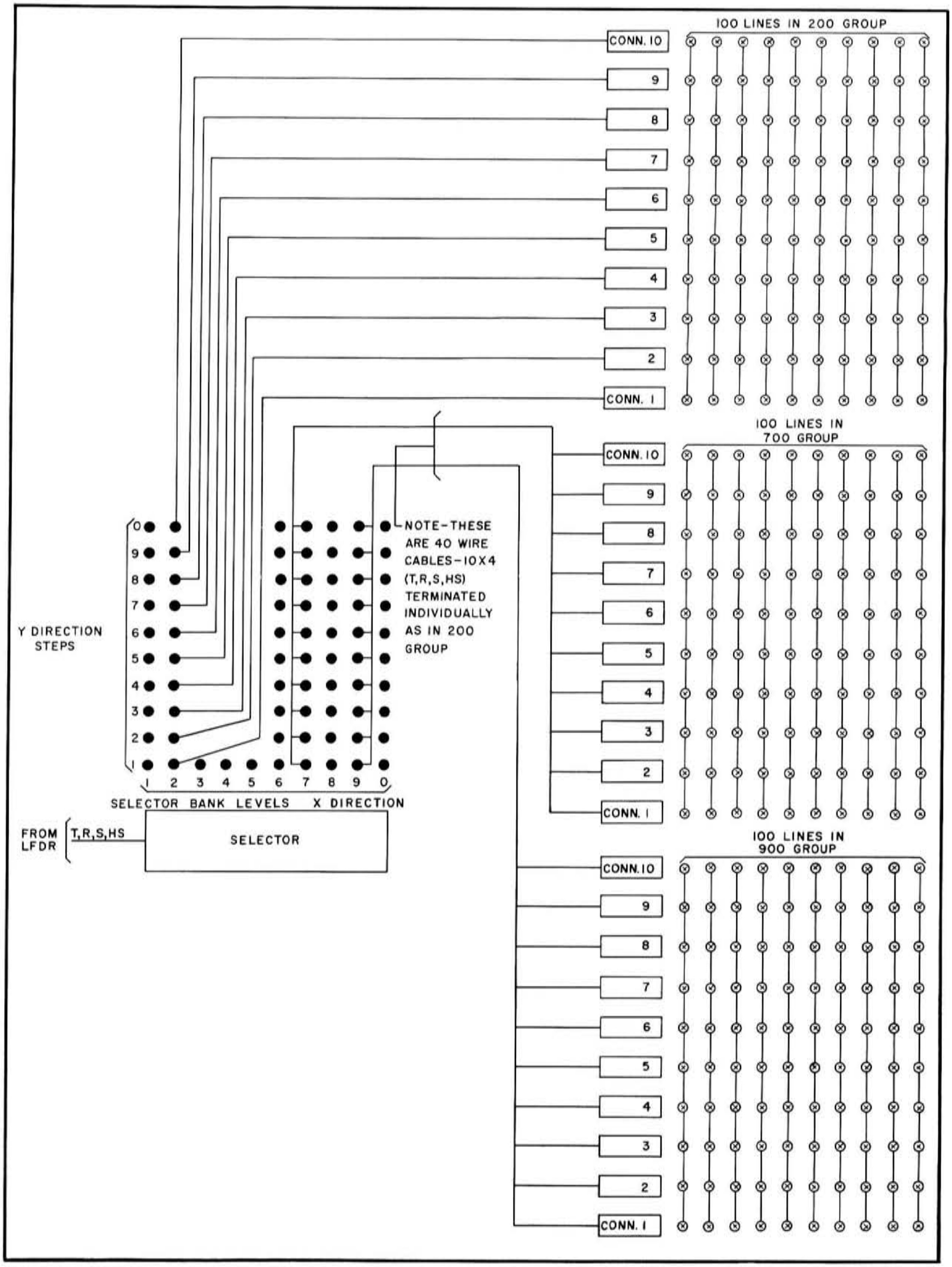


Figure 14. Selector Operation

Referring to Figure 14, it will be seen that if the digit 2 is dialed, the Selector will move to position X-2 under the control of the dial. As soon as it determines that there will be no additional pulses which will send it out further in the X direction, it starts to search over the 10 possible paths to Connector group No. 2. It first tests step 1 in Level 1 and determines if it is busy as a result of a call which is already in progress.

If so, it then advances the wipers one more step and repeats the test. If step two is busy, it continues to step until it either locates an idle Connector switch, or steps into the final position from which busy tone is returned to the calling subscriber indicating that no additional paths to that Connector group are available at that particular moment. Should it locate an idle Connector, it will stop on the path to that idle Connector and "Switch through", switching the pulsing leads which it has just utilized through to the Connector. The Selector switch then remains in position for the duration of the call. Since all of the Connectors may locate any line in the hundreds group chosen by the dial, it makes no difference whether the Selector finds an idle Connector on the first or tenth step or any intermediate step.

It is necessary that all of the stations dial three digits to identify the called station; one in the Selector and two in the Connector.

The Selectors must be made available as shared equipment. To accomplish this, the Linefinders are associated with the Selectors permanently. The block diagram shown in Figure 15 illustrates this type of operation.

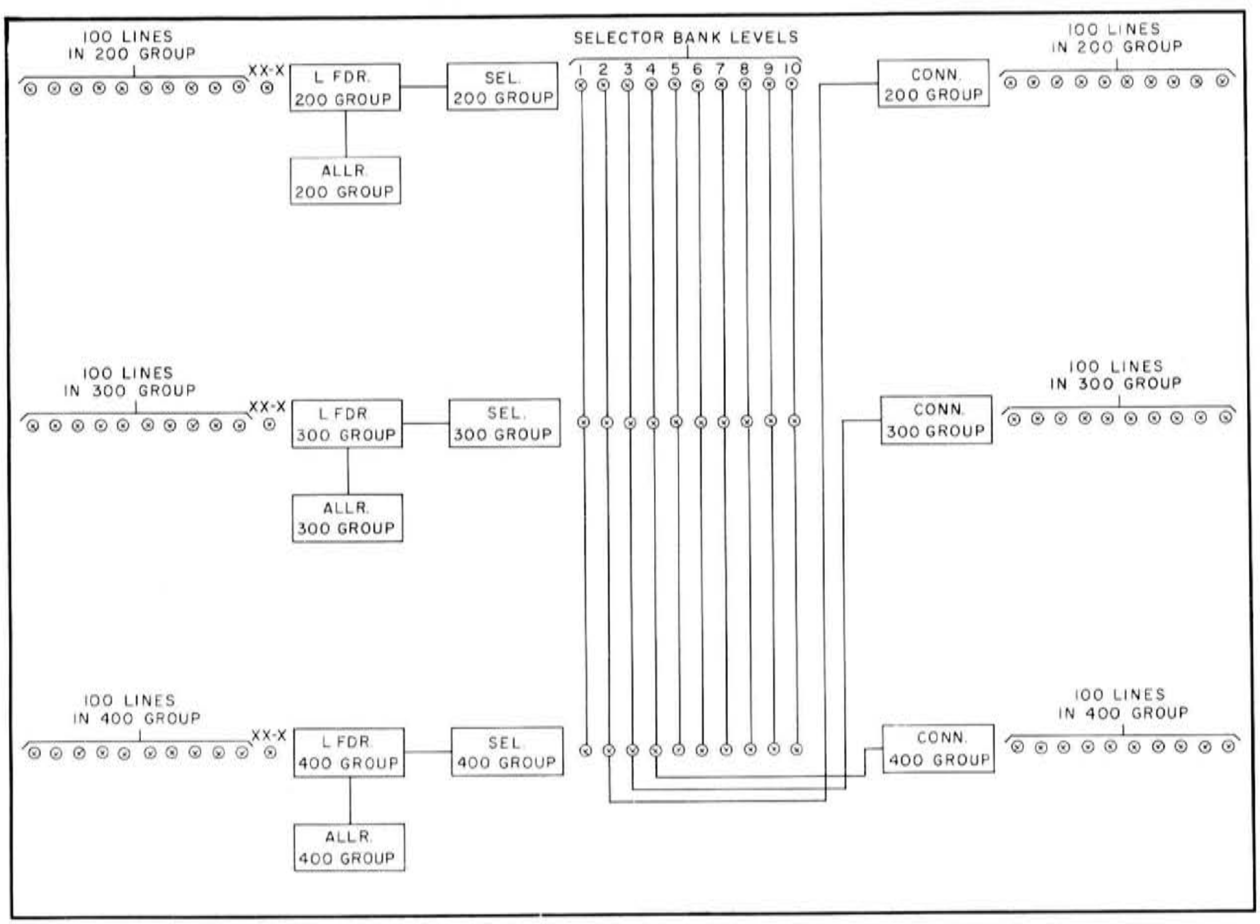


Figure 15. Block Diagram of 300 Line Selector Type XY System

In this system, Connector group No. 2 is spoken of as the "two hundred group" and Connector group No. 3 as the "three hundred group."

This designation has been used because the Connector groups are connected to the Selector banks in such a way that digit "2" must be dialed to locate the first group and digit "3" to locate the second. Connector groups connected to the seventh and eighth Selector levels are designated the "seven hundred" and "eight hundred" Connector groups, respectively. If the XY Dial System illustrated is to be expanded to 1,000 lines, seven more groups of 10 Connectors each may be added. At the same time, it will be necessary to increase the number of Selectors by a corresponding proportion in order to handle the increased traffic brought about by the 700 additional lines. It will also be necessary, of course, to increase the number of Linefinders; one for each Selector. By adding 700 more lines, we completely exhaust the selection possibilities of the one "rank" of Selectors which we have, and, to expand further, it is necessary to provide Selector switches which will select the thousands group desired, just as the Selectors illustrated select the hundreds group. If this is done, the Linefinders are then permanently connected to the thousands group Selectors and the hundreds group Selectors work from the wire banks of the thousands group Selectors. The Selectors permanently connected to the Linefinder are called 1st Selectors and the second "rank" of Selectors are called 2nd Selectors.

In addition to connecting to the groups of succeeding switches within the exchange, certain levels of the Selectors may be used to enable subscribers to dial directly to another exchange, or to obtain an operator when the external exchange is manually operated, or is a toll board. The circuits which signal between exchanges are called "Trunks".

The individual outgoing trunk circuits are distributed in the Selector banks in the same manner as the Connectors illustrated in Figure 14. When a Selector level is used to allow access to outgoing trunks, it cannot, at the same time, be used to connect to a group of Connectors.

Incoming trunks are generally terminated in an XY Dial Office by providing access to individual Incoming Selectors, or are terminated on Line Circuits in a manner similar to subscribers' lines. Two-way trunks have "appearances" both at the Selector banks for outgoing service and at an incoming Selector or Line Circuit for incoming service.

Selector banks also may be arranged to provide access to Intercept service, Reverting Call service, or other special services. In each case the distribution of the trunks or special service equipment follows a pattern similar to the distribution of the Connectors.

TYPES OF EXCHANGES

Main Dial Office. (MDO)

A Main Dial Office is an attended office equipped with a Toll Board. Both the Dial Office and Toll Board may serve satellite exchanges.

Community Dial Office. (CDO)

A Community Dial Office is an unattended exchange which is normally arranged to extend toll traffic to an MDO or Manual Toll Office.

Private Dial Branch Exchange. (XY-PBX)

A Private Dial Branch Exchange is usually a small office located in a business establishment with trunks extended to a Manual Office, MDO or CDO. The Private Dial Branch Exchange usually is equipped with an Attendant's Cabinet for handling incoming calls.

Trunks to a PBX are normally terminated on Line Circuits in the central office and, therefore, are treated in a similar manner to an ordinary subscriber line.

Private Dial Exchange. (XY-PX)

The Private Dial Exchange is an exchange which normally serves merely as an intercommunication system in a large office or similar establishment. There are no outside trunks.

SWITCH TRAINS

Local Switch Trains

As a call progresses through the exchange, various XY Universal Switches are seized. This group of switches used for a call is referred to as a "train". When the call is of the intraexchange type, the switches involved are spoken of as the Local Switch Train.

Toll Switch Train

This train handles Toll Traffic. In the XY Dial System, toll trains and local switch trains are combined to give maximum flexibility.

Test Switch Train

In order to make tests of subscribers lines and to verify busy indication which appear to be peculiar, a separate train of switches is usually used. This "Test Train" is not available to Local Traffic, but is available to Toll operators for busy verification.

COMPONENTS OF XY DIAL SYSTEMS

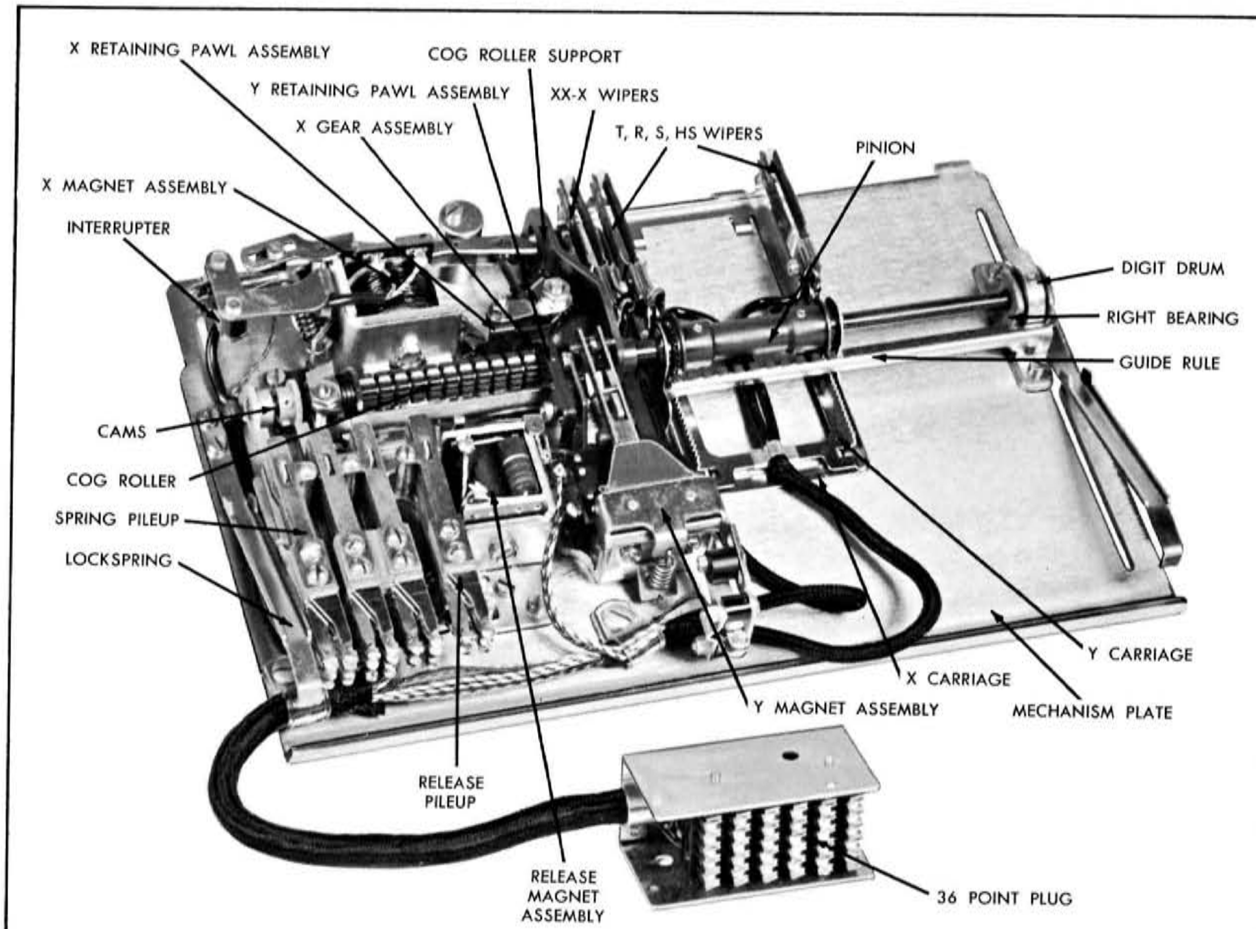


Figure 16. Stromberg-Carlson XY Universal Switch Assembly

THE XY UNIVERSAL SWITCH

Figure 16 is a general view of the XY Universal Switch with the main parts and assemblies identified.

Construction

Figure 17 shows the Mechanism Plate of heavy gauge steel. All components are securely screwed into mounting holes whose locations are governed by close tolerances. Lock Springs on each side are made of special alloy steel, clamping the Switch into place in the cell, but requiring only light pressure to release when shifting Switches from one cell to another. All springs in the Spring Pile-ups have twin precious metal contacts. The Switching Lever actuates the X-off Normal spring pile-up, and the X-Overflow spring pile-up, depending upon the position of the Cog Roller.

In Figure 18 the Cog Roller, which slides on a hardened steel tubular shaft, and shaft bearings have been added to the mechanism plate. The ratchet teeth on this Cog Roller, in conjunction with a Y-Drive Pawl, control stepping in the Y direction (into the wire bank multiple). Annular grooves between these teeth mesh with the sprocket of the X-gear assembly, providing the means for stepping the switch in the X direction (along the axis of the shaft).

Included in the X-Gear Assembly is a ratchet, which, in conjunction with the X-Retaining Pawl, holds the Cog Roller in the correct X position once this has been established. Nesting in the gear is the coil spring which returns the Cog Roller home when the pawl is released. Also added at this time is the Horizontal Guide Rule used to prevent switch motion in the "X" direction until "Y" motion is completed, when the switch is releasing. It is also valuable for a visual check of the X position.

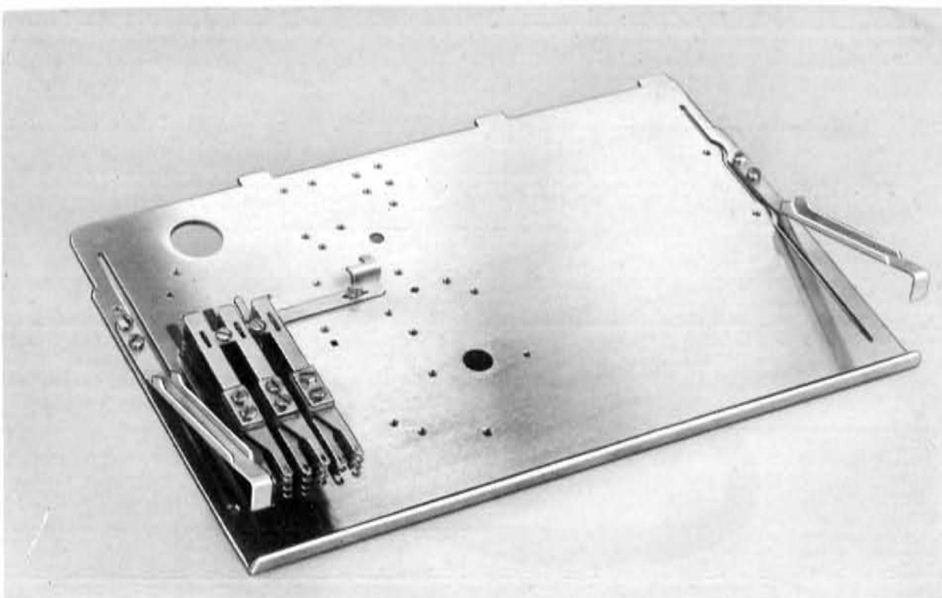


Figure 17. The Mechanism Plate

Figure 19 shows the addition of the X-Magnet Assembly and the associated X-Driving Pawl of casehardened steel. The Armature of the X Magnet, when operated, causes the Driving Pawl to actuate the X-Gear Assembly, moving the wiper carriage out along the shaft. Retractile pressure is maintained mechanically by a heavy duty coil spring on the X-Magnet Armature. The X-gear is prevented from over-running by the tip of the Armature, which engages a tooth of the X-Gear Assembly sprocket at the completion of each stroke. The Cog Roller Support gives the shaft complete and positive lateral support.

In Figure 20, the Y-Magnet Assembly has been added to parts previously assembled. When pulsed, the armature is drawn down and the Y-Driving Pawl engages a ratchet tooth of the Cog Roller, stepping the switch into the wire bank. Here, also, a heavy duty coil spring maintains proper retractile pressure. An Ejector, protruding from the Cog Roller Support, governs the travel of the "Y" Driving Pawl. The Stop Bar, operated by a cam on the Y-Armature, engages a ratchet gear on the Cog Roller as the Y-Magnet is pulsed, limiting the travel to a single step at a time.

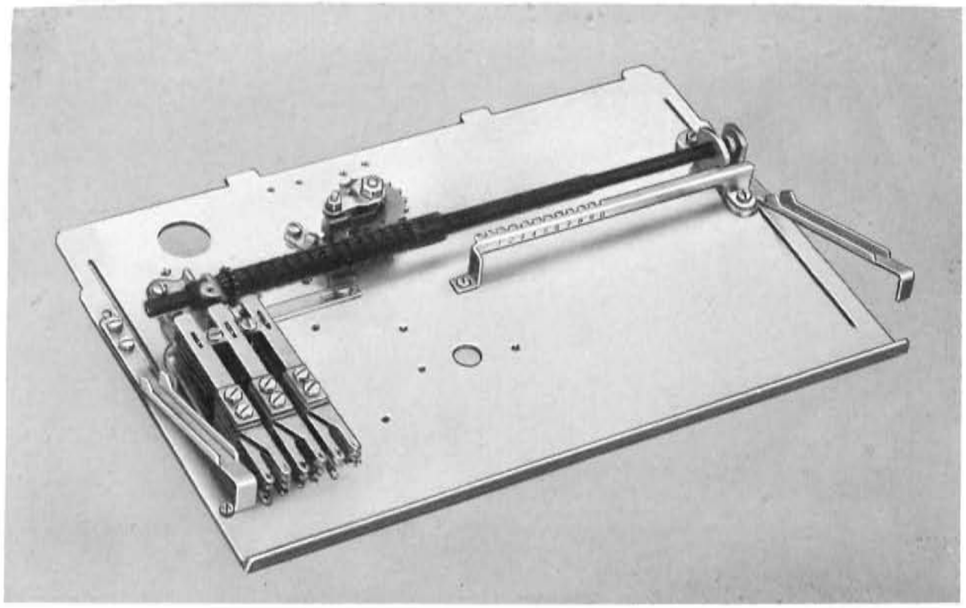


Figure 18. Addition of the Cog Roller and Shaft Bearings

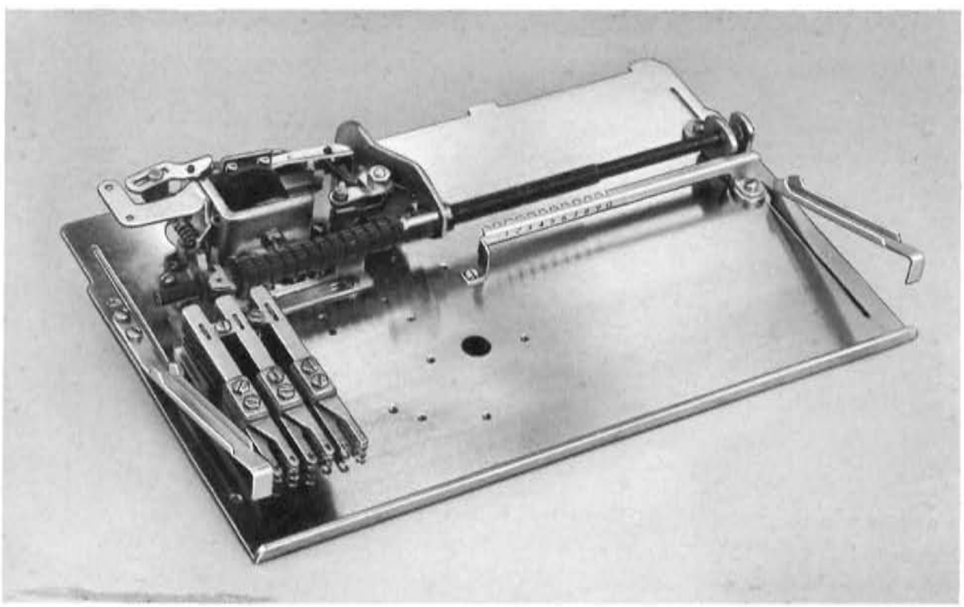


Figure 19. Addition of the X-magnet Assembly and Associated X-driving Pawl

Figure 21 shows the addition of the X-Carriage and the Y-Carriage, and the Wiper Blades which make contact with the Wire Banks. The Y-Carriage is mounted on the X-Carriage and travels with it in the X direction. Gears locked on the Cog Roller assembly engage the rack on the Y-Carriage, advancing the Tip, Ring, Sleeve and Hunt Sleeve Wipers into the Wire Bank. The XX-X wipers, mounted on their own carriage, move into the XX-X banks as the Switch moves in the X direction. The Switch uses twin Nickel Silver Wipers with the wiping surfaces under sufficient pressure for positive contact with the smooth round vertical wires of the Wire Bank. The usual replacement because of wear is eliminated.

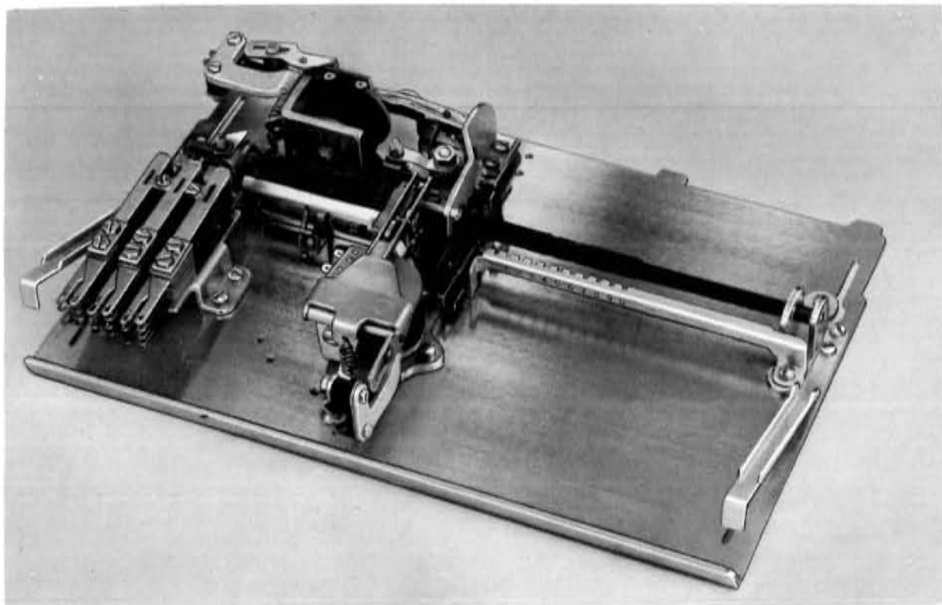


Figure 20. Addition of the Y-magnet Assembly

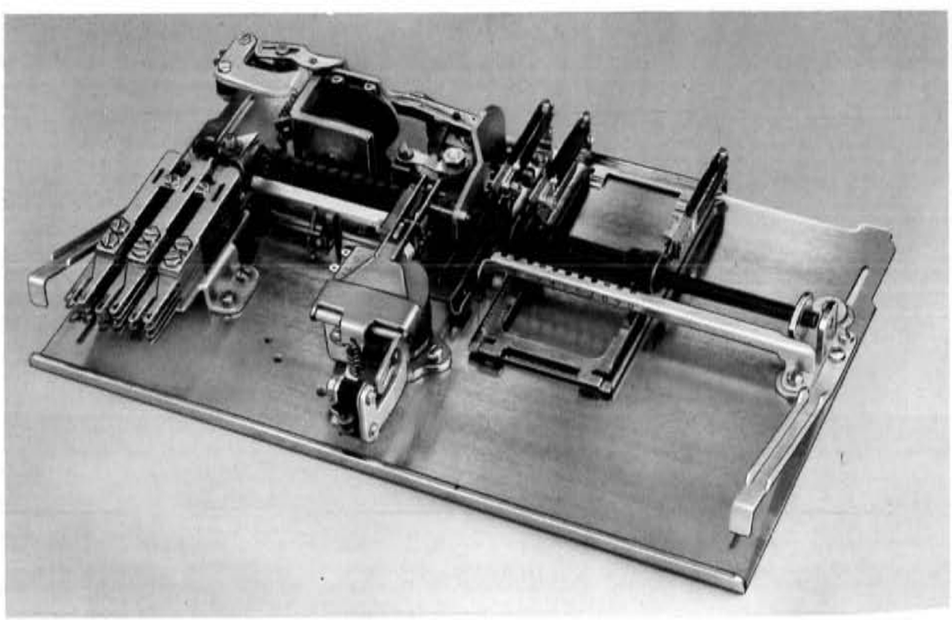
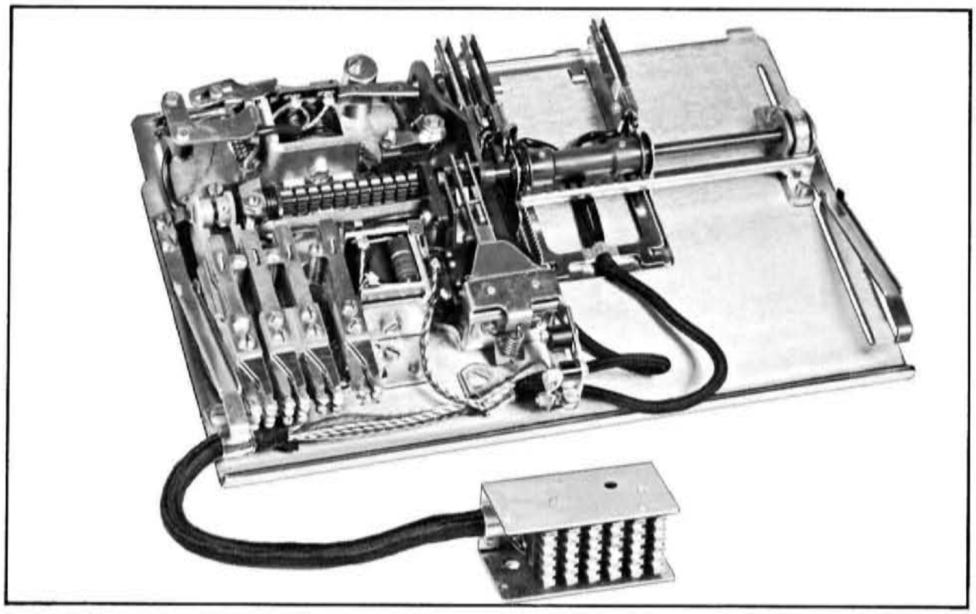


Figure 21. Addition of the X-carriage, Y-carriage and Wiper Blades

Figure 22 shows the completed Switch, ready for immediate plugging in to any shelf for use as a Linefinder, Selector or Connector. Among the additional components are the "Z" or Release Magnet, which releases the two Retaining Pawls upon release of the switch train, allowing the Y-Return Spring to-return the Y-Carriage to its home position. After this the two carriages return home in the X direction. Interrupters have been added to both the X and Y Magnets for the purpose of opening the impulsing paths to the magnets at the end of the respective armature strokes. The wiring and cabling is terminated in a 36-Point plug.



Operation

The basic function of a telephone switch is to make an electrical connection with a chosen line out of a group of lines. The XY Universal Switch takes two motions to accomplish this connection. With the Switch in a horizontal plane, as shown in Figure 16, the carriage is moved first to the right, or X direction, then out in the Y direction.

Since the XY Universal Switch is 100 point, the X motion is given 10 steps (plus one which provides for marking overtravel) and the Y motion 10 steps, thereby making possible the selection, by the wipers, of any one of 100 lines. An 11th step in the Y direction again marks overtravel. Since four wipers are involved and each wiper has its own set of 10 wire banks, 40 rows of wires each 11 deep are lined up along the front edge of the mechanism plate, immediately before the wipers, as shown in Figure 23. Also Figure 23 illustrates the XX-X wipers and their banks.

In some operations of the Switch it is necessary to mark the level of X travel. In order to accomplish this, another set of wipers (known as the XX-X wipers) enter a separate XX-X Wire Bank. These are operated by teeth on a rack, which engage the X Gear cluster. The wipers are mounted on the racks. Thus, as the X Magnet steps the X-Gear, both the Cog Roller and XX-X Wiper Rack move. When the XX-X Wipers have found the proper level, thereby positioning the Wipers on the carriage before the proper level wire banks, the X Magnet is de-energized and the Y Magnet takes over. It should be recognized that the momentum of the Switch, if not arrested, would carry each step beyond its limits. This is more easily realized when one considers that the stepping speed is often as high as 40 steps per second and the X and Y motions are both completed before the mind can register the start. In order to stop the X motion of each step, the end of the Armature of the X Magnet engages a tooth of the sprocket at the bottom point of the armature travel. The sprocket motion is, therefore, locked each time the X Magnet completes a pulse. In the Y motion, a cam on the underside of the Y Armature operates against the stop

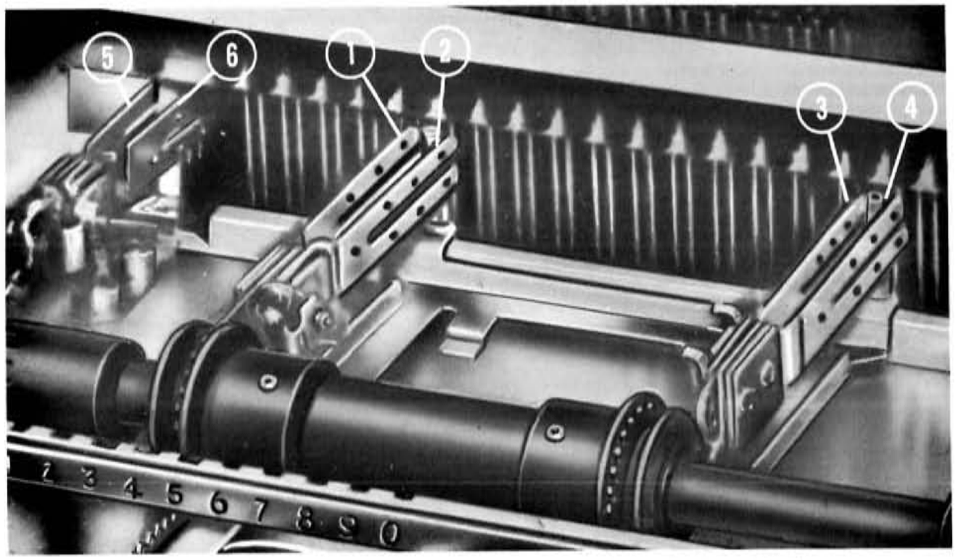


Figure 23. Wipers 1, 2 and 3 are Tip, Ring and Sleeve. Wiper 4 (Hunt Sleeve) is the Exclusive Stromberg-Carlson fourth wire. Wipers 5 and 6 are XX and X Respectively.

bar. This stop is rocked forward at each downward stroke of the Y Armature. A knife edge on the stop bar engages a ratchet wheel on the end of the Cog Roller, locking the rotation of the Cog Roller, and thus arresting the advancement of the wipers at the completion of each Y Armature stroke.

The Interrupters. Both the X and Y Magnets of the XY Universal Switch are equipped with interrupter contacts which open as the armature moves toward the core. These interrupters are used during hunting operations of the Switch.

Control Springs. The Control spring pile-ups used in the spring combinations on XY Universal Switches are composed of standard parts from the "A" Type Relay. All advantages of these springs as used in the "A" Type Relay are thus incorporated in the pile-ups.

There are four sets of control springs:

X Off-Normal	Y Off-Normal
Overflow	Release

The first three are mounted on a common assembly located at the lower left hand corner of the switch plate as shown in Figure 16. The Release springs are mounted on a separate assembly located near the release magnet.

X and Y Off-Normal Springs. The X and Y Off-Normal springs have a similar function which is to indicate the position of the wipers to the associated relay equipment. Operation of the X Off-Normals, for instance, indicates that the switch has taken at least a single step in the X direction. As the name would imply, the Off-Normals indicate that the wipers are not in their normal resting position.

Overflow Springs. In the event of certain incorrect manipulations or an all-trunks-busy condition, hunting switches may progress the entire length of the bank without encountering a stopping signal. Unless some stopping means is provided, they will continue to hunt vainly until the circuit is deenergized.

To avoid this, the overflow springs are arranged to operate on the extreme position of the wipers in either the X or Y directions (namely the 11th X or Y step) to stop further stepping.

Release Springs. The release springs operate when the Release Magnet is operated. They are normally used to prevent seizure of the switch as it returns to normal.

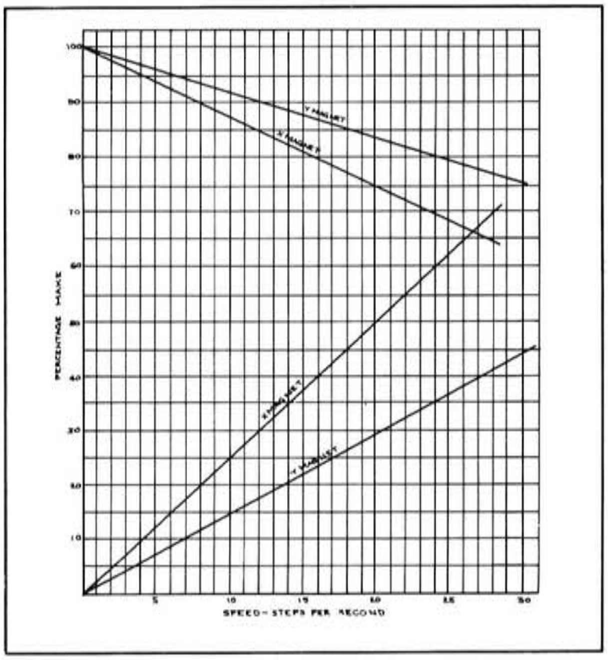
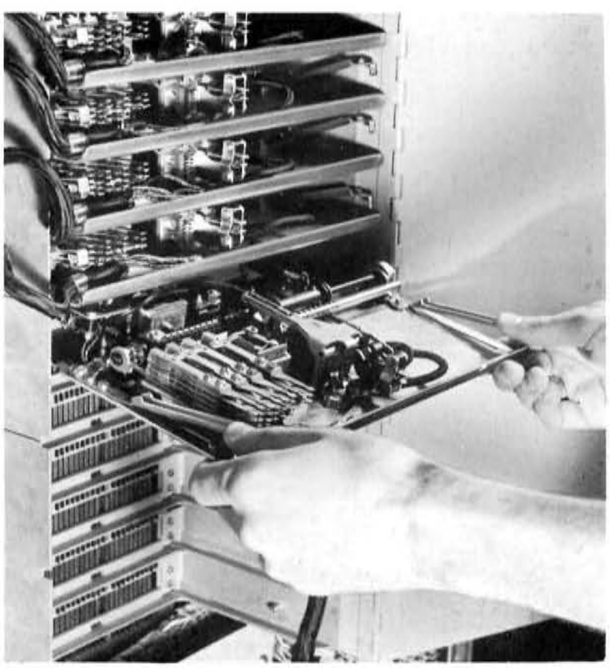


Figure 24. XY Universal Switch Characteristic Curve

Operating Characteristics

Figure 24 shows the characteristic curve of the XY Universal Switch when pulsed from an external source. The chart shows the effect, in steps per second, of changing the percent make. Both the X and Y Magnet are shown with the percent make starting at 0 and going up, and starting at the maximum of 100 and coming down.



Removing an XY Universal Switch

Adjustment and Maintenance

Detailed information for routine servicing, adjustment and maintenance is thoroughly covered in a bulletin entitled, "Maintenance of the XY Universal Switch," and can be obtained through the Telecommunication Division Sales Department.

THE TYPE "A" RELAY

The Type "A" Relay features include the use of twin contacts, card operated spring assemblies, preformed springs, and an improved method of adjusting the armature travel. The Type "A" Relay (Fig. 25) was designed specifically for dial systems.

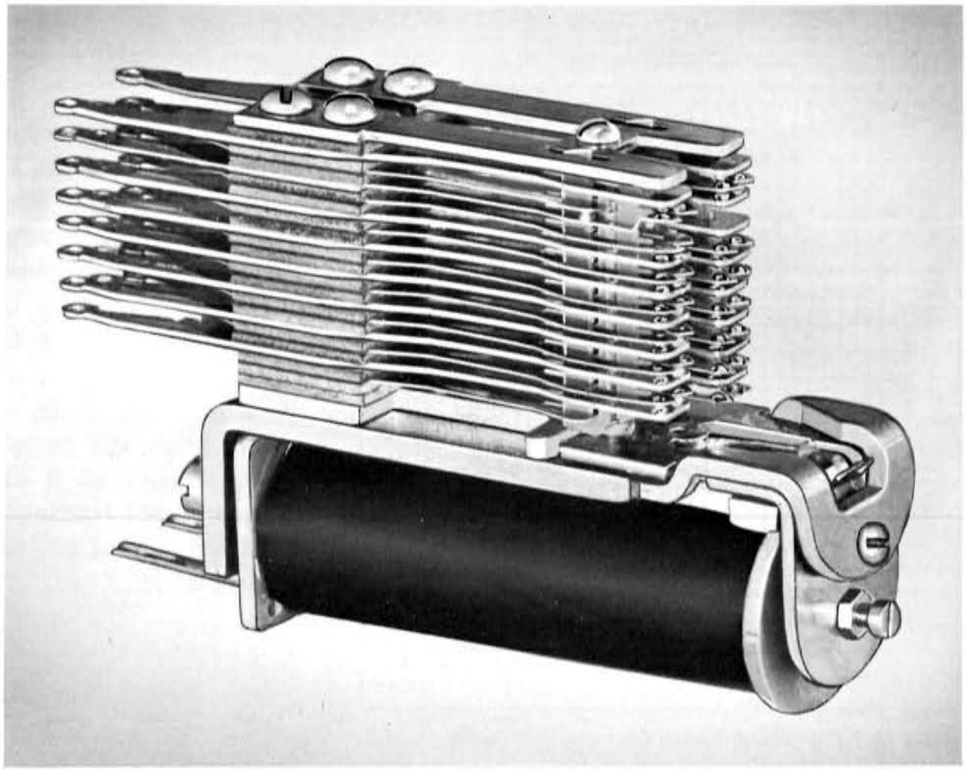


Figure 25. The Type "A" Relay

Construction

The Type "A" Relay is comprised of four major assemblies; the frame, armature, coil, and spring combination assembly. The frame, armature, and core are made from Armco iron and are annealed after working to remove stresses which affect the magnetic characteristics adversely. The frame and armature are plated with either nickel or zinc. The core is plated with nickel. The coil is wound with the number of turns as the control factor (resistance may vary ±10 percent); it is insulated from the core by a sleeve of cellulose acetate. The coil is readily removable by unscrewing the core nut on the heel of the frame. The wire is unsulated with either double or single enamel insulation depending upon the size, and both wire diameter and insulation thickness are held to commercial tolerances. Coils used in slow acting relays are equipped with copper sleeves or slugs as required.

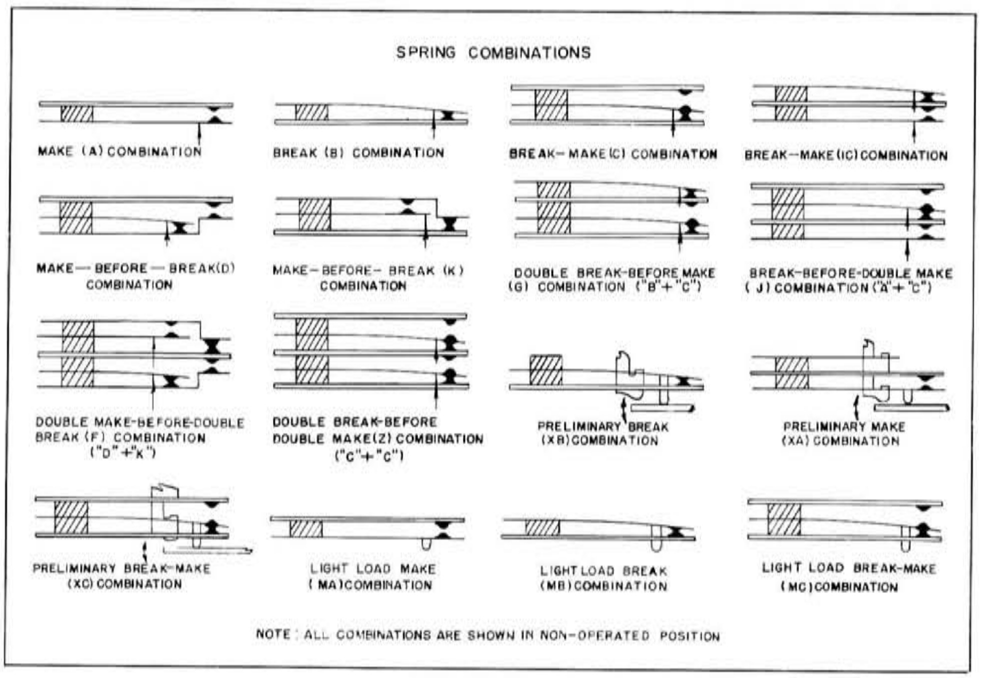
Non-inductive windings are sometimes wound on the coil with the inductive relay windings. The resistive tolerance of these windings is ±5 percent.

The armature is equipped with either a non-magnetic residual disc which provides for a .004″ minimum operated air gap or an adjustable screw to allow the operated air gap to be adjusted as required. The armature is also equipped with a support to prevent bending and to facilitate adjustment of the travel. The entire armature assembly is retained on the frame by a welded spring clip positioned so that it does not bind the armature at the pivot and allows the armature to move freely.

The spring combination assembly is a separate unit mounted on a base plate which is secured to the frame by two screws. The springs are preformed and assembled in the spring combination assembly as required.

One special combination, used on relays which must repeat pulses, appears upon cursory examination to be the same as the ordinary combination used on the relay. This combination, however, is constructed so that the contacts are separated by only .005″ instead of the usual .010″. As a result of this construction the armature is required to move less distance in order to operate the combination. This enables the ratio of the operate current to the release current to be less than normal (approximately 2:1) and is an advantage on relays which repeat pulses from subscriber lines. Relays using this combination are known as "limited travel" relays to distinguish them from the others.

The individual combinations are coded as shown below:



Prefix codes are added to the above codes to indicate special conditions. These prefix codes are:

Code	*Function or Description*
N	A MAKE combination with additional preform pressure (NA)
M	A sensitive combination (MA, MB, MC)
L	A "limited travel" combination (LA, LB, LC)

Except for X and M contacts, springs on one side of a combination use a common pusher and stop. The moving springs are bifurcated and each tine is equipped with a precious metal contact. Heavy duty contacts are used when required.

An additional prefix code is used with the codes listed in order to identify the contact material, when it is something other than the standard precious metal. The use of certain precious metal contacts for heavy current load positions, and in locations which are subject to extreme operations, increases the overall life of the system.

Experience has shown that a minimum contact pressure of 11 grams per contact is required to assure a reliable and low resistance contact. For this reason, the contact pressure of the two contacts is maintained between 25 and 40 grams. Raising the pressure much above 40 grams may result in passing the elastic limit of the spring and cause spring fatigue.

The ratio of contact travel to the travel of the armature as measured at the projection of the center-line of the core is normally 2.5:1. This ratio is called the "armature" or "lever" ratio. Certain relays used in the XY Dial System have an armature ratio of 1:1 and are called "short lever" relays. They are used when very long release time or other special circuit conditions must be met.

The method of numbering springs on combinations, and terminals of relay coils are shown on an Engineering drawing, obtained from Telecommunication Division Sales Department. Relay coil windings begin on "a" and "b" and end on "c" and "d", respectively. A single winding on a relay will usually be terminated on terminals "a" and "c", and all other terminals will be omitted. When three windings are used, the ends of the third winding are brought out in flexible leads, and connected as required. These leads are designated "e" and "f", the winding beginning on "e" and ending on "f".

Adjustment

Before leaving the factory, each Type "A" Relay is adjusted, and inspected twice. As is the case with any relay, occasional readjustment in the field is necessary. The proper field adjustment information should be obtained from the Relay Adjustment Sheet for the circuit in which the relay is used.

Pull Curves

The fundamental characteristic of relay operation from the standpoint of application is that of the relationship between the magnetomotive force and the load. This is best expressed by means of a graph which indicates the effective constant load on the Y axis and the magnetomotive force necessary to move this load on the X axis. The load which can be moved is dependent upon the air gap present and it is therefore necessary that a family of curves be made in order to plot this characteristic completely. When this family of curves is plotted properly, it is known as the "pull curve" for the particular structure.

Figure 26 illustrates a basic pull curve for a Type "A" Relay equipped with a 2.5:1 ratio armature and a single coil without a front slug.

It will be noted that the Y axis is labeled "Force in Grams Transposed to Contacts". This means simply that this force applied *at the contacts* can be overcome and moved by the magnetomotive force in ampere turns as read on the X axis with an air gap as indicated. Since the lever ratio is 2.5:1, the force applied at the armature would be 2.5 times that read on this graph.

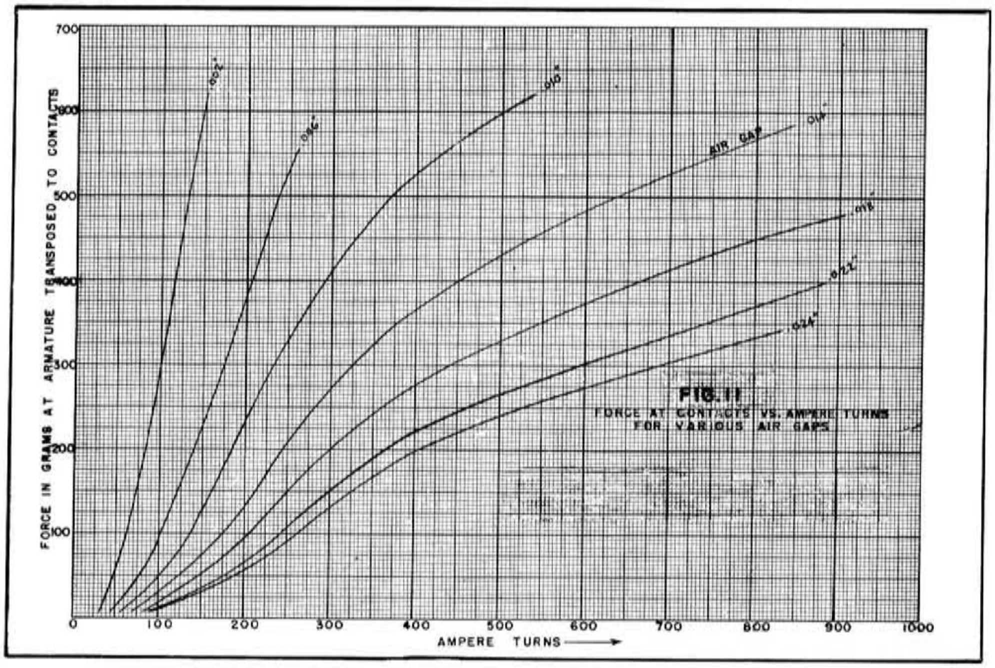


Figure 26. Pull Curve

Loading Chart

The information obtained from the pull curve is not useful until another characteristic has been determined. Although Figure 26 shows the relationship for a constant load, the relay combination does not provide the armature with such. Instead, the load varies with the position of the armature and it is therefore necessary to obtain this relationship before Figure 26 will be useful. Each pile-up has its own load curve which depends upon the number and type of combinations which make it up. Figure 27 shows a part of the load chart for commonly used Type "A" combinations.

		A COMBINATION				B COMBINATION				C COMBINATION			
LOADING POINT		UP	BB	MM	OP	UP	BB	MM	OP	UP	BB	MM	OP
Armature Position Relative to Zero Air Gap Transposed to Contacts (Zero Residual)		.038	.023	.013	.000	.038	.023	.013	.000	.038	.023	.013	.000
	Number of Combinations	GMS	GMS	GMS	GMS	GMS	GMS	GMS	GMS	GMS	GMS	GMS	GMS
NOTE: GMS = Force in Grams at Armature Transposed to Contacts.	1	7	10	11	44	0	32	34	37	0	32	34	67
	2	14	20	22	88	0	64	68	74	0	64	68	134
	3	21	30	33	132	0	96	102	111	0	96	102	201
	4	28	40	44	176	0	128	136	148	0	128	136	268
	5	35	50	55	220	0	160	170	185	0	160	170	335
	6	42	60	66	264	0	192	204	222	0	192	204	402
	7	49	70	77	308	0	224	238	259	0	224	259	469
	8	56	80	88	352	0	256	272	296	0	256	272	536

Figure 27. Loading Point

Composite Curves

Two relationships have now been obtained, that of the magnetomotive force versus the load with air gap as the parameter, and that showing the contact load versus the contact position. Curve 1 must be replotted to indicate load versus air gap with ampere turns as the parameter. Figure 28 is the replotted curve.

From this information, it is possible to determine the magnetomotive force (in ampere turns) required to operate any given combination as long as the loading characteristics of the combination have been determined. By superimposing the load curve on the pull curve and selecting the ampere turn curve just above the highest one crossed by the load curve, the operating ampere turns may be obtained.

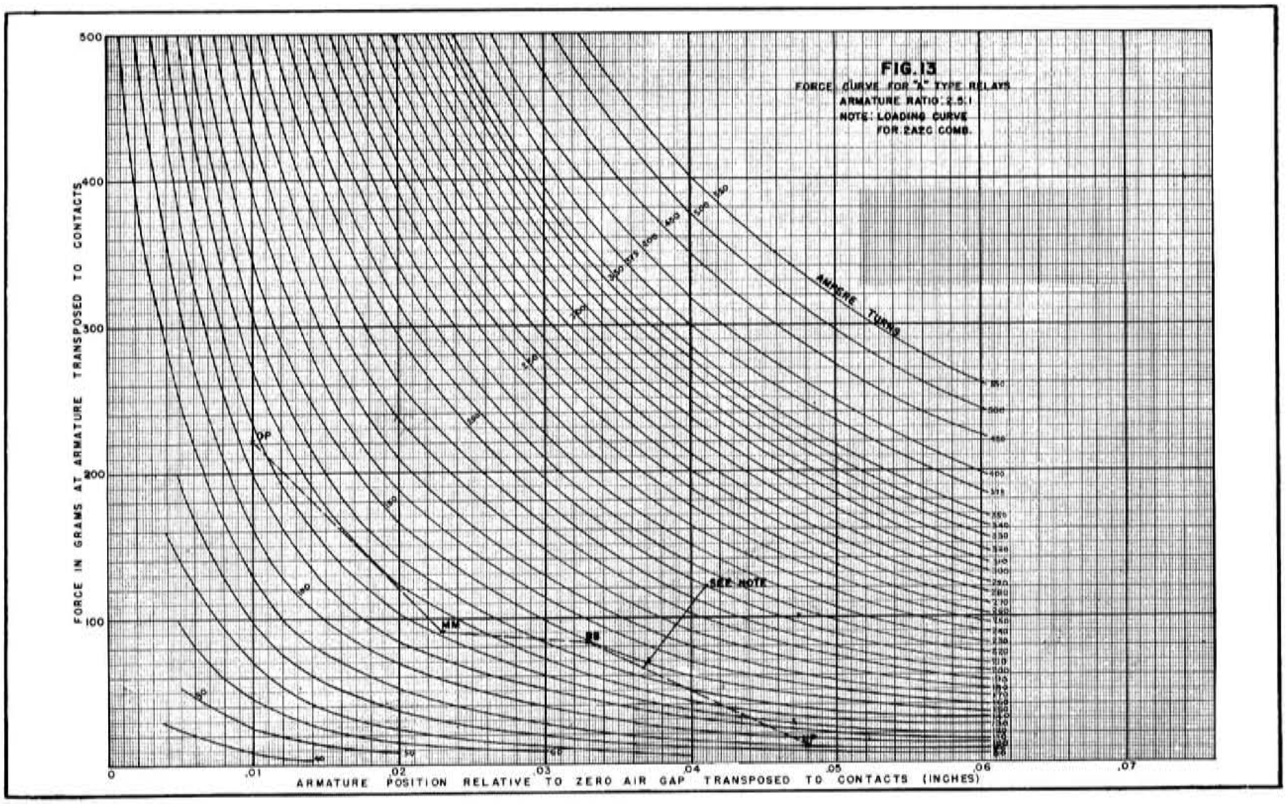


Figure 28. Force Curve

The residual projection, of course affects the air gap and it is therefore necessary to increase the air gap by the value of the residual projection when determining the ampere turns necessary to operate a given combination with a particular residual projection. Since the ampere turns are known, the current required for operation may be determined by knowing the number of turns on the coil. In this way, any combination and coil may be made to work together.

Use of the Loading Chart (Fig. 27)

Combination	2A2C
Armature Ratio	2.5:1
Coil	Standard
Residual Projection	.004″

a. From the chart read the total force in grams at the armature transposed to the contacts for 2A's and 2C's at the unoperated (UP), breaks-break (BB), makes-make (MM) and operated position (OP).

	UP	BB	MM	OP
2As	14	20	22	88
2Cs	0	64	68	134
Total grams	14	84	90	222

b. Multiply residual projection by 2.5.
.004″ x 2.5 = .010″ (equivalent residual projection)
c. Add .010″ (equivalent residual projection) to each of the four armature positions UP, BB, MM, OP relative to the zero air gap transposed to the contacts (to correct for residual projection).

UP	BB	MM	OP
.038″	.023″	.013″	.000″
.010″	.010″	.010″	.010″
.048″	.033″	.023″	.010″

d. Plot the grams at each corresponding armature positions on the "pull curve" Figure 28 (see curve).
e. Select the ampere turn curve above the highest crossed by the loading curve just plotted and read the ampere turns at the end of the curve.

AT = 150

f. Divide the ampere turns (150) by the turns on the coil to determine the required operating current.

Other curves are necessary if the relay is equipped with a front end slug or the armature has a different ratio. Release curves may also be determined. The curves shown in Figures 26, 27, and 28 are provided for academic purposes only.

THE TYPE "C" RELAY

The Type "C" Relay is actually two independent relays in one structure, occupying the same space and mounted in the same manner as a single Type "A" Relay.

Construction

Figure 29 illustrates a typical Type "C" Relay. The two sections utilize a common frame but have separate armatures and coils so that they operate independently.

The spring combination assembly is the same as that used on the Type "A" Relay. Each armature operates one side of a double spring combination assembly, i.e., one armature operates the spring combination assembly of springs numbered 1-19 and the other operates the spring combination assembly of springs numbered 21-40. The armatures are pivoted on non-magnetic pins instead of on the pivot edge of the frame and the pins can be located so that the contact to the armature lever ratio may be made large or small as required. The heel end of the core is drilled and tapped and the coil is mounted on the frame by means of a flat head machine screw.

The coils are wound so that the windings begin on "a" and "c" and end on "b" and "d", respectively. Note that this is different from the Type "A" Relay coil. The "a-b" coil operates the 1-19 spring combination assembly and the "c-d" coil operates the 21-40 spring combination assembly.

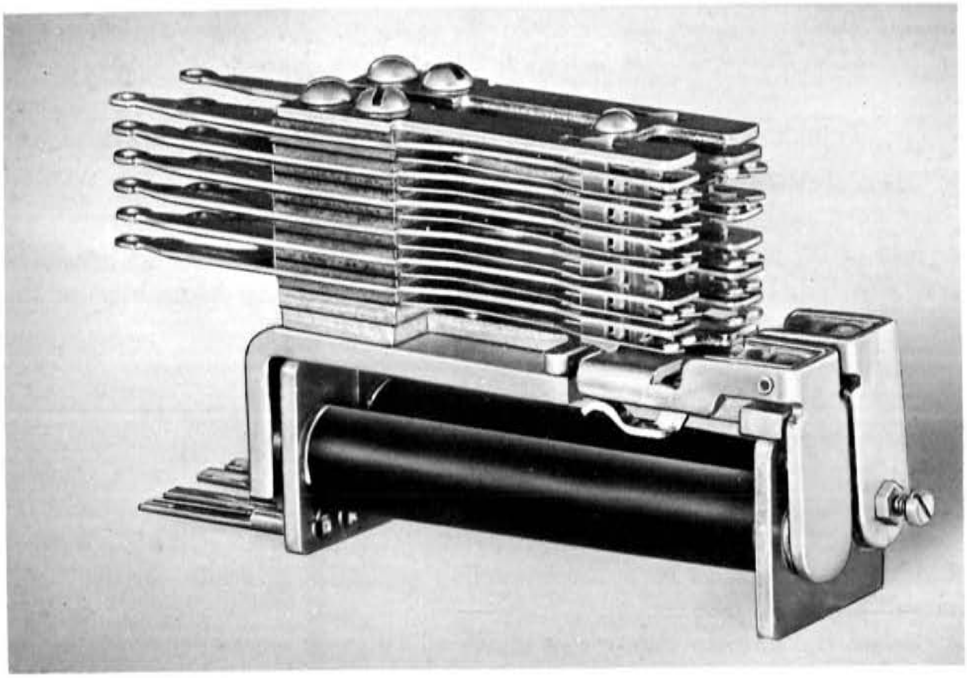


Figure 29. The "C" Type Relay

Adjustment

Adjustment of the Type "C" Relay is carried out in a manner similar to the adjustment of the Type "A" Relay. Mechanical adjustment information is available through the Telecommunication Division Sales Department.

THE ROTARY SWITCH

The rotary switch is found in the Allotter, in inter-office trunking arrangements, and occasionally in other circuits of the XY Dial System. In the Allotter, its function is that of pre-selecting a Linefinder switch so that one will be available for the next call originated. After line finding is completed, the rotary switch disconnects itself from the call and proceeds to the next idle Linefinder. Figure 30 identifies the principal parts of the switch.

Construction

The rotary switch is a unidirectional switch which does not have a "home" or normal position. It has either a 20 or 26-point bank and has a capacity up to 10 levels. It consists of a frame, an electro-magnet, a spring operated rotary mechanism with associated wipers and banks.

When the rotary magnet is energized, it stores energy in the driving mechanism and sets the driving pawl to engage the ratchet teeth of the rotary mechanism. When the magnet is de-energized, it allows the driving pawl to step the rotary mechanism by means of the driving spring. This is called "indirect action." The rotary magnet does not directly drive the rotary mechanism and differs from the minor switch and the XY Universal Switch, which use a direct drive principle.

The wipers are double ended, making contact with either end. The construction of the bank is such that one end or the other of the wipers will at all times engage with a set of bank contacts, the second set of wipers coming into action as the first set leaves the last contact (No. 20 or No. 26) of the bank.

An interrupter spring assembly is provided for "self-stepping" the rotary switch when it is employed in circuits requiring a hunting action.

Adjustments

Information on the adjustment of the rotary switch is compiled on several equipment drawings. These drawings can be obtained on request from the Telecommunication Division Sales Department.

Operating Characteristics

The rotary switch normally runs either self-interrupted or pulse assist. Speeds of operation vary from 60 to 40 steps per second with 48 volts applied to the magnet.

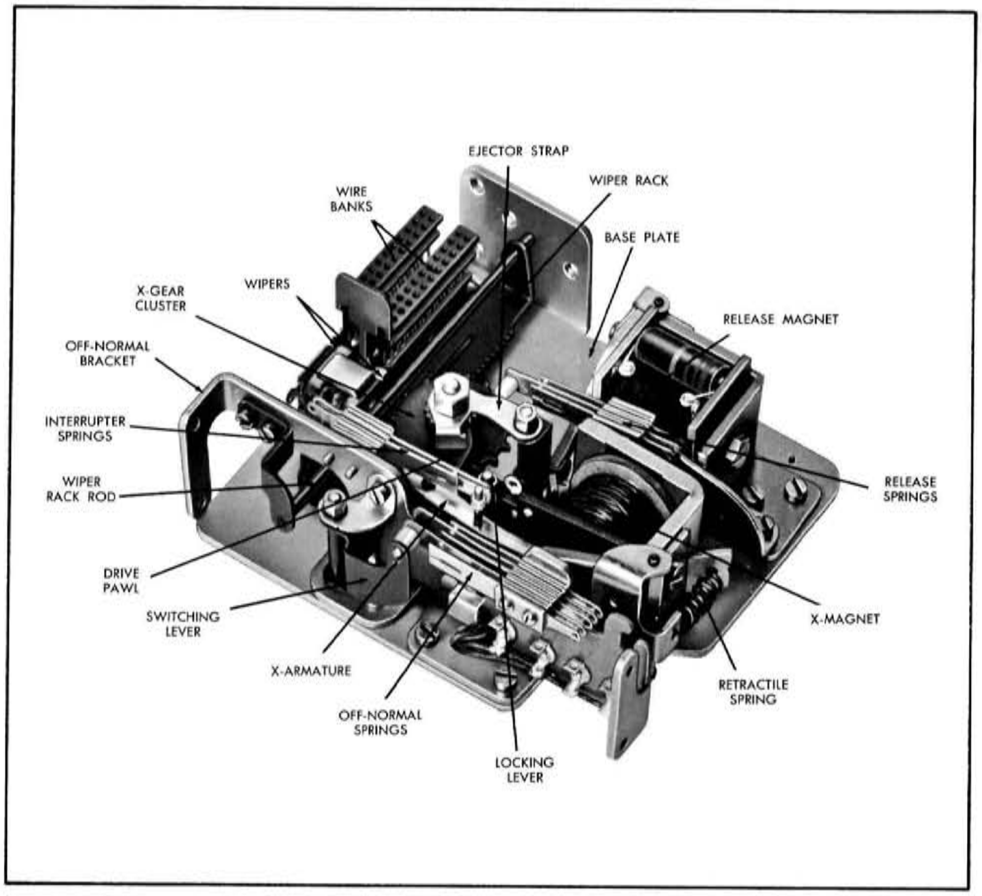


Figure 30. Stromberg-Carlson XY Deca Switch Assembly

XY DECA SWITCH

The XY Deca Switch is a 10-point minor switch. It was designed to function the same as the direct-drive, homing (or reset) type of 10-point stepping switch formerly used.

Based on the time-proven acceptability of the XY Universal Switch, the XY Deca Switch incorporates many of the components and design features of this famous Switch—to name a few: "X" Gear Cluster and Drive Mechanism, Vertical Wire Banks, Birfurcated Wipers, Release Magnet and Mechanism, and Parko-Lubrite finished case-hardened working parts.

THE TELEPHONE

The telephone set consists of a housing, handset, hookswitch, signalling bell, coil capacitor set, and dial.

1553W Wall Telephone

1543W Desk Telephone

1600 Petite Telephone

The functional parts of the transmitter are a carbon chamber with a fixed electrode, a moving electrode attached to a thin metal diaphragm clamped at its edge, and carbon granules which provide an electrical path between the fixed and moving electrodes. The diaphragm converts the sound waves into mechanical motion which, in conjunction with the carbon granules, produces alternating components of current superimposed on the direct current supplied by the office battery.

The functional parts of the receiver are a polarizing magnet, a thin metal diaphragm clamped at its edge, and activating coils. Alternating current passing through the activating coils causes mechanical motion of the diaphragm. The mechanical motion of the diaphragm produces sound waves.

The hookswitch is necessary to connect the transmitter and receiver to the line when the subscriber is making a call and to permit only the ringer to be connected to the line when the telephone set is not being used.

There are various types of ringers used for signalling a subscriber, all based on some form of a polarized ringer. Commonly used types include the untuned type for straight lines and the superimposed, harmonic, synchromonic or decimonic tuned types for multiple party lines. A ringer consists of a coil and magnet assembly, a pivoted armature carrying a clapper rod and clapper and two gongs. These parts are so mounted that the armature vibrates in front of the poles of the coil. The clapper alternately strikes each gong. The tuned ringers require a certain thickness of spring to support the clapper rod so that, in conjunction with properly weighted clappers, the ringer can be tuned to the desired frequency. Ringers are operated in series with a capacitor of proper value.

The Standard Coil and Capacitor set consists of a capacitor, a three winding induction coil, and a second capacitor in series with the ringer. The capacitor mounted within the coil-capacitor unit prevents the flow of direct current through the receiver. The three winding induction coil provides anti-sidetone balance and matches the impedance of telephone set to the impedance of the average line. The "W" type coil-capacitor unit contains the three winding induction coil, an additional capacitor and varistors. This unit is a self compensating network, designed for superior performance under adverse line conditions.

THE DIAL

The dial consists principally of the finger plate, number plate, impulse cam and springs, speed governor and spring mechanism compactly mounted on a suitable mechanism plate.

In operating the dial, the finger plate is turned in a clockwise direction and the distance of travel is governed by the number hole into which the finger has been inserted. In removing the finger from the finger plate, the dial mechanism returns to normal, its speed controlled by the torque of the spring driving mechanism and the regulation of the speed governor. The spring driving mechanism is a helical spring which is "wound up" in turning the dial in a clockwise direction.

Figure 31. Dial Face

The speed governor consists of a shaft to which are attached two wings, each having a friction shoe. The shaft is supported at one end by a governor cup. The speed of the dial on its return to normal is thus controlled by the amount of friction exerted on the inside of the governor cup by the friction shoes. The rotary motion of the shaft causes the wings to fly outward and by the medium of centrifugal force, cause more friction to be exerted as the speed increases. The speed is regulated by adjusting the wings so that they either cause more or less friction with the governor cup.

The impulse cam is operated by the ratchet on the pinion shaft assembly and its speed is controlled by the speed control governor. The impulse springs are operated by the impulse cam, which while revolving as the dial returns to normal, will break and make the spring contacts a number of times corresponding to the figure dialed. The ratchet on the pinion shaft assembly does not operate the impulse springs as the finger plate is rotated in the clockwise direction.

The shunt springs are used to shunt the receiver and transmitter circuits of the telephone while the dial is in an off-normal position. The shunt springs are so controlled that whenever the dial is in an off-normal position they are closed, and when the dial is at normal, they are in an open position.

Adjustment information on the telephone dial is shown in a technical bulletin entitled "Construction and Maintenance of the Stromberg-Carlson® Telephone Dial."

SWITCHING EQUIPMENT

The equipment layout of an XY Dial Office obviously will vary to some extent depending upon the original size, expected future growth and the type of building supplied by the customer. Drawings showing the office layout, cable plan, distributing frame layout, initial grading cross-connections and other items peculiar to the particular office serve to handle this situation.
Considerable standardization has been achieved, however, with respect to the various units which go to make up an office of any size. Whenever possible, standard drawings are used so that individual exchanges in a particular network will vary as little as possible.

The XY Universal Switch is always mounted with the mechanism plate horizontal and the switch magnets on top. The Switch is locked into a "cell" which has the bare wire bank multiple on the rear. The cells are "stacked" vertically so that they completely fill the available mounting space on the shelf even though only a fraction of them are to be equipped with an XY Universal Switch at the time of cutover. The wire bank multiple is made in lengths which occupy the same space as the cells. This arrangement allows an increase in percentage trunking simply by plugging in additional Circuit Plates and XY Universal Switches. No wiring is necessary.

CIRCUIT PLATES

"Circuit Plate" is the name given to the punched cold rolled steel strips which mount the relays and associated equipment for controlling the XY Universal Switch. It is also used to mount relays and associated equipment for trunks and power equipment where no XY Universal Switch is involved. A Circuit Plate is illustrated in Figure 32.

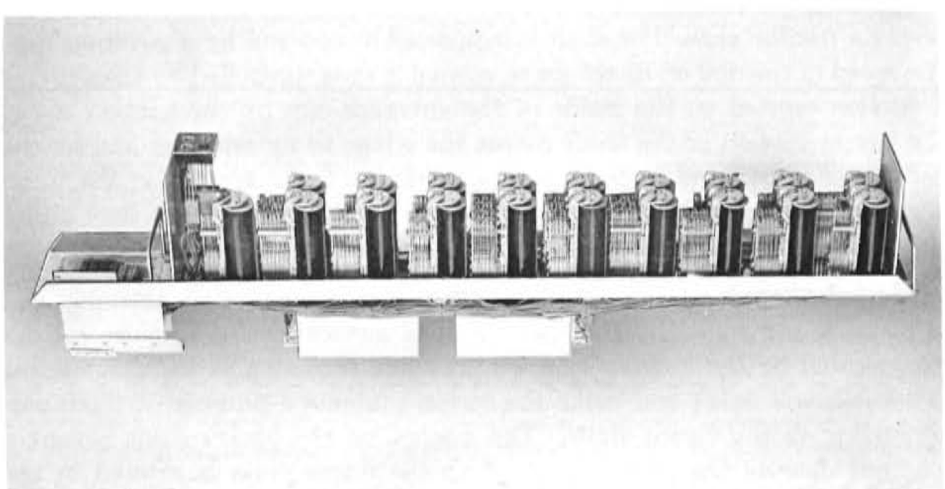


Figure 32. Circuit Plate

The Circuit Plates are manufactured in several lengths and widths to meet the mounting requirements of the various circuits, and ordinarily are equipped with a plug for connecting the Circuit Plates to the shelf, a jack to accept the plug on the XY Universal Switch, and a Make Busy and Test Unit, all at the right hand end of the plate. The Circuit Plate is mounted on the shelf with its major axis horizontal and the relays are mounted on the plate so that the spring surfaces are vertical, thus minimizing the troubles caused by dust on the relay contacts. Each Circuit Plate is equipped with a cover to prevent dust from getting into the relays.

SHELVES (FIG. 33)

The Shelves are iron frames of various sizes which are welded together and precision drilled and tapped to accept the XY Universal Switch cells and Circuit Plates. Identification of the Circuit Plates when mounted on the shelf is accomplished by means of consecutively numbered positions from the top down.

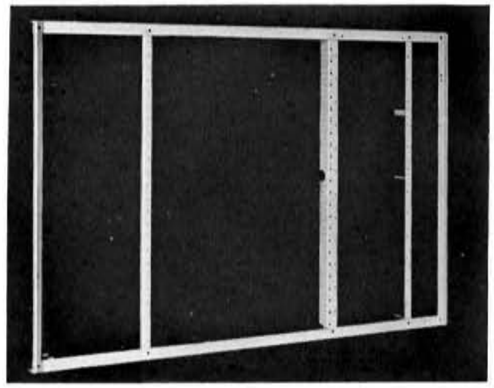


Figure 33. A Typical Shelf Framework

Linefinder and Line Relay Shelf (Fig. 34)

These units mount 100 line circuits either lock-out or non-lock-out and the associated Linefinder relays and switches. These shelf units are normally wired for 14 or 18 Linefinders per shelf and equipped as required to carry the traffic. Lines can be arranged for lock-out in multiples of 5 or 10 lines. The finder switches are in one common group, and any finder may be assigned from either of two Allotters depending on whether the call comes from odd or even level lines. If either Allotter fails, its load is transferred to the other Allotter. This arrangement provides for more even distribution of originating traffic over all finders and associated Selectors in a particular group.

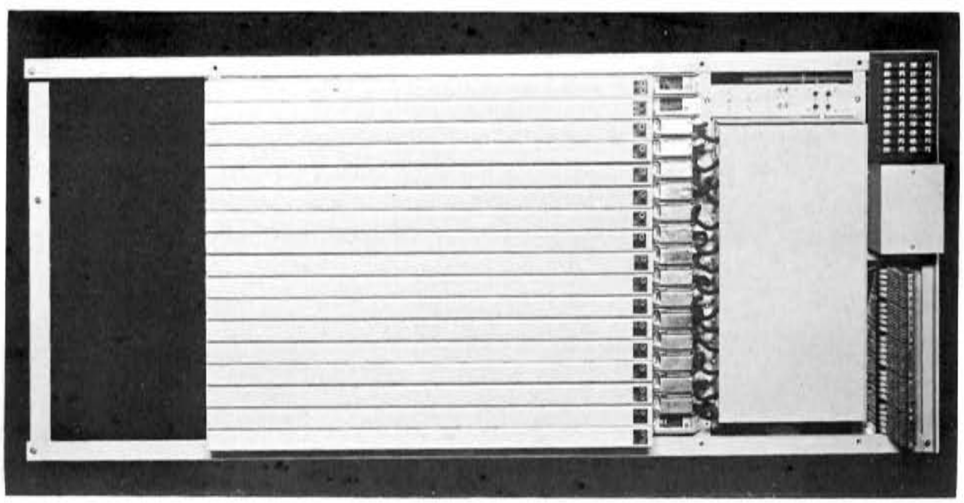


Figure 34. Linefinder and Line Relay Shelf

Selector Shelf (Fig. 35)

These units are normally arranged for mounting 20 Selectors with their associated switches and wire banks. The wire banks are normally split into 2 groups in order to privide flexibility in trunking. On equipment for smaller offices the wire banks will be wired to terminal blocks on the shelf, and on larger installations the wire banks will be wired directly to terminals on the grading bay. There is one grading bay located between two bays of Selectors of the same rank, and serving both. In either case, the Selector shelf will have its own common equipment and be a complete unit. These shelves mount all types of Selectors (local, incoming, or toll). Multiple digit adding selector circuits have been designed for use in XY Dial Offices to provide for 2-5 numbering without the addition of any ranks of Selectors to meet the requirements of nationwide intertoll dialing. These Selectors make use of the XY Universal Switch with its auxiliary wipers and banks used for level marking. Each shelf has its own fuse panel, various timing leads and alarm lamps.

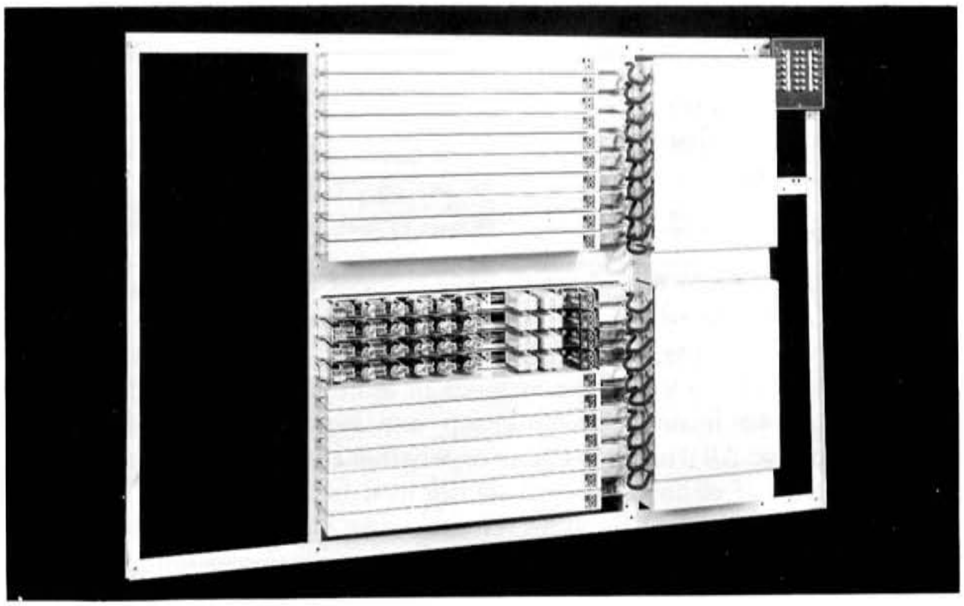


Figure 35. Selector Shelf

Connector Shelf (Fig. 36)

These units are arranged for mounting either 11, 16, or 21 Connectors, one of which is the test Connector. There is space for mounting 10, 15, or 20 local Connectors on a shelf, depending on the trunking requirements. These shelves are also complete units in that each shelf has its own fuse panel, common alarm circuit and alarm lamps. The Connector wire banks are wired to a terminal block mounted on the shelf. The Shelf Supervisory Circuit can be mounted directly beneath the regular Connectors.

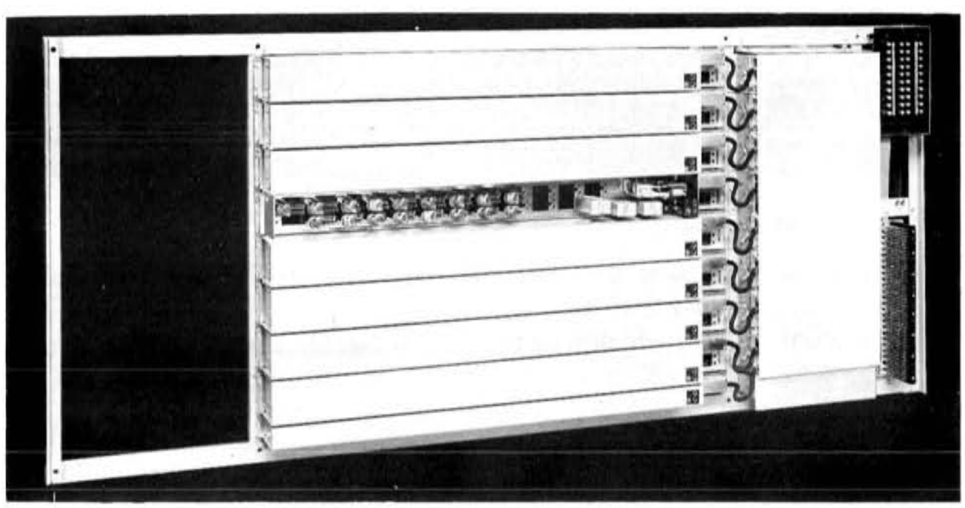


Figure 36. Connector Shelf

Trunk and Other Shelves (Fig. 37)

Trunk circuits, reverting call circuits, and all miscellaneous circuits (pay station, information, intercepting, etc.) not requiring switches will be mounted on trunk shelves. These shelves are made on a standard size, one with a capacity of 20 single wide mounting plates, and the other for 10 double wide mounting plates, and necessary space for supervisory equipment. The number of circuits which will mount on these shelves will depend on the amount of equipment required for each circuit. These shelves are also complete units in that fuses, alarm circuits and alarm lamps, are all individual to each shelf.

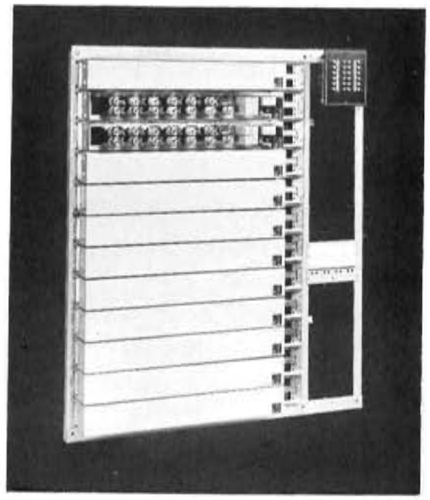


Figure 37. Trunk Shelf

GRADING PANEL (FIG. 38)

When used, the Grading Panel is located between the eight Selector shelves which it serves, and ordinarily will accommodate 16 groups of Selectors. The Grading Panel is mounted on the uprights which mount the Selector shelves which it serves. The panel itself consists simply of individual terminals for each wire from the Selector bank multiples (400 wires per group of Selectors) arranged so that by vertical strapping on the front all Selector groups may be multiplied as required by the amount of equipment in the next switching stage and the traffic. Figure 38 illustrates a typical Selector Shelf Grading Panel assembly.

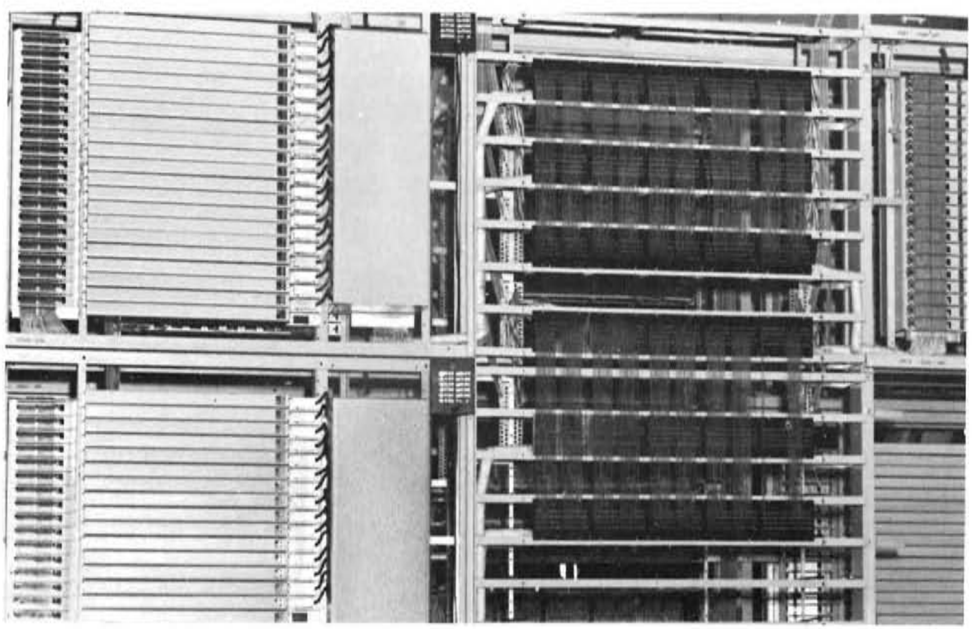


Figure 38. Grading Panel

Interconnection between the outgoing trunk cables and the Selector bank multiples fanned on the Grading Panel is accomplished by jumper wires run on the rear of the panel.

The Grading Panel is mounted only on the front of the bay, and the rear is therefore easily accessible. The Grading Panel described herein is that used for 9-foot high equipment. Grading Panels are also available for 11′6″ equipment.

SHELF DESIGNATION CARDS

Each shelf in an XY Dial Exchange has a shelf designation card. This card shows the physical path to and from all the circuits on the shelf, and the abbreviated notations on the card indicate particular circuits, rows and shelves that the various leads terminate on. It is of prime importance to the maintenance man to be able to follow the physical circuitry from a certain circuit plate, so that he can readily locate and correct physical faults in the exchange.

BAY FRAMEWORKS

Each bay accommodates four shelves, two on the front and two on the rear, identified for 9′ equipment as follows:

Shelf A—Top Front
Shelf B—Top Rear
Shelf C—Bottom Front
Shelf D—Bottom Rear
When 11′6″ equipment is supplied the shelf identification is similar to that for 9′ equipment with the bottom two shelves designated E and F.

All bay frameworks are equipped with a terminal block and toggle switches located at the top center for the purpose of terminating the signal leads and turning off the signals to the bay respectively.

Except for the horizontal length, the bay frameworks are practically identical. The Linefinder and Connector bays are 9′ or 11′6″ high by 6′ wide, the Selector bay 9′ or 11′6″ high by 5′1″ wide, and the Trunk bay 9′ or 11′6″ high by 3′ wide. All bays are 1′4″ deep measured at the guard rail which is mounted approximately 6″ from the floor in front and rear, and which serves to protect the equipment. At the end of a row of bays an end guard rail is located which continues the guard rail so that it completely encircles the equipment.

Where the switching room will allow, 11′6″ high bay frames, which will mount six shelves, may be used. Considerable saving in floor space requirements will result from using this type of bay. Except for height and number of shelves mounted, there is no essential difference between the 11′6″ and the 9′ bays.

SUPERSTRUCTURE AND CABLE RACKS

The bay frameworks are supported at the top by the superstructure which consists of channel iron run at right angles to the direction taken by the row of bay frameworks. Each framework is secured to the superstructure by "J" bolts which also are used to mount the cable runways on the top of the superstructure. The superstructure is supported either from the ceiling or walls of the equipment room.

CABLING

Cables are run on cable runways mounted on the superstructure and are formed down to the bays from the runways. Cables are secured to the runways by lacing cord or clamps.

Power Cables

The Battery lead is run in insulated cable of size adequate for the exchange along the cable rack. "T" taps are used to multiple the battery to the bays where additional "T" taps multiple it to the shelves on the bay. The ground lead is bare wire and is tapped and multipled the same as the battery lead.

Signal Cables

The signal cables are terminated on terminal blocks at the top of the bay and are multipled to the shelves from the terminal block. Ordinary telephone cables are used for the majority of these leads.

Trunk Cables

The trunk cables are brought to the tops of the individual shelves and are butted and fanned to the shelf jacks. All cables are run on the bay down to the shelves.

MAIN DISTRIBUTING FRAME

Each telephone in a system must be associated with Line Circuit equipment and must be accessible from the banks of the Connectors.

The outside telephone lines are carried into the telephone plant in lead-covered cables and terminated on the Main Distributing Frame (MDF). The switchboard Line Circuits are brought from the switching equipment in braid-covered cables which also terminate on the MDF. Connections of the outside telephone lines to the switchboard Line Circuits are made by means of relatively short lengths of paired wires, called jumpers. If it becomes necessary due to traffic or for other reasons to dissociate one circuit from another and make a new connection, a jumper change can readily be made (Fig. 39).

The MDF can be arranged for protectors directly connected to the switchboard Line Circuits (Type A equipment) or directly associated with the outside cable pairs (Type B equipment). Protectors include not only carbon blocks for protection against lightning and high tension exposure, but also heat coils for protection against abnormal current conditions (Fig. 40).

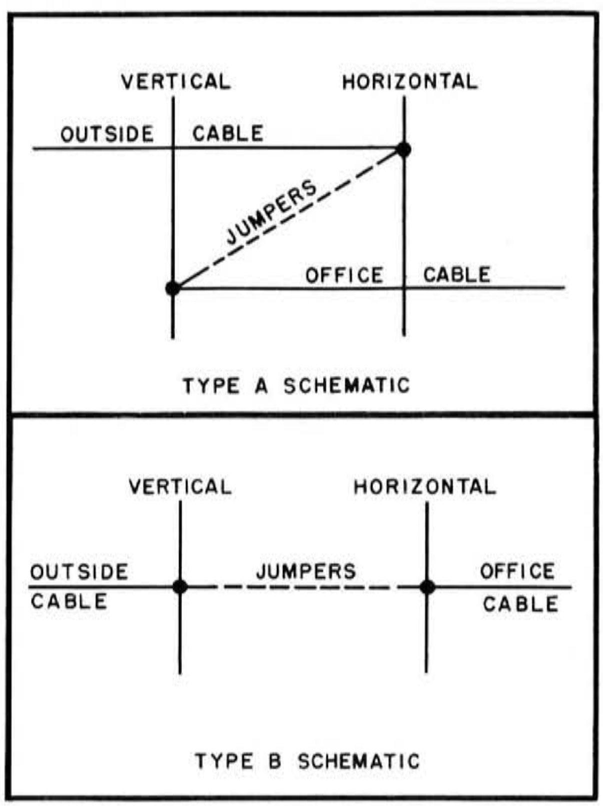


Figure 39. Main Distributing Frame

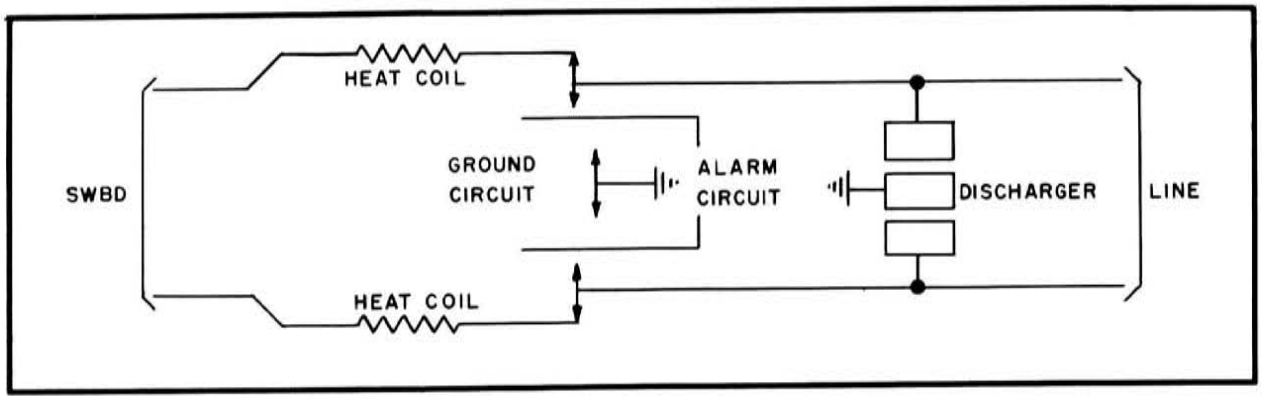


Figure 40. Schematic-Protector Circuit

Framework (Fig. 41)

The MDF is an open metal framework, extending at right angles in three directions. Its vertical, longitudinal and lateral members form vertical and horizontal runways for jumpers. The assembled frame, consisting of verticals (uprights), miscellaneous hardware, protectors, fanning strips, and terminal boards, is located in the central office in a position which permits convenient cabling to the outside plant and to the switchboard equipment.

The vertical members mount the protectors and associated fanning strip. If a Type A frame is used, the switchboard Line Circuits are cabled directly to these protectors; if a Type B frame is used, the outside cable pairs are directly cabled to the protectors.

The longitudinal members mount the terminal boards, consisting of a terminal block and associated fanning strip. If a Type A frame is used, the outside cable pairs are cabled to these horizontal terminal boards; if a Type B frame is used, the switchboard circuits are cabled directly to these terminal boards.

Jumper rings are fastened to the horizontal side of each vertical angle, in line with the channel crossarms. These rings serve to guide the jumpers where they make sharp changes in direction, and have an insulated cover to protect the jumper wire insulation.

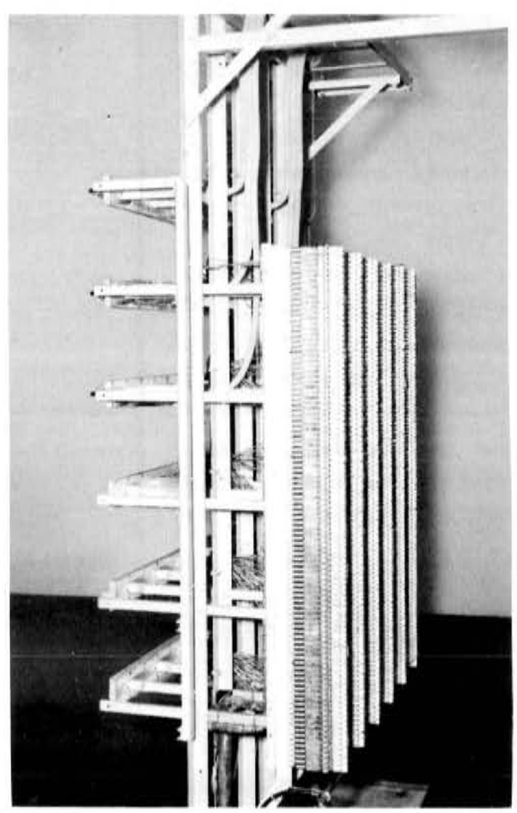


Figure 41. Typical MDF Employed in a CDO

Telltale Lamp

A telltale lamp assembly is fastened at the top of the fanning strip on each vertical member. One side of each lamp is connected to negative battery and the other side to the alarm terminal of the protectors. When a heat coil operates, a circuit is closed to ground at the inside alarm spring which has pressed against the grounded mounted plate. This lights the telltale lamp to indicate that a heat coil has "blown".

Test Shoe (Fig. 42)

The test shoe is rectangular metal framework, housing six insulated springs, three on each side, which mate with six of the springs on a protector pair. The test shoe must be inserted with the words "Up" or "Right" on top.

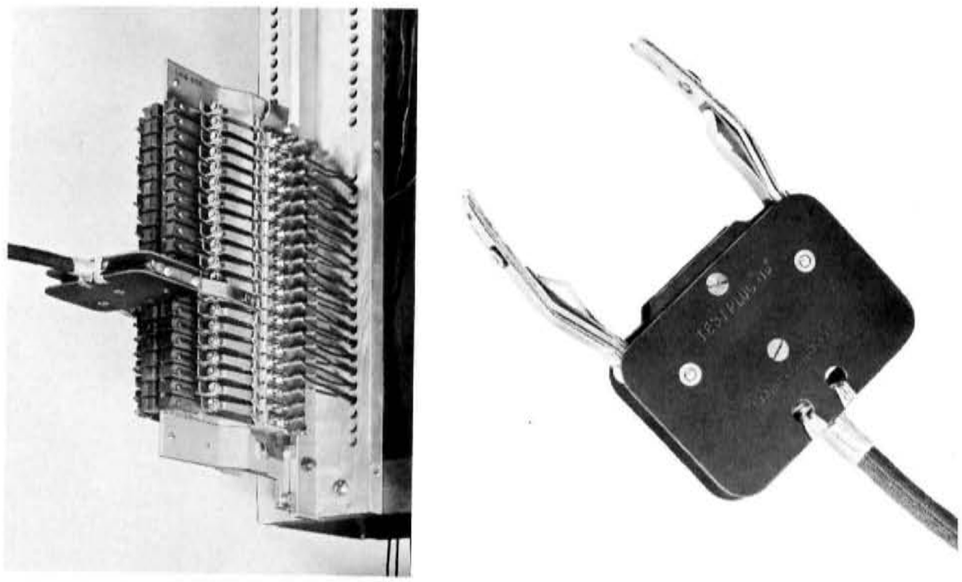


Figure 42. The Test Shoe

The six leads from the test shoe terminate in the test desk, or test equipment, and are designated Tip-in, Ring-in, Tip-out, Ring-out, Heat Coil Tip, Heat Coil Ring. When the test shoe is inserted in a protector pair it connects the test equipment into the line so that monitoring and testing can be accomplished on the outside line or the switchboard line, with these lines disassociated from one another. Insertion of the test shoe does not affect the heat coils, and testing can be accomplished either through or around the coils.

The test shoe provides a rapid means to test the complete exchange lines, outside or inside, without disturbing any solder connections.

POWER, RINGING AND SUPERVISORY EQUIPMENT

GENERAL The batteries, battery charging devices and power board comprise the equipment necessary to provide power for the XY Dial System. The ringing equipment consists of a suitable ringing unit for the type of ringing employed in the

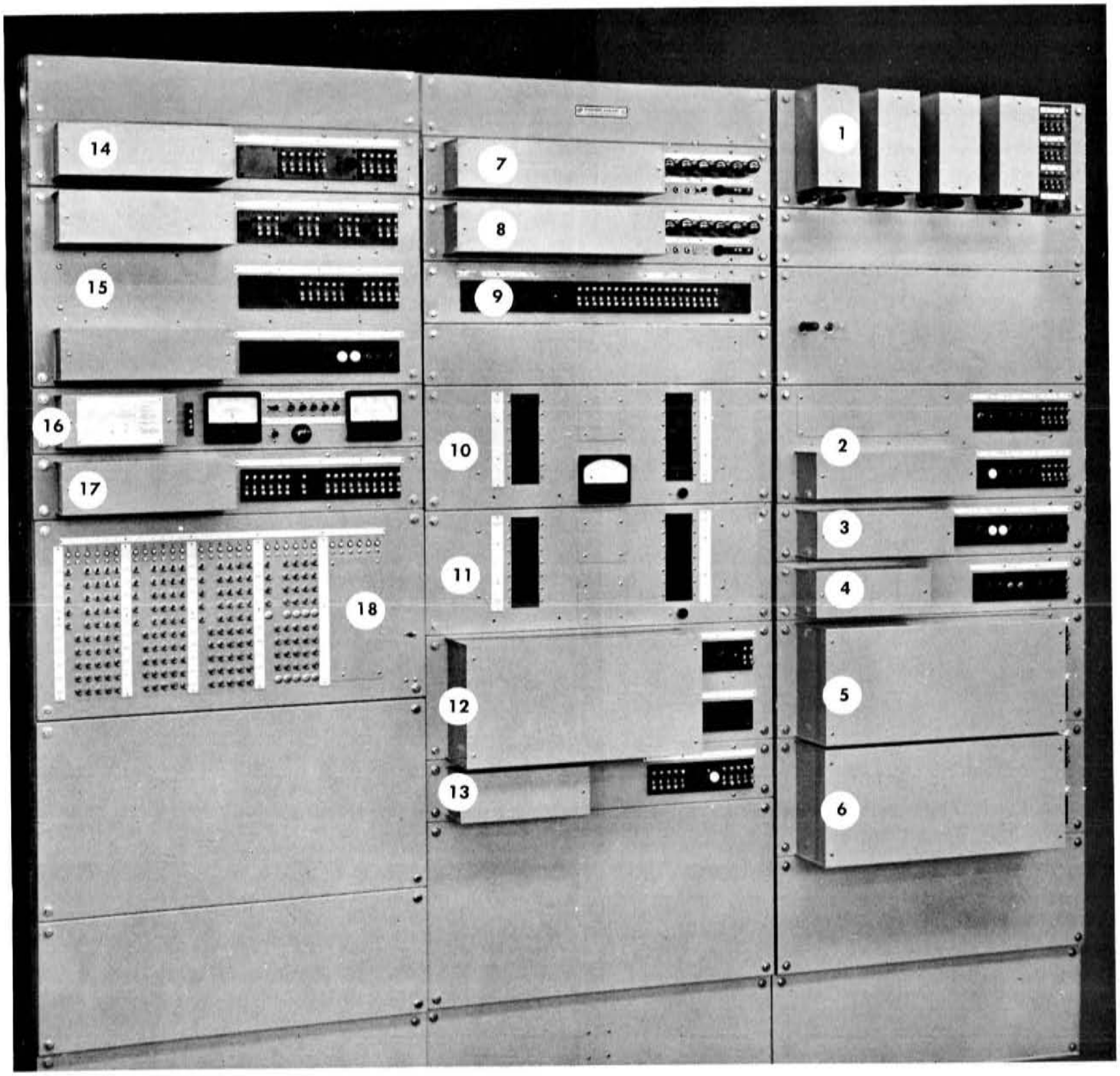


Figure 43. A Typical Power and Supervisory Panel

LEGEND

1. Group Supervisory Panel
2. Common Supervisory Panel
3. Miscellaneous Supervisory Panel
4. Mark & Common Alarm Panel
5. A-C Interrupter Control and Machine
6. D-C Interrupter Control and Machine
7. #1 Tone Generator Panel
8. #2 Tone Generator Panel
9. P.B.X. Ringing Panel
10. Battery Distribution Panel
11. Battery Distribution Panel
12. Vibrator Panel
13. Coin Control Panel
14. Ring & Relay Panel
15. Ringing Control Panel
16. Frequency Indicator Panel
17. Ring & Relay Panel
18. Frequency Marking Panel

office, and a standby ringing unit to be used in case of commercial power failure. Ringing equipment is usually mounted on the power board (Fig. 43).

The supervisory (alarm) equipment is closely associated with the power and ringing equipment and is generally incorporated in the power board. It is easily understood that the power board, and its associated components, form the control center for the entire XY Dial System. From the power board the general condition of the system is apparent.

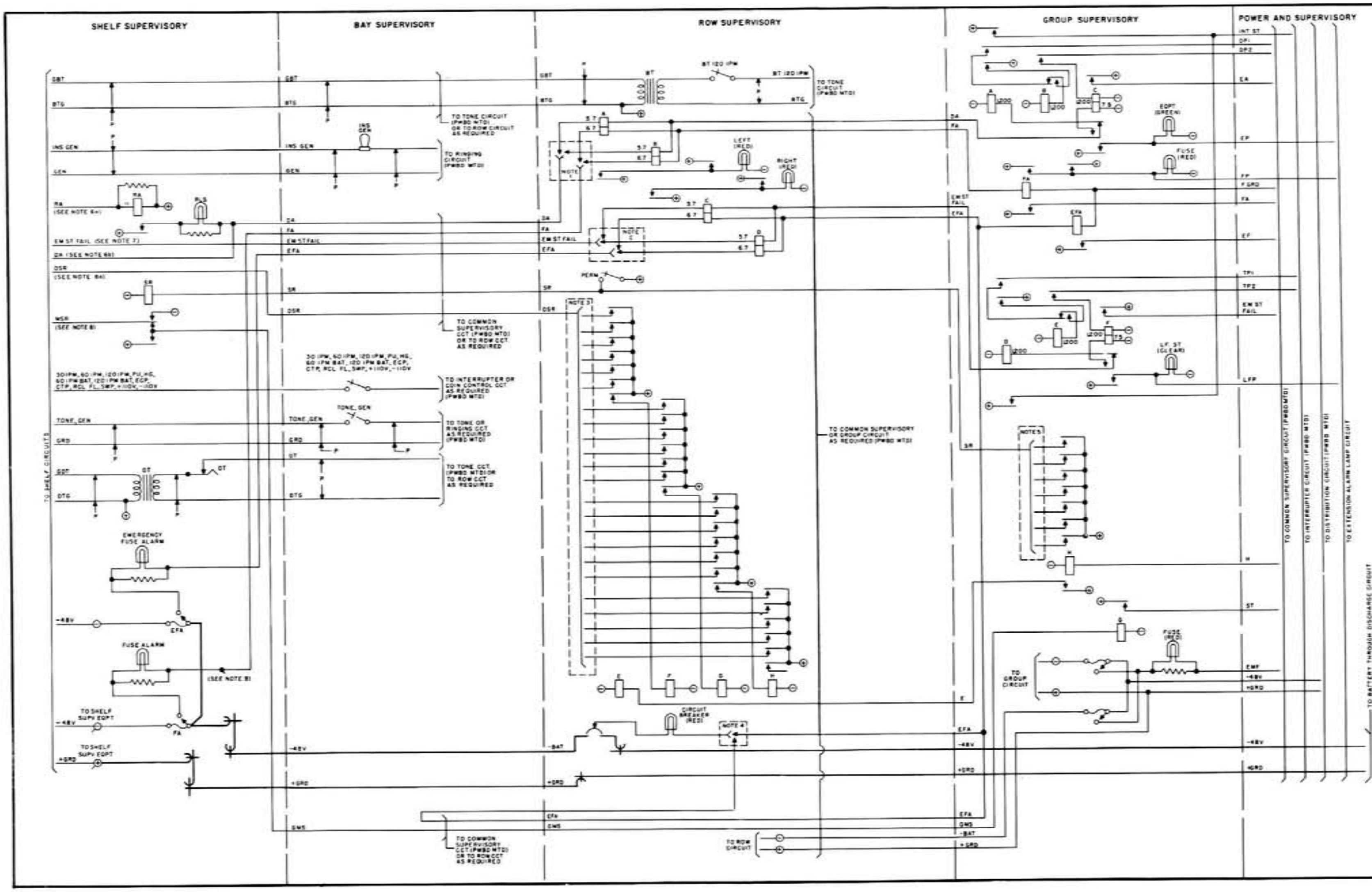
OFFICE BATTERIES

There are numerous types of batteries which are specifically designed for use in the telephone exchange. These batteries are continually being improved in their characteristics of life, size, and power output. Batteries used in the telephone exchange may be of various types, i.e. Planté, Manchester, lead calcium, and lead antimony. Each of these types of batteries have their own inherent advantages, and the selection of the batteries is dependent on the particular exchange application. There are several arrangements of batteries which will provide the proper office voltage and regulate the reserve capacity of the batteries when they must provide the entire power for exchange operation.

Use of a 23 cell battery, with sufficient ampere-hour capacity to give the desired number of hours reserve in case of charging unit failure, may be the solution for one exchange problem. This battery is "floated" at approximately 49.45 (lead antimony) and 49.91 (lead calcium) volts across the charging unit, and this "float" voltage is the working voltage of the exchange. The use of a single counter electro-motive force (C.E.M.F.) cell with a 24 cell battery provides for the use of smaller capacity batteries which will still give the required number of hours of reserve power. The C.E.M.F. cell is a means of lowering the voltage from the 24 cells by approximately 2½ volts across its terminals. This approximate 2½ volt drop, in the discharge lead to the exchange equipment, lowers the normal battery voltage from 51.60 volts (lead antimony) to approximately 49.10 volts, 52.08 volts (lead calcium) to 49.58 volts. The charging unit is set to "float" the 24 cell battery at approximately 51.60 volts (lead antimony) and 52.08 volts (lead calcium). It should be understood that the C.E.M.F. cell is not a power generating cell such as a standard cell, it is a means of lowering the voltage by approximately 2½ volts. (It should also be noted that the voltage drop increases as the cell ages.) The combination of a 23 cell battery, with three end cells, is also used to provide exchange voltage. The 23 cell battery is "floated" at approximately 49.45 volts (lead antimony) and 49.91 volts (lead calcium) across the charging unit. If the voltage drops to a predetermined value, the three end cells are automatically put in series with the regular 23 cells, providing an increase of office voltage during the emergency period. The normal operating voltage for the XY Dial System is between 48 and 52 volts.

BATTERY CHARGING UNITS

The battery charging units are set to maintain a constant voltage output of approximately 49.45 volts (lead antimony) and 49.91 volts (lead calcium) for a 23 cell battery and approximately 51.60 volts (lead antimony) and 52.08 volts (lead calcium) for a 24 cell battery. The voltage output from the charger will "float" the battery sufficiently to compensate for internal losses, prevent sulphation, and maintain the specific gravity at the proper level. Thus the



NOTES:

1. DA and FA leads shall be connected to the A and B relays depending upon which side of the bay an alarm originates from.
2. EM ST FAIL and EFA leads shall be connected to the C and D relays depending upon which side of the bay the alarm originates from.
3. Connect each DSR lead to not more than one shelf if the E, F, G and H relays serve 24 shelves or less. When the E, F, G, and H relays serve more than 24 shelves connect each DSR lead to not more than two shelves.
4. EFA lead shall be connected through bay supervisory terminal block when no row supervisory equipment is used. When Row Supervisory equipment is used connect EFA lead through Row Supervisory terminal block.
5. Connect each SR lead to one row of bays end to end.
6. (a) −BAT is placed on the "RA" lead from the shelf circuits when all relays in the Linefinders, Selectors, or Connectors are normal and the XY Universal Switch is off-normal in either the "X" or "Y" direction and in the case of Connectors when the minor switch is off-normal.
   (b) +GRD is placed on the "DA" lead when the "AS" relay or the "busy and test" key in the Allotter is operated. (This also illuminates the "transfer" lamp of the Allotter.)
7. +GRD is placed on the "EM ST FAIL" lead from the Allotter when the "TST" key in the Allotter is not operated and the "SA" relay is operated. (This also illuminates the "EM ST FAIL" lamp of the Allotter.)
8. +GRD is placed on the "MSR" lead from the shelf circuits under the following conditions:
   (a) When a shelf circuit is in the "talking" condition, +GRD from within the shelf circuit or, from the "DSR" lead through the shelf circuit, illuminates the "MON" lamp in series with a resistance causing a steady dim "MON" lamp indication when the "PERM" switch is operated.
   (b) When a Selector is in a "permanent" condition or when a Connector or trunk is held by one party, +GRD within the shelf circuit illuminates the "MON" lamp in the shelf giving a steady bright "MON" lamp indication when. the "SR" switch in common supervisory is operated.
9. When both the "A" and "B" Allotter fuses have blown, −BAT is placed on the "EFA" lead through the shelf supervisory of the Allotter.

Figure 44. Schematic-Supervisory Circuit

battery is kept in full readiness to provide current to supply the entire exchange load for a predetermined time interval in case of commercial power failure. It is customary in large exchanges to have an auxiliary generator to provide power for the charging units, in case of long range commercial power failure.

The charging unit is usually a constant voltage, variable current device, which automatically maintains the operating voltages within rather close limits. These chargers usually are the dry-disk rectifier type and they can be obtained in small or large ampere capacities. Automatic coupling of several units may be accomplished to meet peak load demands.

POWER PANEL

The power panel provides ammeters which indicate the charge and discharge current of the office battery, a voltmeter to indicate the exchange voltage, circuit breakers in the principal charge and discharge leads, and alarm type fuses for certain groups of equipment.

SUPERVISORY AND ALARM EQUIPMENT

The exchange equipment is provided with numerous alarms to indicate any condition that is abnormal in the equipment. The alarm circuits are designed to indicate with audible and/or visual signals the type of fault and its general location. Relays on the power board, or the equipment shelves operate, in conjunction with the alarm circuits, to provide the alarms. The size of the exchange defines the complexity of the alarm system. Figure 44 is a general breakdown of the supervisory circuitry and gives the general scheme of various types of alarms and how they appear on the supervisory equipment. Special fuses are used in the equipment, which complete an external circuit and will open the circuit on overload. These fuses, known as indicator-alarm fuses, are usually supplied in 1⅓, 3, and 5 ampere ratings. In circuits requiring higher current ratings, alarm type circuit breakers are used, these breakers are of the magnetic type.

RINGING TONE, AND INTERRUPTER EQUIPMENT

Various types of ringing equipment are provided to generate ringing and tone voltages. The interruption of these voltages, and of the various pulses and tones necessary for exchange operation, is accomplished by the motor driven interrupting machine. (Fig. 45)

Multifrequency Ringing.

a. *Vibrator type converters.* Vibrating-type ringing converters are sometimes used as a source of ringing voltages required for exchanges equipped with multifrequency ringing. The converter sets are generally comprised of 5 vibrators, either the "Harmonic" type with frequencies of 33⅓, 50, 66⅔, 16⅔ and 25 cycles, or the non-multiple frequencies, "syncromonic type" with frequencies of 30, 42, 54, 66 and 20 or 16 cycles or the decimonic type of 30, 40, 50, 60, or 20, cycles. These sets are often in duplicate with automatic transfer in case of failure of one set.

b. *Static-type converters.* This is a frequency generator which operates from commercial 60 cycle power, and by means of "tuned circuits" produces the various ringing frequencies, usually in the "decimonic type", of 30, 40, 50, 60, and 20 cycles, however all types of ringing frequencies may be produced by this equipment. It is standard practice to provide a set of battery driven vibrators to produce the ringing frequencies when commercial power fails for the static-type converters.

c. *Motor-generator sets.* Motor-generator sets are available for use in large multifrequency exchanges. The motor-generator is frequently the type of frequency generator which can meet the ringing load demands of such offices. These sets can furnish multiple, non-multiple, or decimonic type ringing, and are usually installed in pairs, with the number one machine operating from commercial power, and the standby machine from the exchange battery.

Single Frequency Ringing The frequency used in a single frequency exchange is usually 20 cycles. These exchanges usually use a static-converter operating from commercial power, with a standby vibrator operating from the exchange batteries. Motor-generators are also used in offices requiring single frequency ringing voltages. These sets may be used either as normal or standby equipment for static-converters.

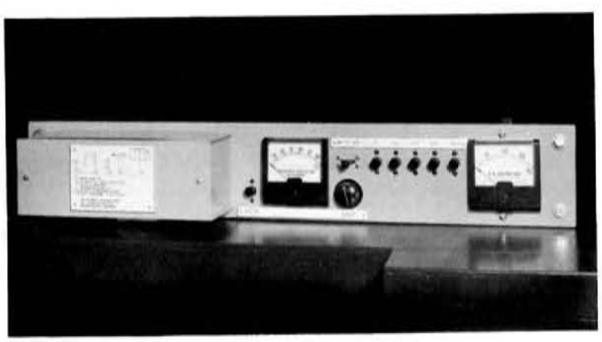
Superimposed Ringing The polarity of the ringing voltage, on the tip or ring lead, can be used for selective ringing. Each telephone instrument is so equipped that only a certain polarity on the correct lead will energize the ringer coil. This ringing scheme provides for selective ringing of four parties, or using a code, semi-selective ringing of eight parties.

Tone Equipment Tone voltages for dial and busy tones are generated by a vacuum-tube oscillator with individual amplifiers for each tone. Standard radio tubes are used, and are operated from the exchange battery. Duplicate tone equipment may be furnished when desired.

Interrupter Equipment A.C. or D.C. motor driven, cam type interrupter equipment is generally used. If provided in duplicate, the number one machine is operated from commercial power, and the standby machine from the exchange battery. If only one machine is provided it is operated from the exchange battery.

The interrupter provides the proper ringing periods or codes (when code ringing is employed), the proper periods for busy tone, and the proper pulse and time delay leads necessary for supervisory and alarm circuits.

The equipment discussed in this section is located, with associated relays, on the main power supervisory panel and is readily located on Figure 43. The power board and its components are, by necessity shipped as a complete unit. This unit is specifically designed for the individual exchange requirements. For more information contact the Telecommunication Division Sales Department.



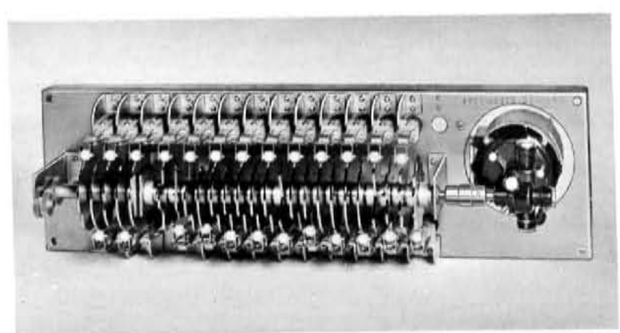


Figure 45.

The Stromberg-Carlson Frequency Meter is a self-contained unit offering a new and much simpler way to test line frequencies. It can be built into any standard power board.

The Stromberg-Carlson Interrupter Machine has completely interchangeable parts, including an A.C., or D.C. motor, two-speed shaft, and demountable snap action switches.

OPERATING FEATURES OF THE XY DIAL SYSTEM

While all step-by-step telephone systems operate on the same general principles, there are numerous items which may make a particular system outstanding. Included in these are the following:

- First Cost
- Space Requirements
- Expected Life
- Ease of Installation
- Ease of Expansion and Change
- Maintenance Cost and Ease of Maintenance
- Cost of Operation
- Circuit Operating Features

This section gives in outline the features of the XY Dial System with particular regard to the above list.

FIRST COST

The XY Dial System is competitive in price. The many extra features contained therein have been obtained by skillful design and efficient manufacturing practices.

SPACE REQUIREMENTS (FIG. 46)

As a result of its complete "plug in" design, it is possible to mount switching circuits on both the front and rear of the bays. This method of mounting reduces floor space requirements considerably.

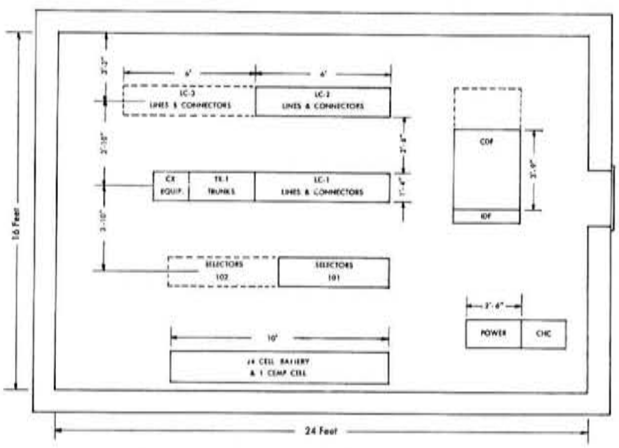


Figure 46. Typical Medium Size Exchange

The plan, (Fig. 46), of an existing XY Dial exchange may be a suggestion for any installation of up to six hundred lines capacity. Little more floor space would be required to add the equipment for another four hundred lines.

EXPECTED LIFE

XY Dial Systems are designed to provide a minimum of 30 years of excellent dial telephone service. (See also the sections entitled INTRODUCTION, HISTORY and COMPONENTS OF THE XY DIAL SYSTEM).

EASE OF INSTALLATION

The largest and heaviest unit which must be handled in the process of installation is the unequipped shelf, which generally is light enough to be lifted by one man. The bays and power equipment are shipped as units. Switches and circuit plates are packaged individually in corrugated cardboard cartons. Several complete sets of drawings accompany the equipment when it is shipped.

EXPANSION AND CHANGE

Large Group Additions to Existing Equipment

XY Dial Offices are designed with a view to the ultimate size. The original floor plan drawings generally indicate the proposed layout of additional groups of 100 lines, which may be quickly installed as needed.

Small Additions to Existing Equipment

All shelves are designed to accommodate the maximum number of units ever needed, and are equipped as required for the initial traffic. Should changes in traffic occur, the additional Switches and Circuit Plates may be plugged in without additional wiring; or individual Switches and Circuit Plates may be moved from one location to another quickly and without any change whatsoever.

Selector Bank Terminal Assembly

The Selector Bank Terminal Assembly is designed to enable one man to run the jumpers when making additions or changes. Changes in grading of Selector banks may be made in the usual manner.

XY Universal Switch

The XY Universal Switch may be plugged in as a Linefinder, Selector, or Connector without modification.

Intermediate Distributing Frames

Intermediate Distributing Frames and Trunk Distributing Frames are used as required so that jumper changes may be made in a convenient manner.

Power Board

The Power Board is built up on unistrut framework, with standard self-contained units. Additions or changes may be made by replacing the blank panels with panels mounting the additional equipment in any desired combination. With the exception of the bus-bars, all wiring is terminated on terminal blocks mounted on the individual panels.

MAINTENANCE COST AND EASE OF MAINTENANCE

Recommended maintenance practices are outlined in a separate bulletin entitled "XY DIAL SYSTEMS, BASIC MAINTENANCE PRACTICES", obtainable from the Telecommunication Division Sales Department.

Alarms

The general alarm system used in an XY Dial Office consists of distinct fuse and equipment alarms classified as major and minor alarms. The alarms usually are indicated in several places in addition to the audible alarm; on the defective equipment, shelf or row, and also on the Group and Common Supervisory equipment. The Group Supervisory equipment is usually located at the end of a row of bays. The Common Supervisory equipment is part of the Power Panel.

The audible alarm may be switched off before the alarm condition is cleared. The visual alarms are self-restoring when cleared.

Extention alarms are provided for if required. Figure 44 shows the general alarm circuitry used in an XY Dial Exchange. The size of the exchange dictates the alarms used, and the techniques by which they are located. On the figure, the dotted lines between the supervisory titles indicates the separation between circuits. For example, a 300 line exchange might require only a shelf, Bay and Group Supervisory alarms, while a larger exchange (approximately 1,000 lines) may require the addition of Row and Common Supervisory equipment. These values are used only as an example, and show only the manner in which the alarm circuitry is applied.

The notes, and the figures indicate what happens when certain conditions occur within the exchange.

Monitoring Service (Bright-Dim Supervision)

Each switching Circuit Plate (except the Linefinder) is equipped with a lamp which glows bright when the circuit is seized or locked by a "permanent". If a call is completed and conversation is in progress, through the circuit, the lamp glows dimly. When the circuit is idle, the lamp is out. The lamp signals do not function until a key on the power board is thrown.

Each Circuit Plate also is provided with a monitoring jack, for audible monitoring of the circuit with a hand test telephone.

Test Facilities

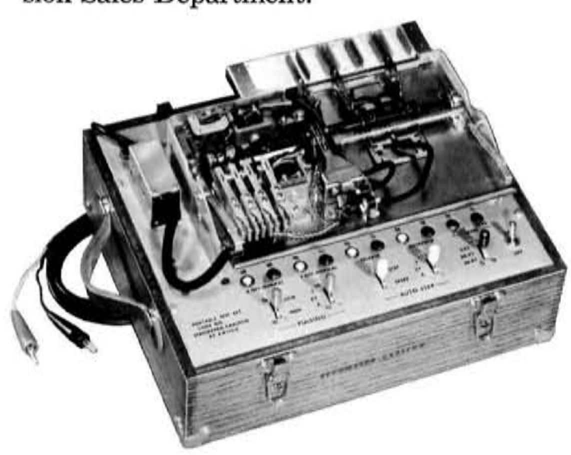
Each switching Circuit Plate is equipped with a "Make Busy and Test" jack. The circuits may be routined and tested by plugging the proper test equipment into the jack. The testing equipment for an XY Dial Exchange can be divided into two groups. The first section applies to stationary circuits which automatically routine or check various exchange conditions.

The second section refers to portable equipment which can be used to test small components of the system, such as the XY Universal Switch, or the relays within a certain circuit.

Some stationary testing circuits, are: Wire Chief Test Set, testing position circuits, and various routining circuits. The portable testing equipment includes the XY Universal Switch Test Box, Current Flow Test Set (for relay adjustment), Circuit Plate Test Box, Hand Test Telephone, Pulsing Limits Test Set, Portable Voltage and frequency meter, and the Speed and Percent Make Meter.

Each item of the test equipment referred to is a unit within itself and information on the various units may be obtained from the Telecommunication Division Sales Department.

XY Universal Switch and Wire Bank



As pointed out previously, the XY Universal Switch may be removed as a unit and tested to standard conditions in the "XY Universal Switch Test Set" (Fig. 47). While one Switch is being serviced, another may be substituted, thus maintaining the grade of service originally supplied.

Figure 47. No. 10B Portable XY Universal Switch Test Set

The wipers of the XY Universal Switch and associated wire banks need not be replaced due to wear during the life of the exchange. The banks do not require oiling at any time. Generally speaking, the vertical position of the banks eliminates the need for cleaning.

The XY Universal Switch is a 100 point, basically simple device, which is easy to maintain because of its simplicity and reliability.

The Switch is equipped with visual indicators which show the steps to which the Switch has been pulsed when it is in the off-normal position.

Refer to the sections entitled HISTORY and COMPONENTS OF THE XY DIAL SYSTEM for a more complete description of the XY Universal Switch and wire banks.

Type "A" Relay

The features of the Type "A" Relay are also given in the section entitled COMPONENTS OF THE XY DIAL SYSTEM.

COST OF OPERATION

From the standpoint of current drain, the cost of operation of the XY Dial System is approximately the same as that of other step-by-step systems.

CIRCUIT OPERATING FEATURES

The list of circuit operating features which follows is not a complete list of all features available. The differing requirements of operating companies and new advances in the science of telephony cause this list to be expanded constantly.

It is therefore not possible to maintain a completely up to date list in a publication of this kind. Generally speaking, it is possible to design circuits to accommodate any reasonable operating requirement.

Line Circuit, Linefinder, and Dual Allotter Operation

The Linefinder Allotter shelf is the first unit of switching equipment to function when a subscriber originates a call. The Linefinder action takes place between the time the subscriber lifts the handset and the moment at which the subscriber receives dial tone. The shelf consists of the shelf supervisory circuit, 100 line circuits, a maximum of 14 or 18 Linefinders, and two control circuits, called Allotters, which allot each idle Linefinder in rotation to find a calling line in the 100-line group. The wipers of each Linefinder are wired thru the switchthrough relay of the Linefinder circuit to a first Selector which is individually associated with the Linefinder.

Description of Normal Operation. Normally, each Allotter serves only half of the lines in the 100-line group. Allotter "A" serves lines on the odd-numbered levels and Allotter "B" serves lines on the even numbered levels. The purpose of this division is to reduce the delay in finding calls on the higher-numbered levels which might occur during periods of heavy traffic, since the Linefinders always stop on the lowest-numbered calling line which the wipers meet. It also permits two Linefinders to search simultaneously when calls are originated in both odd and even level groups. Each Allotter has access to all the Linefinders on the shelf through a 20-position rotary switch. Between Allotters A & B the wiring of Linefinders to the rotary switch banks is reversed, so that the rotary switches hunt over the Linefinders in opposite directions when searching for an idle Linefinder. The Allotter rotary switches have eight levels, one for each of the eight leads necessary for control of a Linefinder while it is finding a line, and each Allotter pre-selects an idle Linefinder as soon as the Linefinder on which it was standing has been stepped to a calling line, except when all Linefinders become busy.

When a subscriber lifts the handset to originate a call, the line relay operates. The line relay provides a start signal to the Allotter on the AST Lead, it marks the XX or X bank level corresponding to the line level with ground, and marks the line position on that level with battery through the cut-off relay of the line circuit to the S-bank contact. The line relay marks the line busy to the Connectors by a ground on the SN lead to the Connector banks.

The start relay of the preselected Linefinder operates and the Linefinder begins to step in the X direction. At the same time, its associated Selector is pre-seized by a resistor across the T & R leads in the Linefinder, so that the Selector will be ready to dial as soon as the Linefinder switches through to it.

The Linefinder X stepping is controlled by a pulse assist relay which closes the X-magnet circuit until the switch steps and the X-interrupter springs open the circuit to the pulse assist relay. Then the pulse assist relay releases, opening the X-magnet circuit, which allows the X-magnet to release and re-close the circuit to the pulse assist relay. This cycle is repeated for each step at the rate of about 25 to 30 steps per second until the X-wiper arrives on the bank marked by ground, which operates the X stopping relay. This causes the Allotter to transfer the pulse assist relay to the Y-magnet circuit and the Linefinder begins to step in the Y direction at the rate of about 32 to 35 steps per second. When the Linefinder S-wiper arrives on a contact marked with resistance battery, the Y-stopping relay operates, the Linefinder switch-through relay operates, and the Allotter rotary switch steps to the next idle finder.

At the same time, the cut-off relay of the Line Circuit operates, disconnecting the line relay from the T and R leads. When the Linefinder switchthrough relay operates, the line is extended through to the associated Selector and the subscriber receives dial tone. The line is kept marked busy to the Connectors by ground on the S-lead coming from the Selector, and this ground is used for holding the Linefinder switchthrough relay and the cut-off relay of the Line Circuit.

When all of the Linefinders are busy, the Allotters stop hunting until a Linefinder is released.

In the event that both Allotters are prepared to use the same finder and simultaneous calls come in; one from an odd level and one from an even level, the "A" Allotter is given preference while the "B" Allotter will have to hunt for another idle finder.

Features of Abnormal Operation. In the event of failure of a Linefinder to operate or find a line, the Allotter will step to the next idle Linefinder after a timing period of a few seconds. If the second Linefinder also fails to find the line, the Allotter transfers control of the Linefinders to the other Allotter. The Allotter which failed is locked out until it is manually reset. While only one Allotter is in service, it operates on calls from both odd and even numbered levels and distributes them to all the Linefinders. Transfer is indicated by a lamp on the shelf and by a non-emergency alarm signal.

In the event of failure of the Allotter to transfer when it should, or a failure of both Allotters, the failure is indicated by an "Emergency Start Failure" lamp and an emergency alarm signal after a delay period which allows sufficient time to prevent an alarm during normal finding operations. The "Emergency Start Failure" alarm operates directly from the start relay of the Allotter, so that an alarm will be given if for any reason calls are not being found while Linefinders are idle. Fuse Alarms are arranged so that if the fuse blows on one Allotter, the Allotter transfers and a non-emergency alarm is given, but if the fuse blows on both Allotters an emergency alarm is given. The Line Circuit fuses also are arranged to give an emergency alarm. The Linefinders are fused individually and when a fuse blows give a non-emergency alarm.

The release alarm is the same as on other XY Universal Switch shelves; a non-emergency alarm is given after a delay of a few seconds if a Switch fails to release when its release magnet circuit is closed.

Test Facilities. Each Linefinder has a busy key and monitor jack, and the Linefinder is also busied out if the busy key of its associated Selector is operated.

Each Allotter has a busy key, but the circuit is arranged so that both Allotters cannot be busied out at the same time. The Allotter busy key also serves as a reset key for resetting an Allotter which has transferred.

Each Allotter has a test key which when operated causes each idle Linefinder in succession to step to the tenth X-level and to overflow in the Y-direction to test the Allotter and Linefinder action. While the test key is operated, the Linefinders will continue to find any calls which may be originated in the group. Two jacks on the shelf supervisory circuit above the two Allotters are provided for testing for actual stopping on a line. These are wired to line 21 and 39 so that odd and even levels can be tested by plugging in a test telephone.

Selectors

The selecting speed, approximately 40 steps-per-second, is somewhat faster than other systems. This speed effectively eliminates wrong numbers caused by missed pulses when the interdigit time is short.

There are many features available in Selector circuits, which offer advantages to the operating companies.

Several of the more important are as follows:

Digit Absorbing Selectors. This is a general grouping of Selector circuits which use certain wiring to add or cancel digits for various applications.

a. Multiple Digit Adding—for use in XY Dial Offices to provide for 2-5 numbering without the addition of any rank of Selectors, to meet the requirements of nation wide toll dialing. Various levels may be marked so as to:

1. Cancel the first digit with removal of dial tone after the first digit, possible reuse of the level.
2. Cancel first digit and all succeeding digits with removal of dial tone after the first digit (digit adding for the first digit, and digit cancelling thereafter).
3. Digit cancelling without reuse of level indicates that each time a marked level is dialed, the Switch will return to the "home" position.
4. Digit cancelling with or without reuse of level. Certain digits can be

eliminated. Indicates that levels may be marked so as to:

(a) Cancel first digit and all succeeding digits without removal of dial tone, and without reuse of the level.

(b) Allow use of the level if dialed as the first digit, but cancels when dialed as the second digit without reuse of the level. Dial tone is removed after the first digit.

Note: The preceding statements cover only a small portion of the various wiring options available in Stromberg-Carlson Selector circuits. The complexity of these circuits prevents a thorough discussion in this volume, however, complete detailed information may be obtained from the Telephone Sales Department.

Level Restriction by Line Marking. Indicates that certain levels may be made unavailable to certain lines by marking Line Circuits to such lines.

Level Restriction by Toll Marking. Indicates that levels restricted to local calls may be made available on calls from toll.

Permanent Timing. Indicates that the Selector will disconnect the call if for any reason it is not completed through the Selector in a predetermined interval. Used with lockout Line Circuits.

Lock Pulse. Indicates that the circuit is designed to "lock" the lock pulse relay in the operated position until the Switch steps successfully. Used with heavily loaded subscriber lines. (Refer to "lock pulse" in the section entitled "CIRCUIT PRINCIPLES".)

Stop Dial Signal. Indicates that the Selector is suitable for use in an intertoll dialing network, and provides off hook supervision when reaching designated levels until the succeeding equipment is ready to accept dial pulses.

Pulse Repeating. Indicates that the Selector is designed to repeat pulses to succeeding circuits.

Repeating With Pulse Correction. Indicates that the Selector is designed to repeat pulses to succeeding equipment and to correct the pulse ratio to approximately 40% make, no matter what pulse ratio is received.

Pad Control by Level Marking. This type of Selector is designed to insert pads (attenuators on marked levels). Generally used in toll operation only.

Normal Level Hunting. To provide an additional trunking path, without adding additional Selector ranks. By dialing a specific combination, the Switch will step a certain number of times in the X direction, then release to the normal position, and immediately hunt in the Y direction, from the X normal position. The addition required with this circuitry is the normal level wire bank and associated leads.

Connectors

Connector circuits separate into terminal-per-line or terminal-per-station types. They are designed for both local and toll operation, as determined by the condition of the HS lead. Some of the circuit features available in Connectors include:

Individual Lines. Indicates that the Connector is designed to connect to single station lines with or without extensions.

10 Party Divided. Indicates that the Connector is designed to connect to 10 party divided ringing lines, or the equivalent.

10 Party Bridged or Divided. Indicates that the Connector is designed to connect to 10 party bridged or divided lines.

20 Party Bridged or Divided. Indicates that the Connector is designed to connect to 20 party bridged or divided lines.

Last Party Release. Indicates that the Connector is designed so that it is released by the last party to hang up.

Calling Party Release. Indicates that the Connector is released when the calling party hangs up.

Re-ring on Toll. Indicates that the Connector is designed to re-ring a station under operator control when the call is a toll call.

Control Ring on Toll by Key. Indicates that the start of ringing is controlled by the operator with a key on calls from toll.

Reverting Call by Directory Number. Indicates that the Connector is designed to disregard the busy test, when it is established that the calling line is the same as the called line, and to complete the call. The number dialed is the directory number.

Lock Pulse. See Selector-Lock Pulse.

Conversation Timing. Indicates that the Connector is designed to limit the length of conversation to a predetermined interval and to warn the subscriber that the connection is about to be broken.

Level Discrimination. Indicates that the Connector is designed to prevent reversal of battery upon answering, when the call is to a PBX. This prevents the operation of paystation magnets.

PBX Trunk Hunting without Night Service. This is the simplest form of PBX Trunk hunting. These Connectors are actually designed to hunt when any number in the PBX Trunk group is dialed. In order to allow the greatest selection possibilities, only the lowest number is listed in the directory. No night service feature (individual line test of all lines but the first) is available. The number of PBX Trunks cannot exceed ten.

PBX Trunk Hunting with Night Service. Connectors arranged for this feature are designed to provide normal PBX Trunk Hunting when the first line of the PBX Trunk group is dialed. When any number in the PBX Trunk group but the first is dialed, it is tested and rung as an ordinary line. The number of PBX Trunks cannot exceed ten.

Level Hunting. These Connectors are designed to hunt over more than ten PBX trunks in one group.

Coin Control with Automatic Coin Collect. The standard paystation type of Connector which collects the coins, when on-hook supervision is received from the called party, after conversation is completed.

Executive Right of Way. These PBX Connectors are designed to allow marked lines to over-ride the busy test on called lines and establish the connection when the called station is busy.

Terminal-per-Station. Indicates that each station on a given line has an individual terminal in the Connector bank multiple and hence a different number from the other stations on the same line. The XY System has an improved method of ringing selection which allows any ringing frequency to be connected to any Connector bank terminal.

Terminal-per-Line. Any Connector not designated "Terminal-per-Station" is a "Terminal-per-Line" Connector. In this type of operation, all stations on the same line appear on only one terminal in the Connector banks.

No. 3 Toll Switchboard

The No. 3 Toll Switchboard has supervisory relays in the Line and Trunk Circuits, rather than cord circuits. Operator supervision is by the sleeve circuit, leaving the talking path free of loss inducing components. Keysenders may be used with the No. 3 Toll Switchboard, which comes equipped with dials (Fig. 48).

Cord Circuit. The cord circuit is basically a patching cord with talking, monitoring, supervisory, and signalling facilities. It can be cut into by the position and dial circuits so that they can perform their functions. The cord circuit also contains a RING REAR—RING FRONT key and a TALK-MONITOR key.

Figure 48. Typical Installation of a No. 3 Toll Board Equipped with Keysenders

Typical Information Desk

Position Circuit. The position circuit, common to the position contains:

a. Means for preventing the operator from cutting into more than one cord circuit at a time.

b. Sleeve Control Relays

c. Busy Testing

d. Coin Control

e. Splitting Key

f. TX transfer key

g. Coin control lamps

The position circuit is associated with a cord circuit only when the cord circuit Talking Key is operated.

Dial Circuit. The dial circuit, common to the position, includes the dial, lamps, key for front or rear cord, a means for associating the dial (or Keysender) with a particular cord, and holding that cord until dialing is complete, and a means of automatically starting the ringing as soon as dialing is complete.

Operator's Circuit. The operator's circuit provides for talking and monitoring by the toll operator. The operator's circuit also enables her to "overlap". The "overlap" operation means the operator can monitor one line, and with a second key, talk on a completely different line.

Position Switching Circuit. The position switching circuit, under control of a key in the position to be vacated, will disconnect all positional leads from the operator's circuit of that position and connect them to those of an adjacent position. With positions thus switched together, the talking key guard is still effective.

Pilot and Alarm Circuits. Every panel of face equipment is equipped with a line pilot circuit. This provides a visual pilot light whenever an incoming call is waiting. The code alarm circuit, when connected, audibly repeats rural line code ringing, without interfering with the operation of the Night Alarm Circuit, which is equipped common to each switchboard lineup, or several lineups, as required.

Other Circuits

Paystation Adapter Circuits. The standard paystation adapter is part of the primary trunk between the Linefinders and first Selector. The adapter circuit operates when the HS lead of the line is marked, thus allowing both paystation and ordinary lines to be used in the same group.

Reverting Call Circuits. (Refer to CIRCUIT PRINCIPLE Section).

a. Reverting call by special Trunk—

This circuit operates from a given Selector level. The last digit of both the calling and called party is registered and both parties are rung alternately until either party answers. Used primarily with Terminal-per-Line offices.

b. Reverting Call by Directory Number—

This method of reverting call operation enables the subscriber to dial the directory number of the called party. When all digits are dialed the calling party is signalled, and ringing ceases when either party answers. This is a Connector circuit function.

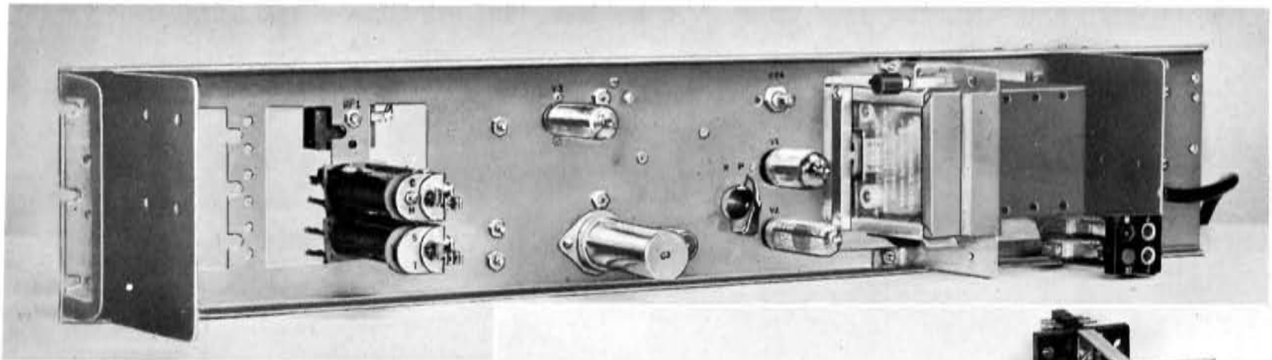
c. Reverting Call by Prefix Directory Number—

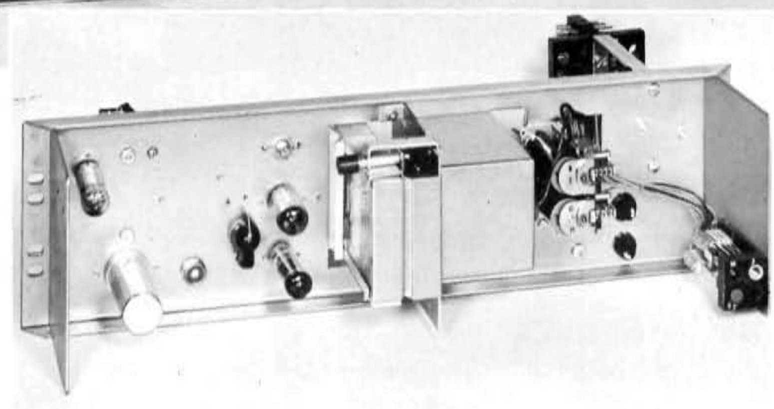
This reverting call circuit, normally used in a terminal-per-station exchange, requires a prefix code of digits in addition to the directory number and operates in the same manner as in reverting call by directory number.

Code Call Circuits. Code call circuits are available for 36 and 125 codes. The 36 code unit operates from either Selector or Connector banks, while the 125 code circuit may be connected to Selector or Switchthrough Connector banks. The fire alarm code takes precedence over all other calls in the code call circuits, and certain circuits are designed to actually operate the local alarm signalling device.

There are numerous features available in code call circuits, such as: Last Party Release, Night service and a feature which permits the calling party to abandon the call any time without mutilating the code signals.

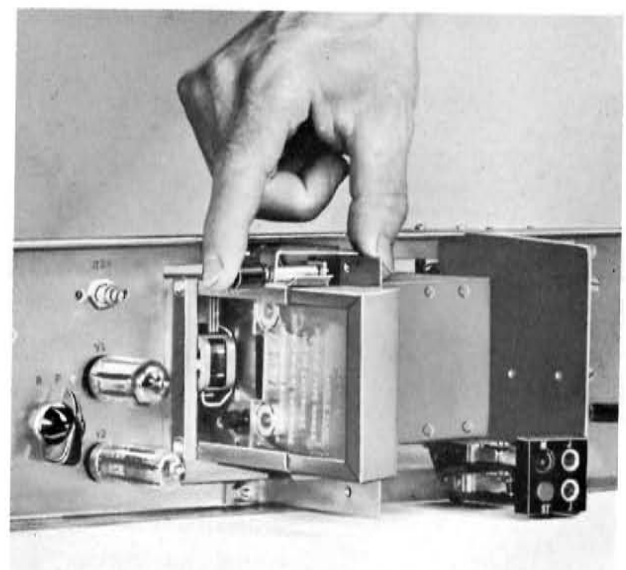
Intercept Circuits. Intercept circuits are connected to unused Selector levels, unused Connector terminals or lines as required. The Tape Announcer equipment may be installed in the intercept circuit to provide completely automatic answering of calls which go to dead levels, disconnected or unused numbers. When automatic Tape Announcing equipment is not used, the incorrect call will terminate on an intercept position.





Stromberg-Carlson Tape Announcers for 27½" and 19" Rack

Tape Announcer. The Tape Announcer is an electronic device which uses a pre-recorded message, on a magnetic tape to inform the calling party that the number dialed is incorrect.



The Ease of Ejecting the Tape Cartridge.
Push Button; Cartridge Springs Out Half Way.

OPERATING RANGES OF THE XY DIAL SYSTEM

The standard operating ranges for the XY System are listed below:

BATTERY VOLTAGE

XY Dial Offices will operate satisfactorily on any battery voltage within the limits of 44 to 54 volts.

DIAL SPEED

XY Dial Offices will operate satisfactorily with dial speeds of from 8 to 12 pulses per second from a nominal 38% make dial.

RINGING VOLTAGE

The ringing voltage shall not drop below a minimum of 65 volts RMS with the maximum ringing load.

SUBSCRIBER LINES

Loop Resistance

The maximum loop resistance of lines connected to an XY Dial System is usually 1,200 ohms (including the resistance of the telephone).

Insulation Resistance

The insulation resistance between the conductors of lines connected to an XY Dial Office must be maintained at values above a minimum of 15,000 ohms.

Ringer Load

For an office not equipped with "Lock Pulse" circuits the maximum ringer load shall not exceed 5 bridged Harmonic, Synchromonic or Decimonic series low impedance ringers (one of each frequency), or the equivalent.

For an office equipped with "Lock Pulse" circuits the maximum ringer load shall not exceed 10 bridged low-impedance Harmonic, Synchromonic, or Decimonic series ringers (two of each frequency), or the equivalent.

When medium or high impedance ringers are used in telephone sets, the use of "Lock Pulse" is not necessary for lines having ringer loads up to 10 bridged ringers.

INTER-OFFICE TRUNKS

Loop Operation

Loop Resistance. The conductor loop resistance of the inter-office trunks is limited to a maximum of 750 ohms with loop pulsing. With battery ground pulsing, the conductor loop resistance can be a maximum of 2,000 ohms. Special trunk circuits can be provided to operate on loops up to 3,000 ohms.

Insulation Resistance. The insulation resistance between conductors of inter-office trunks must be maintained to values above a minimum of 30,000 ohms.

Composite Operation, Positive-Negative Signaling

Loop resistance. The conductor loop resistance of the trunks is limited to a maximum value of 1,000 ohms.

Insulation Resistance. The insulation resistance between trunk conductors and between conductors and ground must be maintained to a value above a minimum of 30,000 ohms.

Simplex Operation, Positive-Negative Signaling

Loop Resistance. The conductor loop resistance of the trunks is limited to a maximum value of 2,500 ohms.

Insulation Resistance. The insulation resistance between the trunk conductors and between conductors and ground must be maintained to a value above a minimum of 30,000 ohms.

Composite or Simplex Operation with Polar-Duplex Signalling and Supervision

For this type of operation, polar-duplex signalling will be used and the trunk limits will be determined by the signalling set used.

For a thorough description of Polar Duplex Signaling, refer to page 115 of the CIRCUIT PRINCIPLES Section and Figure 81.

TRAFFIC AND TRUNKING PRINCIPLES

TRAFFIC

The entire Telephone System is designed to meet the requirements of a specific locality. This locality and its needs dictate the type, size, and special trunking that must be considered in the basic design of a telephone system that will handle the largest percentage of all needs for the locality. It is apparent that the subject of traffic is extensive, intricate, and completely dependent on the exchange location. This text will cover only the basic factors of traffic and the principles involved. These principles are not complex, but the application of them to the various telephone exchanges is an involved subject.

The reason for the calculation of traffic and trunking is apparent, the amount of equipment necessary to provide a certain degree of service is a direct function of the amount of telephone calls that the users will make. The observations of traffic load in existing equipment have lead to certain conclusions, which provide means of calculation for establishing the minimum equipment necessary to provide the telephone service desired.

SHARING

Sharing, discussed in the section on step-by-step switching, enables a small amount of central office equipment, to serve a large group of subscribers. The amount of this equipment is dependent on the number of calls by a particular group during a given interval, and the holding time of each call. The local definition of satisfactory service also effects the sharing of equipment.

THE BUSY HOUR

Each day the telephone exchange receives a different traffic load. There is a certain hour during the day when this load reaches a maximum level. When this "Busy Hour" occurs consistantly during a representative season of the year, the traffic load becomes a significant figure in the calculations of satisfactory service, and equipment needs.

GROUP BUSY HOUR

All groups of lines and switching equipment in the same office may not generally have their busy hours occurring simultaneously. When this situation occurs it is necessary to distinguish between the groups and refer to the group busy hour.

THE CALLING RATE

The calling rate is defined as the average number of calls per unit time. The dimensions are generally calls per hour and the term may apply to a single line or to a group of lines. The calling rate varies throughout the day and it is the calling rate during the busy hour which is important for traffic calculations. For example, if a group of 100 lines averages 146 calls per busy hour, over a ten day period in a representative season, then the figure for busy hour calls per line (abbreviated BHC/line) is determined as follows:

$$\frac{\text{146 Busy Hour Calls}}{\text{100 lines}} = \frac{\text{146 BHC}}{\text{100 lines}} = \text{1.46 BHC/line}$$

HOLDING TIME

The Holding Time is defined as the duration of the average call in seconds. As before, it is the Holding Time during the busy hour which is important in traffic calculations. At a given calling rate, if the average call made during the busy hour is of short duration, then the amount of equipment required will be less than that required if the average call is of long duration. It is therefore necessary that the average Holding Time per call be determined. It is generally necessary to determine also the total Holding Time for a given group of lines. The methods used to determine this Holding Time are beyond the scope of this section, however, assuming the average Holding Time per call for the 100 line group mentioned previously is 247 seconds per call will serve for the following sample calculations.

$$\text{Total HT} = \frac{247 \text{ seconds/call}}{\text{call}} \times \frac{146 \text{ calls/Busy Hour}}{\text{Busy Hour}} =$$

$$\frac{36{,}000 \text{ calls-seconds/Busy Hour}}{\text{Busy Hour}}$$

The figures for the BHC/line and Holding Time given in the previous example are averages for the group studied.

Since each hour contains 3,600 seconds and the computation of BHC/line and Holding Time show a requirement of 36,000 seconds, and the maximum possible usage of the equipment is 100%, the

$$\frac{36{,}000 \text{ sec. Holding Time}}{3{,}600 \text{ sec/hour}} = 10 \text{ paths}$$

are necessary to handle all calls in this busy hour. The preceding example is purely hypothectical, since it is impossible to schedule telephone usage to make the simultaneous paths 100% efficient. Therefore a safety factor, which is based on the average number of simultaneous paths required, if the paths were handling 3,600 call-seconds per hour (100% efficiency), is incorporated.

The magnitude of variation between average and the probable instantaneous maximum is governed by some element of chance. On the assumption that the laws governing other elements of chance may also be applied to telephone traffic, it is possible to use a curve which will indicate the number of simultaneous paths which are necessary to provide a certain grade of service.

The application of "pure" mathematical probability to the "practical" telephone traffic problem provides answers, which are generally reliable. Many individuals and concerns have investigated these problems, and applied various theories to them. Among these are Messrs. Erlang, Molina, and the Bell Telephone Laboratories. The Bell Lab. and the Molina Tables are generally used in this country for traffic calculations, while in Europe, Erlang's data is generally used, particularly by the British Post Office (Fig. 49). The unit of measurement used by Erlang is the "Traffic Unit" or Call-hour (3,600 call-seconds) (abbreviated T.U.). Molina and Bell Lab. data is expressed in CCS (hundred call-seconds) or alternately as the Unit Call (abbreviated U.C.). The T.U. unit is related to the CCS or U.C. as follows:

1 T.U. = 36 U.C.

SATISFACTORY TELEPHONE SERVICE

The definition of satisfactory service is dependent on the actual exchange considered, however, a rule of thumb states that only one call out of 101 calls will "fail" due to lack of equipment. This applies to the busy hour, and the number of calls is used only to explain the percentage, or probability of failure. Since it is standard practice to designate "certainty" as "1" and "impossible" as "0" it is possible to indicate by decimal numbers the likelihood of occurrance.

Table A, P = .001
Table B, P = .01
Table C, P = .02

Trunks	Unit Calls (CCS)		
	A	B	C
1	0.036	0.36	0.72
2	1.62	5.36	7.92
3	6.88	15.7	20.5
4	15.4	29.6	36.7
5	26.6	46.1	55.8
6	40.0	64.4	76.0
7	54.7	83.9	96.8
8	70.9	105	119
9	88.2	126	142
10	107	149	166
11	126	172	191
12	145	195	216
13	166	220	241
14	187	244	267
15	208	269	293
16	231	294	320
17	253	320	347
18	276	346	374
19	299	373	401
20	323	399	429
21	346	426	458
22	370	453	486
23	395	480	514
24	419	507	542
25	444	535	572
26	469	562	599
27	495	590	627
28	520	618	656
29	545	647	685
30	571	675	715
31	597	703	744
32	624	732	773
33	650	760	803
34	676	789	832
35	703	818	862
36	729	847	892
37	756	876	922
38	783	905	951
39	810	935	982
40	837	964	1012

Figure 49. Sample Molina Traffic Table

This likelihood becomes greater as the decimal becomes larger, or closer to the maximum of "1". Using the symbol "P" for probability and applying decimals to the rule of thumb, the following results:

$$P = \frac{1 \text{ call failed, lack of equipment}}{100 \text{ incoming calls accepted}} = .01$$

P = .01, for each rank of switches. For example: If the Selectors were not sufficient in number to handle an incoming call, the call would be a "fail", yet there might be many idle Connectors and trunks to carry the call, if it could have gone through the Selector. This applies to the busy hour, since at other times the number of Selectors would be sufficient to handle the lighter load. The various formulae necessary for obtaining the number of simultaneous paths necessary to provide the probability of .01 are dependent on the types of equipment used in the exchange (Fig. 50).

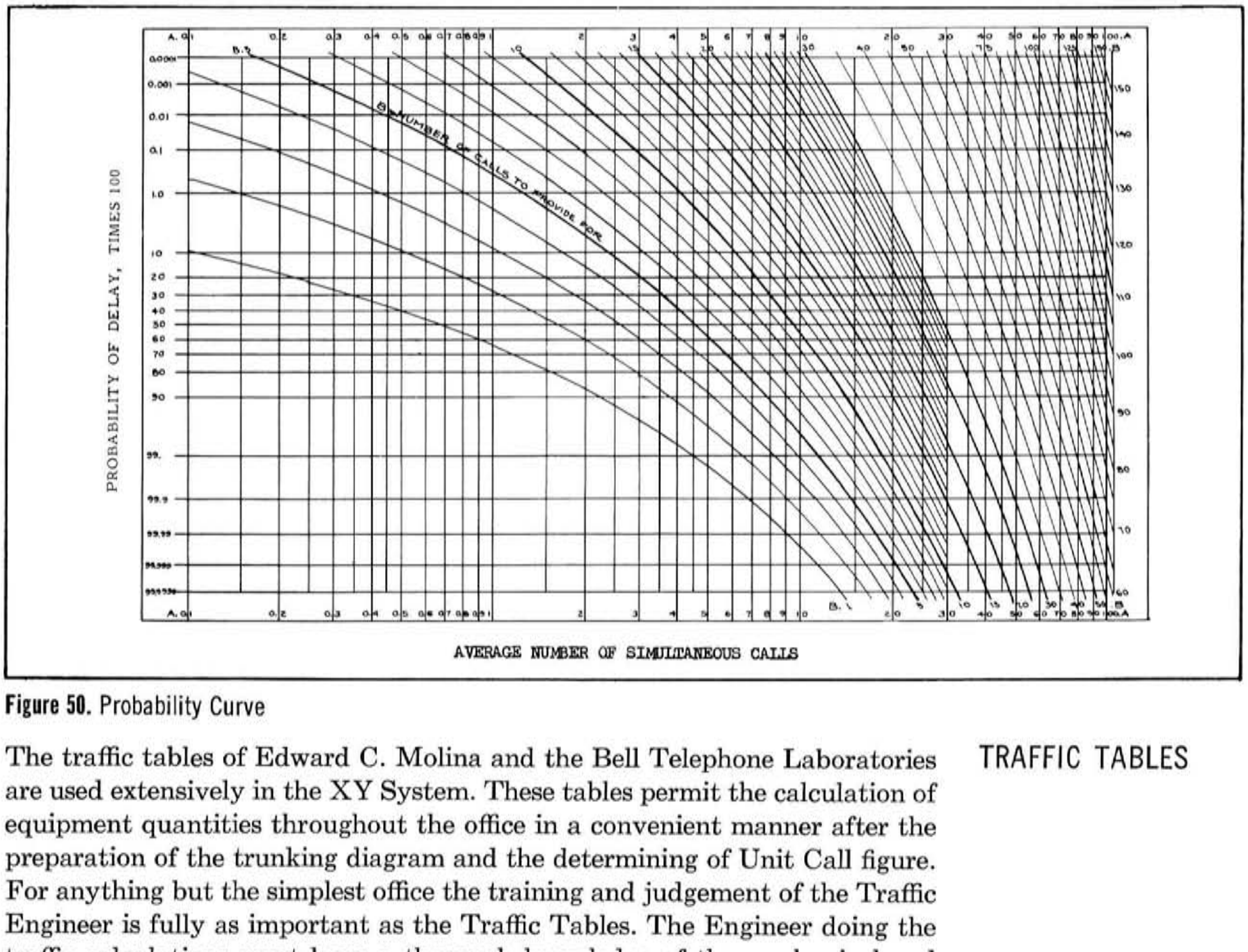


Figure 50. Probability Curve

TRAFFIC TABLES

The traffic tables of Edward C. Molina and the Bell Telephone Laboratories are used extensively in the XY System. These tables permit the calculation of equipment quantities throughout the office in a convenient manner after the preparation of the trunking diagram and the determining of Unit Call figure. For anything but the simplest office the training and judgement of the Traffic Engineer is fully as important as the Traffic Tables. The Engineer doing the traffic calculations must have a thorough knowledge of the mechanical and electrical characteristics of the equipment with which he is working, and the proper methods of making and interpreting traffic studies, as well as the ability to determine the answer by reference to the traffic table.

UNIT CALL OR CCS

The unit call or CCS is the unit of traffic measurement in the Molina and Bell Traffic Tables. It is a 100 Second Call or equivalent.

1 U.C. = 1 CCS = 1 One Hundred Second Call or equivalent

$$\text{Busy Hour Unit Calls Per/line} = \frac{\text{BHC/Line x Holding Time in seconds}}{\text{100 seconds}}$$

In the example cited previously, the number of Unit Calls per line would be 1.46 Busy Hour Calls/Line.

$$\frac{\text{1.46 BHC/Line x 247 seconds/call}}{\text{100 seconds/Unit Call}} = \text{3.60 Unit Calls/Line}$$

This figure, multiplied by the number of lines, becomes Total Unit Calls and is substituted directly into the Traffic Tables to determine the amount of equipment required. For example, in the previous case:

Total Lines = 100
UC/Line = 3.60
Total Unit Calls = 360

Referring this figure to one of the Traffic Tables would give the number of paths required to give a certain degree of service, or a probability of a specified degree.

FULL AVAILABILITY

When the number of outgoing trunks from a given Selector level is limited to 10 or less, all Selectors may hunt over each of the 10 trunks. If all trunks are idle, the Selectors seize and switch through immediately. Thus the term "Full Availability" means complete access to all outlets from all inlets.

TRAFFIC DISTRIBUTION

According to one set of Traffic calculations, 10 trunks in one group, fully available, will carry 149 Unit Calls, if Probability = .01. It is interesting to note the distribution of the calls of the traffic per terminal, as shown in the following table.

Bank Step (Terminal)	Traffic in Unit Calls	% of Total Traffic
1	29.0	20.0
2	27.0	18.5
3	24.2	16.7
4	20.8	14.0
5	16.8	11.2
6	12.6	8.5
7	8.7	4.5
8	5.4	3.6
9	3.0	2.0
0	1.5	1.0
	149.0	100%

This sample table indicates that, under the conditions described, the first three terminals carry more than 50% of the traffic, and the last three, less than 7%. It is apparent that wear on the equipment is far from even, and it becomes necessary to devise a means of more even distribution of traffic. Just how many Selectors will provide a load of 149 Unit Calls for a particular level is dependent upon the terminating equipment. If the level leads to a group of local lines, relatively few Selectors would be required to supply 149 Unit Calls. If, however, the level leads to special services, such as information or repair, a large number of Selectors would be required to provide for 149 Unit Calls. For purposes of discussion, let it be assumed that 100 Selectors will provide for 149 Unit Calls for the level being considered.

In the XY System, the Selectors are divided into groups of 10, hence in this example there are 10 groups. If the banks of these groups are multipled together point for point, the traffic distribution will be as shown in the above chart. The XY Dial System uses primarily the "Reversing of the bank multiple" method to provide more even traffic distribution.

REVERSING THE MULTIPLE

The reverse occurs in a large group of Selector bank terminals. This is usually accomplished in the middle of the group, so that certain switches "see" a lower number terminal, as first choice, while another switch will "see" a different number terminal, as the first choice. The 10 groups of Selectors will allow a change in the traffic distribution so as to more nearly equalize the load over the 10 terminals, if the multiple is reversed. For example, this may be accomplished by reversing the multiple so that the terminating equipment connected to steps 7, 8, and 9, will appear as third, second, and first choice, respectively, so far as a portion of the Selectors are concerned. If properly accomplished, this reversal has the major advantage of equalizing the load to the terminating equipment.

SAMPLE OFFICE CALCULATION

Figure 51 illustrates the trunking diagram of a small XY Dial Office. (This is strictly a hypothetical example.) The numbers adjacent to the interconnect-lines indicate the traffic in Unit Calls. The numbers inside the boxes representing the groups indicate the number of switches or trunks required. These quantities are obtained as follows:

Number of Linefinders
Total Traffic: 750 Unit Calls
Total line equipment: 450
Unit Calls per line equipment: 1.66
Lines per group: 4 groups of 100 lines each
1 group of 50 lines
Unit Calls per group of 100 lines: 166.6
From Traffic Tables 166.6 U.C. requires 11 Linefinders
Unit Calls per group of 50 lines: 83.3
From Traffic Tables 83.3 U.C. requires 7 Linefinders
Total Linefinders: 11 + 11 + 11 + 11 + 7 = 51
Number of Selectors
One for each Linefinder: 51
Number of Local and Toll Connectors per Group
300 Group:
Total Traffic: 180 U.C.
From Traffic Tables 180 U.C. requires 12 Connectors
400 Group:
Total Traffic: 100 U.C.
From Traffic Tables 100 U.C. requires 8 Connectors
500, 600, 700 Groups:
Total Traffic: 140 U.C. to each group
From Traffic Tables 140 U.C. requires 10 Connectors
Number of Special Second Selectors
Total Traffic: 50 U.C.
From Traffic Tables 50 U.C. requires 6 Selectors
Number of Reverting Call Trunks and Repair Trunks
Total Traffic: 10 U.C.
From Traffic Tables 10 U.C. requires 3 Trunks
Number of Information Trunks
Total Traffic: 30 U.C.
From Traffic Tables 30 U.C. requires 4 Trunks

Number of Trunks to CLR Toll Operator
Total Traffic: 75 U.C.
From Traffic Tables 75 U.C. requires 7 Trunks
Number of 1st Selectors from Toll
Total Traffic: 75 U.C.
From Traffic Tables 75 U.C. requires 7 Selectors from Toll
Recapitulation
Total Terminating Traffic:

75 U.C. from Toll	675 U.C. from Local
	750 U.C. Total

Total Outgoing Traffic: 75 U.C. to CLR Toll Operator
Traffic Distribution:

U.C. 300 Group	180	U.C. 600 Group	140
U.C. 400 Group	100	U.C. 700 Group	140
U.C. 500 Group	140	U.C. Spl. 2nd Sel.	50
		750 U.C. Total	

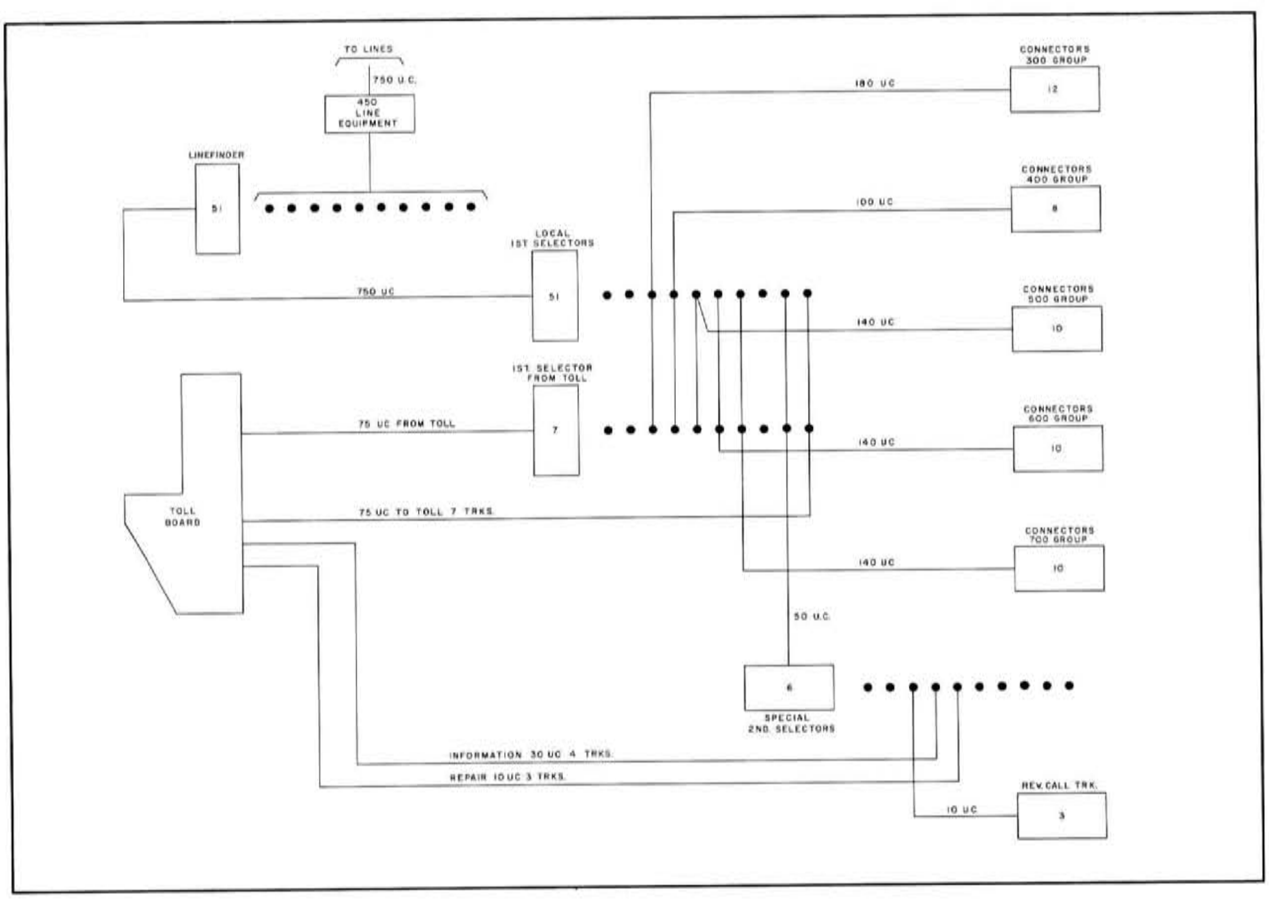


Figure 51. Typical Trunking Diagram

CIRCUIT PRINCIPLES

INTRODUCTION

Telephone switching circuits have at least one common characteristic; their operation may be broken down into logical steps which, if taken alone, are extremely simple. It is the multitude of simultaneous and short interval consecutive operations which make the complete circuit appear to be complex. It seems desirable, therefore, to extract from the circuits certain principles of operation and discuss them. Many different types of circuits utilize the same principles during a portion of their operation and it is intended that this section also will make these similarities apparent.

It is not possible to illustrate all of the many combinations of relays which might be termed CIRCUIT PRINCIPLES. This section illustrates only those which are in general use in the XY Dial System or are important in themselves.

The principles illustrated are generally somewhat simplified in comparison to actual circuits in order to obtain clarity.

CIRCUIT DRAWINGS, DRAWING SYMBOLS AND ABBREVIATIONS

The type of telephone circuit drawing used by General Dynamics|Electronics is one which shows the relays and contacts closely associated with each other. The contacts normally are shown above and/or below a "box" which represents the relay coil, and the coil and contacts are designated by a single code above the coil symbol.

All relays are shown on the circuit drawing in their normal condition with the circuit idle. The moving contacts on relays which are normally operated are shown slanted with respect to the horizontal dimension of the drawing.

The sketches shown in the CIRCUIT PRINCIPLES section represent the parts of the XY Universal Switch involved, and will be separated and distributed among the other parts of the drawing. A special symbol will be used to indicate the off-normal, overflow and release contacts on the Switches.

In order to simplify circuit drawings and facilitate circuit reading as much as possible it is customary to use certain standard symbols and abbreviations to represent certain pieces of apparatus and to identify certain leads. Figure 52 shows the circuit symbols used in the CIRCUIT PRINCIPLE section.

RELAY APPLICATION

Relay Operating Characteristics

The typical telephone type relay operates rather quickly when sufficient current is supplied to operate it at all. Generally speaking, ordinary telephone relays operate in from .005 to .020 seconds after the application of voltage. Relays with low resistance coils normally operate in the lower end of this time range and those with high resistance coils in the higher end.

The release time of the typical telephone relay lies in the same range as the operate time.

Both the operate and release time are influenced by the spring combination assembly, residual screw projection and armature ratio in addition to the resistance of the coil.

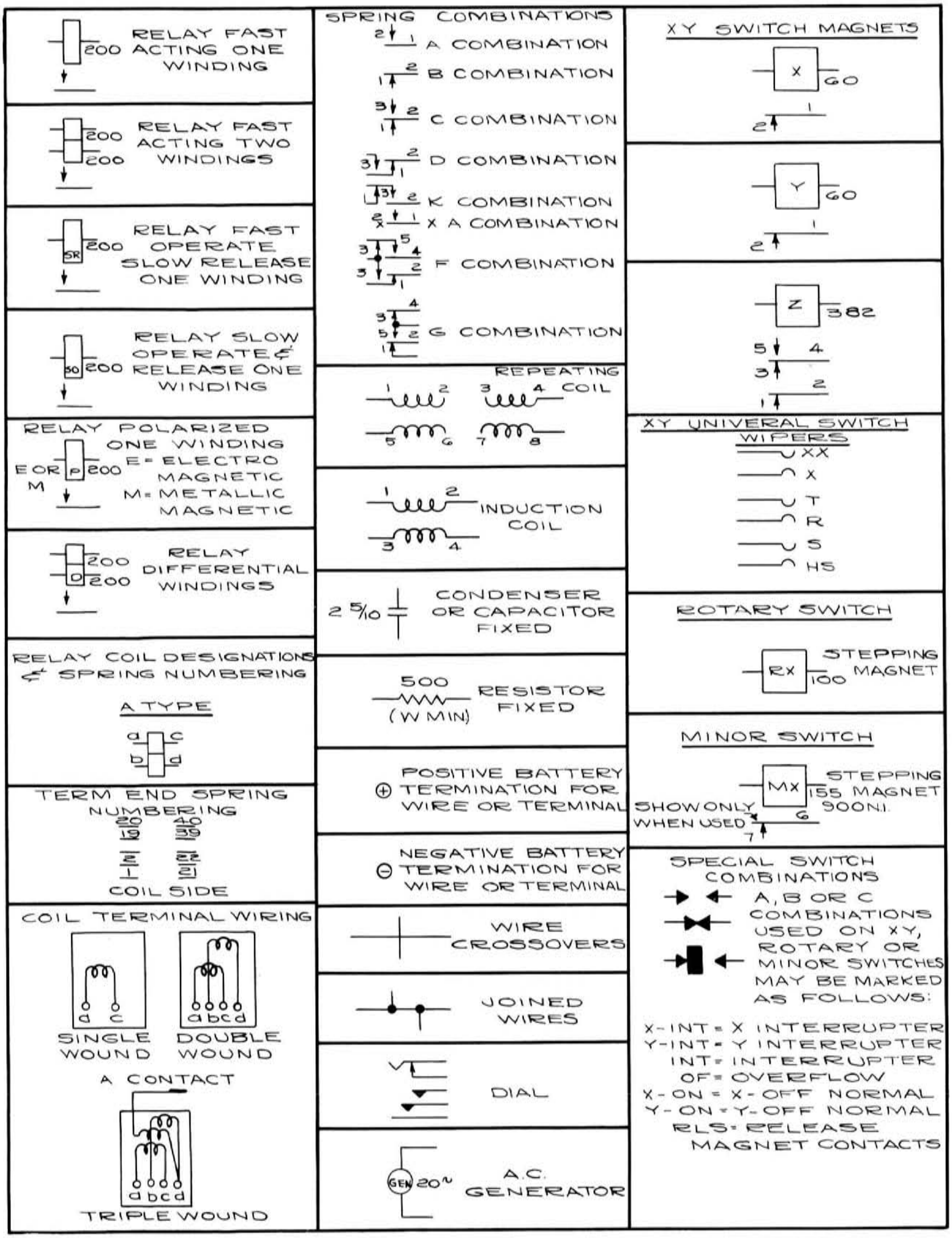


Figure 52. Symbols Used in XY Circuits

Coils are sometimes wound so as to fill only part of the available winding space. This may result in a decreased operating time because of the decreased inductance.

Relays with Long Operate and Release Time. In addition to the basic requirements that the relay must operate when current is applied and release when it is removed, telephone relays are often required to delay operation or release for fractions of a second. Generally this is accomplished by replacing part of the winding with a copper slug or sleeve which affects the rise or decay of flux in the desired manner, thus controlling the operate or release time of the relay. The Table below shows the effect of copper sleeves and slugs on relays.

Type	*Location on Core*	*Effect on Operate Time Compared to Equivalent Coil Without Sleeve or Slug*	*Effect on Release Time Compared to Equivalent Coil Without Sleeve or Slug*
Slug	Armature End	Increases	Increases
Slug	Heel End	None	Increases
Sleeve	Entire Length	Increases	Increases

In general, operate times of from 30 to 50 milliseconds and release times of from 50 to 500 milliseconds are obtainable using sleeves and slugs. The operate and release time of a particular relay may be controlled over reasonably close limits by proper choice of the spring combination assembly, residual projection, armature ratio and sleeve or slug.

Relay Adjustment

Under no conditions should a relay be adjusted so that the operated air gap controlled by the residual screw, is not perceptible to the eye. If this condition occurs, the relay may be held operated by the residual flux after current is removed.

During the first few thousand operations the residual screw may "pound down" about .0005″ because small burrs may be present on the screw or core end and they eventually flatten out. All circuits of the XY Dial System are engineered to require at least a .0015″ operated air gap. Adequate protection against residual magnetism hold-up is in this way provided.

The stroke may be increased or decreased nominal amounts by turning the armature support screw either clockwise or counterclockwise respectively. When it is necessary to reduce the stroke greatly, the armature must be removed from the relay and bent by hand by laying the top against a flat surface after removing the armature support. The armature support screw is held "locked" by application of "Glyptol" cement which must be reapplied if the screw is turned.

Relay adjustments are interdependent. The spring pressure, for example, affects both the operating and release current. The residual projection, the fundamental release adjustment, affects the spring tensions and hence the operating current. For these reasons, the adjustment of a relay is primarily a series of approximations, each adjustment affecting all the others to a certain degree.

If no Release or Hold current is specified it is sufficient to adjust the residual projection to the specified value by means of a thickness gauge.

If a *Hold* or *Release* current is specified it may be necessary to modify the residual projection in order to make the relay function properly. The difference between the value specified and used is usually not greater than .001″.

When a release current adjustment is specified, a "soak" value of current usually is given. This value is necessary because in the majority of cases the relay operates in the circuit with a current greatly in excess of its adjustment value, and hence the magnetic condition of the core when operating in the circuit is different from that found during adjustment. Whenever possible the relay is "soaked" by connecting it directly across the power supply before attempting a release adjustment.

Interpretation of Relay Adjustment Sheets

Associated with each circuit schematic drawing is the Relay Adjustment Sheet. This drawing carries the same number as the associated schematic and is prefixed with the letter "AS.".

The Adjustment Sheet contains the information necessary to adjust the relays used in the circuit, and refers to other drawings which affect the circuit and its components. A typical Adjustment Sheet is shown in Figure 53.

The data shown on this sheet includes the circuit identification, stock number, residual projection and adjustment current for the relays. In the "Notes" and "Circuit Description" sections it provides instructions on the test points when using a current flow test set (Stromberg-Carlson No. 6C or the equivalent) to test and adjust the relays. Notes pertaining to special mechanical adjustment normally are found in the "Remarks" column. Any special adjustments shown on the Adjustment Sheet supercedes the standard adjustment. References to Standard Adjustment Drawings for the relays and other components used in the circuit also are included under the heading "Standard Adjustments". These Standard Adjustment Drawings should be referred to when performing adjustments on the apparatus mounted on the circuit plate.

It is generally accepted practice to provide for each adjustment [operate (O), non-operate (NO), hold (H) and release (R)], two currents, one known as the "Test" current, the other as the "Readjust" current. It is normal practice to inspect the relays periodically and to determine whether or not they meet the "Test" current. If so, no adjustment is necessary. If, however, the relay does not meet the "Test" current as specified on the Adjustment Sheet, it should be readjusted to meet the "Readjust" current. In this way, some change in characteristics is allowed over a period of time and readjustment is necessary less often. Except in the case of specially adjusted relays, the difference between "Test" and "Readjust" current will approximate 10 percent of the total current flowing in the relay during test.

THE FOUR WIRES

The XY Dial System has been called a "four wire" system because there are four wires, called Tip (T), Ring (R), Sleeve (S) and Helping Sleeve (HS) which are switched from circuit to circuit in the progress of the call. The Tip and Ring are the pulse transmission and conversation carrying leads. The Sleeve lead serves to control the switching operations on both local and toll calls. The HS lead, in addition to discriminating between a local and toll call, provides both signalling and supervision between the toll operator and called subscriber.

APPARATUS			CIRCUIT DESCRIPTION			DIRECT CURRENT FLOW REQUIREMENTS					REMARKS
DESIG.	STOCK NUMBER	RESID.	BLOCK OR INSULATE	TEST WITH (SEE NOTE)	TEST SET POINT	TEST WDG.	TEST FOR	AFTER SOAK MA.	READJ. MA.	TEST MA.	
											Operate Busy Key before making current flow tests.
AB	369327	.004	RD(5,6)	5 & 9	SW(23)	b-d	O		48	50	
							NO		43	41	
							R		14	12	
CB	361670	.007	RD(NO)AB(6,7)	1	AB(3,21)	a-c,b-d	O		18.5	19.5	Limited travel relay
							NO		15.5	14.5	
RD	205243	SEE	PD(23,24)	5	CB(5)	a-d	O		41	45	The residual proj. may be varied to meet
		REMARKS	RD(6,7)				H		10	11	currents Mim perceptable-Max. .004"
							R		8	7	
XD	205201	.004		5 & 9	XD(23)	a-c	O		42	44	
							NO		26	22	
YD	207183	.004		5 & 9	TL(3)	b-d	O		28	30	
							NO		24	22	
PD	203120	.004	TL(NO)RD(5,6)	5	TL(2)	b-d	O		40	44	
							NO		28	26	
TL	360765	.004	PD(5,6)	6	PD(5)	a-c	O		20	22	
							NO		16	14.5	
RT	368690	.004			TL(22)XD(4)	a-c	O		82	87	
							NO		58	53	
							O		30	31.5	X Contact only
							NO		25	23	X Contact only
BT	369440	.004	SW(12,13)	5	SW(33)	a-c	O		24	26	
							NO		18.5	16	
SW	369443	SEE	PD(5,6)(23,24)	7	PD(24)BT(3)	b-d	O		82	90	The residual proj. may be varied to meet
		REMARKS					NO		66	59	currents Mim perceptable-Max. .004"
							O		27	29	X Contact only
							NO		23	21	X Contact only

NOTES:

1. BOTH WINDINGS IN SERIES
2. X MAGNET IN SERIES
3. Y MAGNET IN SERIES
4. Z MAGNET IN SERIES
5. POS. BATTERY THROUGH TEST SET TO POINT INDICATED
6. NEG. BATTERY THROUGH TEST SET TO POINT INDICATED
7. TEST SET ACROSS POINTS INDICATED
8. WINDING ENERGIZED AS INDICATED DURING TESTS
9. Disconnect XY switch before making current flow tests.

STANDARD ADJUSTMENTS

"C" TYPE RELAYS: E-75918[illegible] "A" TYPE RELAYS: B-1[illegible]49

-XY SWITCH: E-7591[illegible]

Stromberg-Carlson Company Rochester, N.Y. U.S.A.	DRWN sas	CHKD.	ENG. RPJ	APPR. RPJ	ADJUSTMENT SHEET FOR S-30104	Sheet 1 of 1	AS-30104

Figure 53. Typical Relay Adjustment Sheet

The fundamentals of switching in step-by-step systems have been described in another section. It remains to discuss some of the electrical functions which take place in the switching of calls.

In the following, an office equipped with Linefinders, First and Second Selectors, and three-digit local and toll Connectors is assumed.

Switching a Local Call Through the XY System

Any XY Dial System follows a standard pattern in switching normal calls. This process is outlined below:

Line Circuit. The Tip lead (T) is connected in series with a 200 ohms winding of the Line (LR) relay to the positive terminal of the battery. The Ring lead (R) is connected in series with another 200 ohms winding on the same relay to the negative side of the battery. This is true, only with lock-out Line Circuits.

Back and Front Sleeve. In Linefinders, Selectors and Connectors there are generally two distinct sleeve leads. These are known as Back and Front Sleeve.

Back Sleeve is defined as the sleeve lead to which the holding ground is applied when the circuit is seized.

Front Sleeve is defined as the sleeve lead attached to the sleeve wiper of the associated XY Universal Switch.

At some time in the course of switching these two sleeve leads may become the same. In this case, the terms Back and Front Sleeve refer to the two ends of the lead within the particular circuit.

Linefinding. When the subscriber closes the path between T and R at the station, the LR relay operates, marking the XX or X bank of the Linefinder with ground, and placing a 1,200 ohms resistance to negative battery on the proper sleeve bank wire in the Linefinder banks. At this time, the LR relay sends a start ground signal to the Linefinder. The Linefinder starts searching for the line, searching first for the ground which marks the level in which the line is located on the X or XX bank.

When this ground is found, the Linefinder stops moving in the X direction and begins moving in the Y direction in search of the 1,200 ohms battery on the sleeve bank terminal. When the Front Sleeve wiper locates the proper terminal, the Linefinder stops and connects the T, R, S and HS leads through to the Selector. The T and R leads are connected to the impulse repeating relay in the Selector.

The Selector returns a ground on its Back Sleeve lead upon seizure, and this ground operates the Cut-off (CO) relay in the Line Circuit which disconnects the Line Relay from T and R. The ground on the Back Sleeve lead also holds the Linefinder Switchthrough relay (usually designated as SW). At this point in the switching operation dial tone is applied to the line.

The Linefinder has been under the control of the Allotter during the linefinding process and since this has now been completed, the Allotter disconnects itself from this Linefinder and searches for another idle Linefinder to serve the next call.

First Digit. When the first digit is dialed, the Selector Switch follows the pulses repeated by the impulse repeating relay, moving in the X direction. When the Selector determines that no additional pulses are to be sent in that digit, the X-Delay Relay (XD) releases, and the Selector starts searching for an idle Second Selector in the level dialed. Busy Second Selectors have marked the sleeve bank terminal of the First Selector with ground. Idle Second Selectors have marked the sleeve bank terminal of the First Selector with absence of ground.

When the Front Sleeve wiper of the First Selector locates the first sleeve bank terminal marked with absence of ground, it will switch through, seizing the impulse repeating relay in the Second Selector. When the impulse repeating relay is seized in the Second Selector, ground is applied to its Back Sleeve lead.

The Back Sleeve ground returned by the Second Selector holds the Switch-through (SW) relay of the First Selector and also the Linefinder SW relay and the CO relay of the Line Circuit, both of which formerly were held by the Back Sleeve ground returning from the First Selector. The impulse repeating relay of the First Selector is disconnected by the switchthrough process and the Back Sleeve ground returned by the First Selector is removed.

Second Digit. The second digit operation duplicates that of the first digit, except that the Connector has marked the sleeve bank terminal of the level dialed with ground (busy) or absence of ground (idle). The switchthrough process is the same, the impulse repeating relay of the Connector being seized and a ground returned on the Back Sleeve lead of the Connector to hold the Second Selector, First Selector and Linefinder switchthrough (SW) relays and the Line Circuit CO relay operated.

SLEEVE LEAD CONDITIONS IN SWITCHING

Circuit	*Condition of Circuit*	*Condition of Sleeve Lead*	*Remarks*
Line Circuit	Seized—awaiting Linefinder	1,200 ohms resistance to negative battery	Tens position marking ground on XX or X bank
Line Circuit	After linefinding	Grounded	Ground originates in 1st Selector
Line Circuit	Idle—waiting for Connectors to test	1,200 ohms resistance to battery	Idle line to Connector
Line Circuit	Seized—waiting for Connector to test	Grounded	Busy line to Connector
Selector	Seized	Grounded	
Selector	Idle	Absence of ground	
Connector	Seized	Grounded	
Connector	Idle	Absence of ground	
Trunk	Seized	Grounded	
Trunk	Idle	Absence of ground	

Note: It will be noted that the important lead in this process is the Sleeve lead

Third Digit. The third digit moves the Connector in the X direction.

Fourth Digit. The fourth digit moves the Connector in the Y direction. When the Front Sleeve wiper has stopped on the line dialed, it tests the line to determine whether it is busy or idle. Busy lines will mark the Connector bank sleeve terminal with ground. Idle lines will mark it with a 1,200 ohms resistance to negative battery. If the line is busy, the Busy Test (BT) relay of the Connector operates.

If the line is idle, nothing further happens on local calls.

Fifth Digit. The fifth digit pulses the Minor Switch (ringing frequency selector) or the equivalent. When this digit is completed, the Connector Switch-through (SW) relay operates if the line is idle, and ringing is applied to the line. If the line is busy, Busy Tone is sent to the calling subscriber. When the Connector switches through to the called line the Front Sleeve wiper grounds the sleeve lead to the line to make it busy to other Connectors.

When the called subscriber answers, the potential applied to the T and R leads is reversed and conversation may take place.

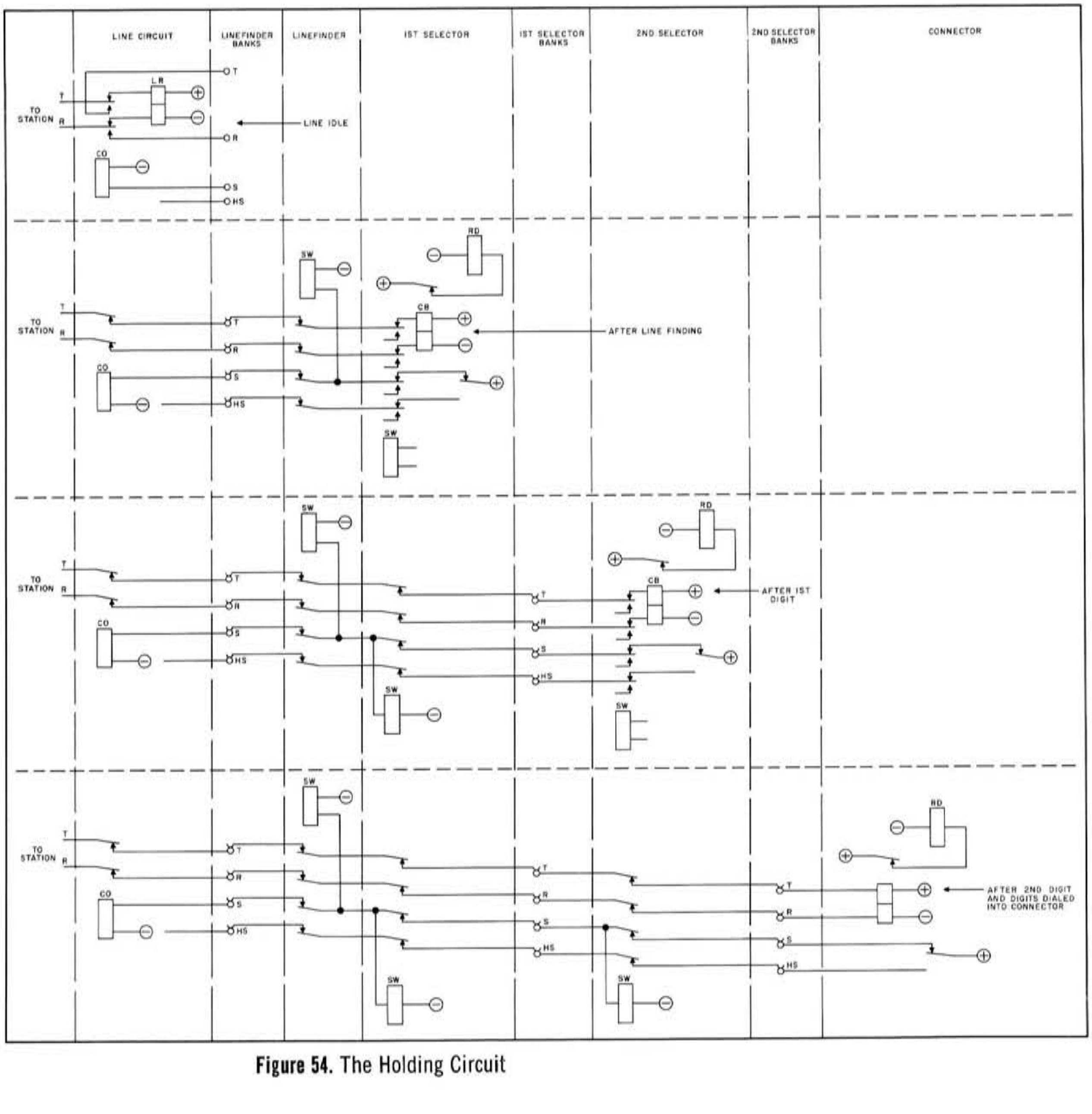


Figure 54. The Holding Circuit

Release. When the calling subscriber replaces the handset on the cradle of the telephone, the bridge on T and R is opened and the impulse repeating relay of the Connector releases. The release of the impulse repeating relay removes ground from the sleeve of the called line and from the Back Sleeve of the Connector. The removal of ground from the Back Sleeve of the Connector releases all of the SW relays involved and also the CO relay of the calling Line Circuit (Fig. 54). The release of these relays returns the various XY Universal Switches to normal and the T and R leads are reconnected to the LR relay.

Calls Outside the XY Dial Office

The switching process on calls going outside the XY office is the same within the office as a local call. The trunk circuit involved marks the sleeve terminal of the Selector bank in the same way as the Selector or Connector.

Switching a Toll Call Through the XY Dial System

In the XY Dial System, toll calls follow the same switching path as the local calls. Toll operation, however, requires that the method of operation of the Connectors be changed, and a more involved supervision scheme be used. The HS lead provides toll signalling and supervision.

Most Connectors used in the XY Dial System are "combination" Connectors which will accommodate both local and toll calls.

On toll calls, the Connector is arranged to seize the line and mark it busy to other Connectors after the completion of the second digit dialed into the Connector. It also withholds the application of ringing to the line until such time as the operator requires it for ringing the called subscriber. The HS lead provides the signals which cause the Connector to operate in this manner on calls from toll.

Key Controlled Ringing. Certain Connectors are designed to delay the application of ringing until the toll operator operates a key on the operator's position.

In addition to providing toll discrimination, the HS lead returns "off-hook" supervision from Connectors and "flash busy" signals from both Selectors and Connectors to the toll operator when required. The busy signals are the standard 120 IPM and 60 IPM flash busy from Selectors and Connectors respectively.

GENERAL CIRCUIT PRINCIPLES

Percent Make

A term used to identify, percent-wise, the length of time contacts are closed during one impulse. (This impulse is defined as the opened and closed period of contacts once in a given length of time.)

a. As an example: Assume that relay contacts are opening and closing at a uniform speed and generate pulses at the rate of 10 per second. Therefore, one impulse is 100 milliseconds long. Further assume that during this impulse the contacts are closed for 40 milliseconds, open 60 milliseconds. The *percent make* figure can then be obtained by dividing the *made time* by the *total time* of the impulse, and multiplying the result of 100%, or

$$\%\ \text{make} = \frac{\text{made time}}{\text{total time (one impulse)}} \times 100\%$$

b. The speed of impulsing can influence the percent make, if the time of closure of the contacts remains a constant when the speed is changed, or

% make = made time × speed in pulses per second × 100%. Using the above formula, it is apparent, that the pulsing of a component is dependent on the *percent make* and pulse speed. If the pulses supplied to a component do not meet the percent make and speed requirements of the component, the device will not function properly.

The Impulse Repeating Relay

In many dial circuits a relay is required to repeat without excessive distortion, the "pulses" which are formed by successive openings of the dial contacts as the dial is returned to normal. Consider the circuit illustrated in Figure 55 (A).

When the dial contacts are closed the resultant current flow operates the relay. Opening the dial contacts causes cessation of the current flow and ultimate release of the relay. In many relays used in telephone systems, the operate and release times are of relatively small importance. It is precisely these characteristics of the pulsing relay, however, which cause its operation to be of interest so far as successful switching is concerned.

The majority of the time required to operate most relays is caused by electrical, rather than mechanical effects. Because the relay coil is inductive, the current cannot immediately rise to its final value. Since the magnitude of the flux generated is a function of the current, among other things, the force resulting from this flux increases as the current increases until it overcomes the combined force and operating spring pressure and thus causes the operation of the relay. The time consumed after the armature passes this critical point is relatively short in comparison to the time required to raise the flux density to the point where sufficient force is available to operate the relay.

A similar situation exists so far as the release of the relay is concerned, but because of hysteresis and the fact that the armature is much closer to the core than it is at the critical operating point, the current required to hold the relay operated is considerably less than that required to operate it. The current must reduce even further in order to release the relay.

In the circuit shown in Figure 55 (A), the release time of the relay might be considered to be very small because the current may reduce to zero immediately except for the presence of a spark which may form when the contacts are opened and the collapse of the magnetic field causes the voltage to rise rapidly.

Disregarding other possible line conditions and assuming that the dial is one in which the contacts are made 40 percent of the time and not made 60 percent of the time, it can be shown that the relay can distort the pulse only if the operator and release times are not equal, refer to Figure 55 (B).

Figure 55(B) is somewhat distorted to illustrate the principle. Measurement of the distance between the point of closure and opening of the dial springs and comparison of it to the distance between the points where the break contacts break and the break contacts make will indicate that the times are equal. The only result of pulse repeating in this case is something similar to a phase shift in sine wave circuits.

The point of the above discussion is that anything which can affect the operate time of the relay without affecting the release time to an equal extent can cause pulse distortion.

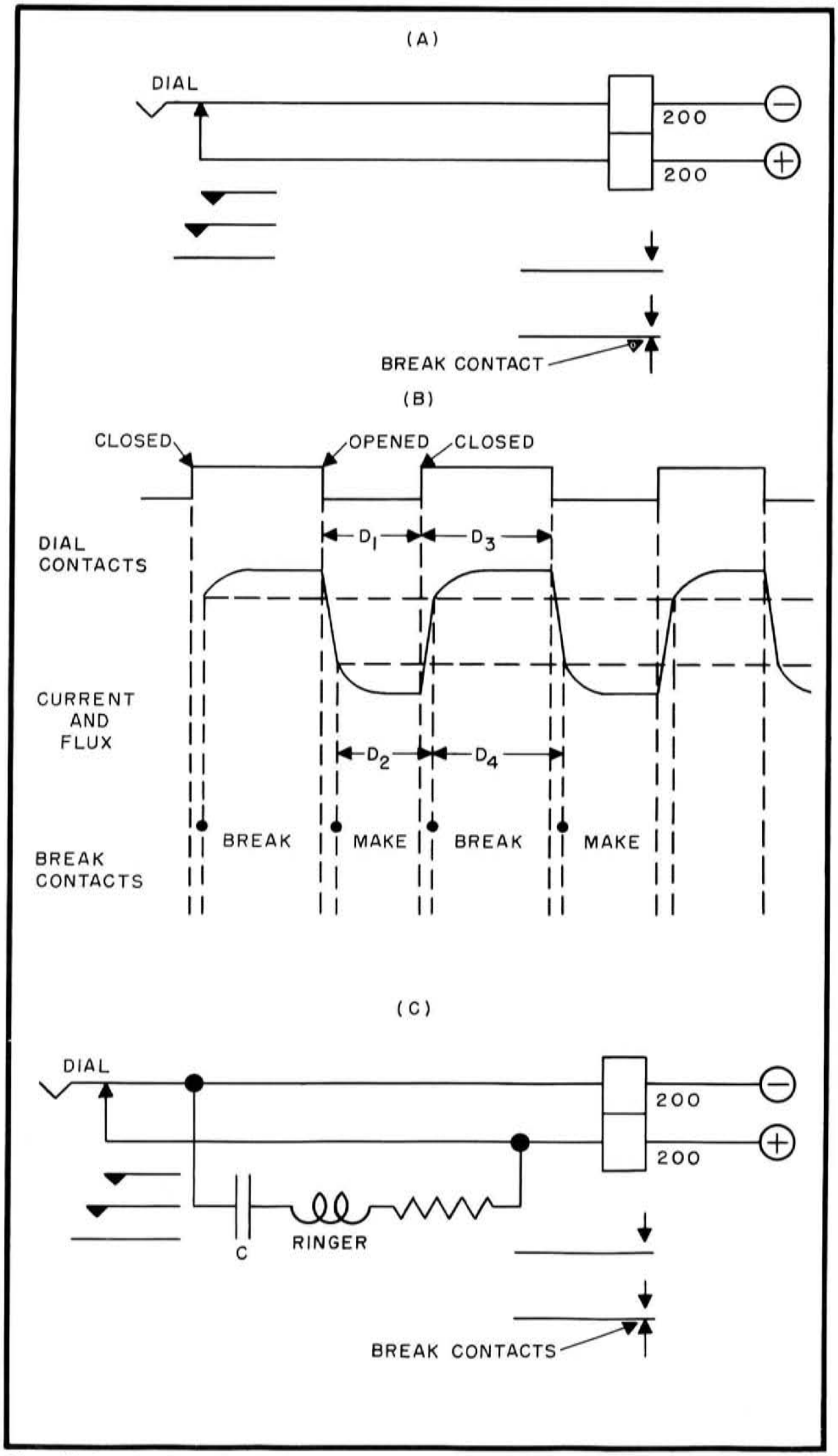


Figure 55. Impulse Repeating Relay

In any actual case, the telephone line is not the ideal one shown in Figure 55(A). Practically, the line may have from 0 to 1,200 ohms resistance in the XY Dial System. Since resistance reduces the total current flow and hence the flux in the relay, we might reasonably expect that the operate time would be greater than it is with zero loop. Also, since the final flux is less than it is in the zero loop situation, it is likely that the release time will be less than it was. Since the operate time is increased and the release time decreased by what we will assume to be an unequal amount, pulse distortion is present.

An additional example of the effect of line conditions is illustrated by the circuit shown in Figure 55(C). Note that when the contacts of the dial are closed the ringer capacitor is shorted out. The operate time of the relay in this circuit is therefore not affected by the presence of the ringer. When the dial contacts are opened, however, the ringer capacitor charges through the relay and consequently the relay remains operated for a longer time than it would be if the ringer were not present. Pulse distortion therefore exists.

When a typical telephone line is considered, the situation becomes very involved. There may be additional ringers on the line and the spacing between these ringers is, of course, not controllable. In addition, the line itself has series inductance and resistance, and shunt capacitance and conductance. All of these factors affect the operation of the impulsing relay to some extent.

Major items which affect the operate or release time of an impulsing repeating relay are as follows:

- Exchange voltage
- Loop resistance
- Leakage resistance magnitude and distribution between Tip and Ring and between either wire and ground
- Number, type, and location of ringers
- Dial speed
- Adjustment of relay
- Answering Bridge Circuit (if connected during dialing)
- Other components. i.e, repeat coils

The one factor of these which normally is under the control of the maintenance personnel is the adjustment of the relay. All others are subject to variation over specified limits with the equipment expected to function properly.

Fortunately, the problem of proper operation of an impulse repeating relay can be made considerably simpler than it appears from the number of variables indicated above. It is possible to develop empirically two well defined conditions which are "worse" than any other combination of circumstances, and therefore, if the relay pulses properly under these two conditions it will pulse properly under the others.

For the relay being described here, these two conditions are as follows:

a. High voltage, 10,000 ohms leakage resistance between Tip and Ring at the exchange, 0 loop, 5 bridged harmonic, low impedance ringers and a 12 PPS dial.

b. Low voltage, infinite leakage resistance between Tip and Ring, 1,200 ohms loop resistance, no ringers and a 12 PPS dial.

The first of these conditions results in low percentage make between the swinger and back contact of the pulsing relay, and the second in high.

Extensive tests conducted on the XY Universal Switch determined the allowable percentage make over which the switch would operate consistently. A certain amount of pulse distortion by the impulse repeating relay cannot be prevented since for one adjustment it is expected to operate over widely varying line conditions. There is a range approximating 35 percent make over which this relay will vary in normal operation and the adjustment given the relay is such that the extremities of this range are safely inside the maximum limits of the XY Universal Switch and the associated slow release relays. (See "The Release Delay (RD) Relay," "The Direction Relays" and "The Basic Impulsing Circuit''.) The controlling factor which enables the relay to be adjusted so that it will remain inside the limits is, of course, the current shown on the Relay Adjustment Sheet.

It must be made clear that the current adjustments shown on the Relay Adjustment Sheet for any impulse repeating relay are those chosen so that the circuit will function properly over the limits specified as (**a**) and (**b**) above, or their equivalents, and therefore, they should not be departed from without careful consideration of the results of so doing.

This relay usually is designated the "CB" relay.

The Release Delay (RD) Relay (Fig. 56)

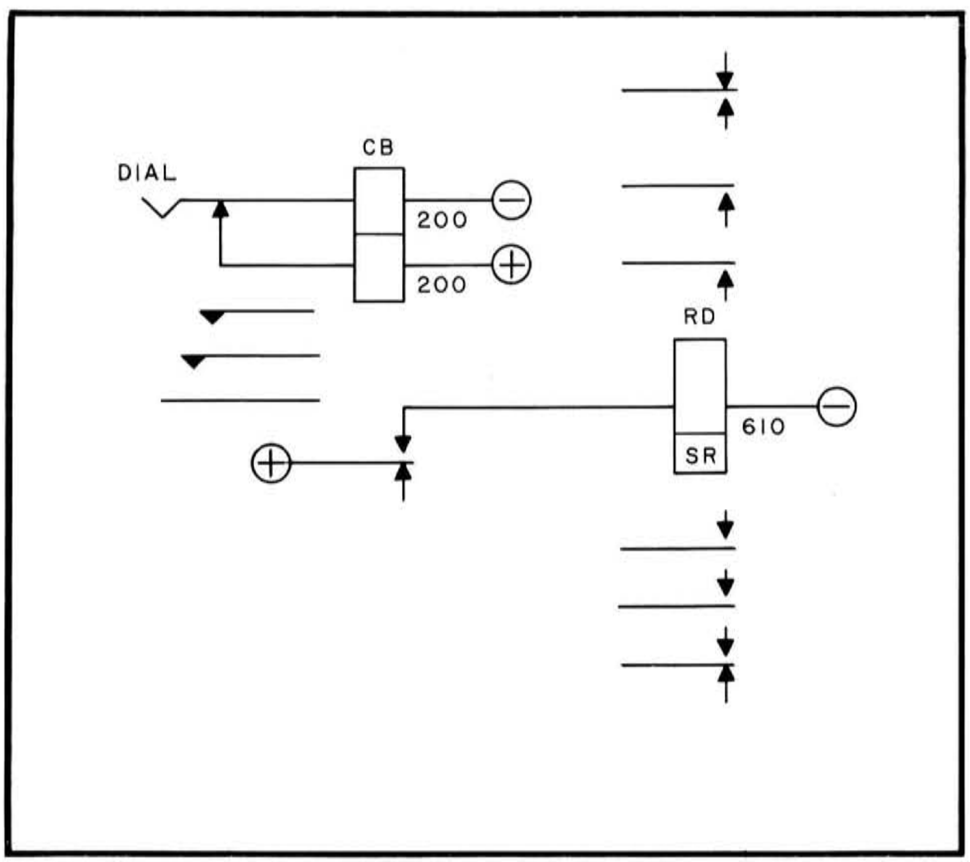


Figure 56. The Release Delay Relay

Most switching circuits require a relay with a long release time which operates from make contacts on the impulse repeating relay and is expected to remain operated while the impulse repeating relay repeats the pulses. Most RD relays remain operated on 25% make or less at 12 I.P.S.

This relay has several functions:

a. It controls the application of a ground which holds other relays in the circuit operated after their normal circuit function is completed. (Master ground)

b. It prevents the circuit from drawing current during the idle periods.

c. It controls the release circuit for the XY Universal Switch.

d. It applies the ground on the Back Sleeve lead which holds the preceding Switches.

The Direction Relays (XD, YD, PD) (Fig. 57)

These relays all have the same basic function—to remain operated while the associated Switch is being pulsed in one direction and to release after the completion of a single digit.

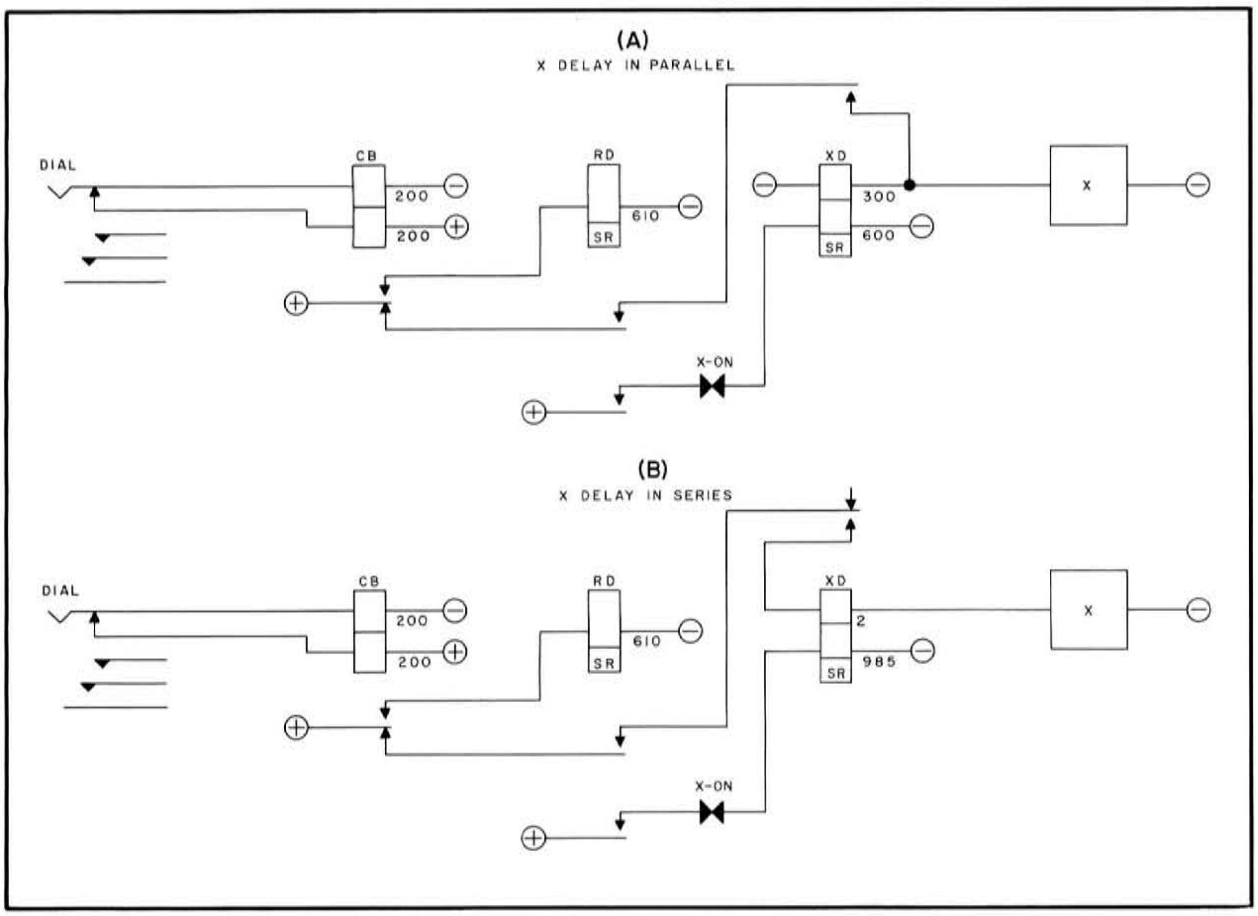


Figure 57. The Direction Relays

These relays generally are equipped with a two winding coil, one winding of which is controlled through the proper off-normal contacts of the Switch being pulsed. This winding serves to operate the relay upon seizure of the circuit, thus preparing the path to the Switch magnet. When the Switch moves one step off normal this winding is deenergized by the opening of the off-normal springs and the relay must remain operated by the pulses being sent to the Switch. When the pulses stop, current no longer flows through the windings of this relay and it subsequently releases, usually setting up a path for additional pulsing or initiating some other action.

There are two versions of the circuit which have been used by Stromberg-Carlson. In one, the winding which carries the pulses is in series with the Switch magnet. In the other, it is in parallel. When the winding is in series, its resistance is low (2 ohms). When in parallel, its resistance is high (300 ohms.)

The Basic Impulsing Circuit

The basic impulsing circuit is illustrated in Figure 58. This circuit is found in Connectors, where it serves to pulse the XY Universal Switch in both the X and Y directions, and in Selectors, where it pulses the XY Universal Switch in the X direction only.

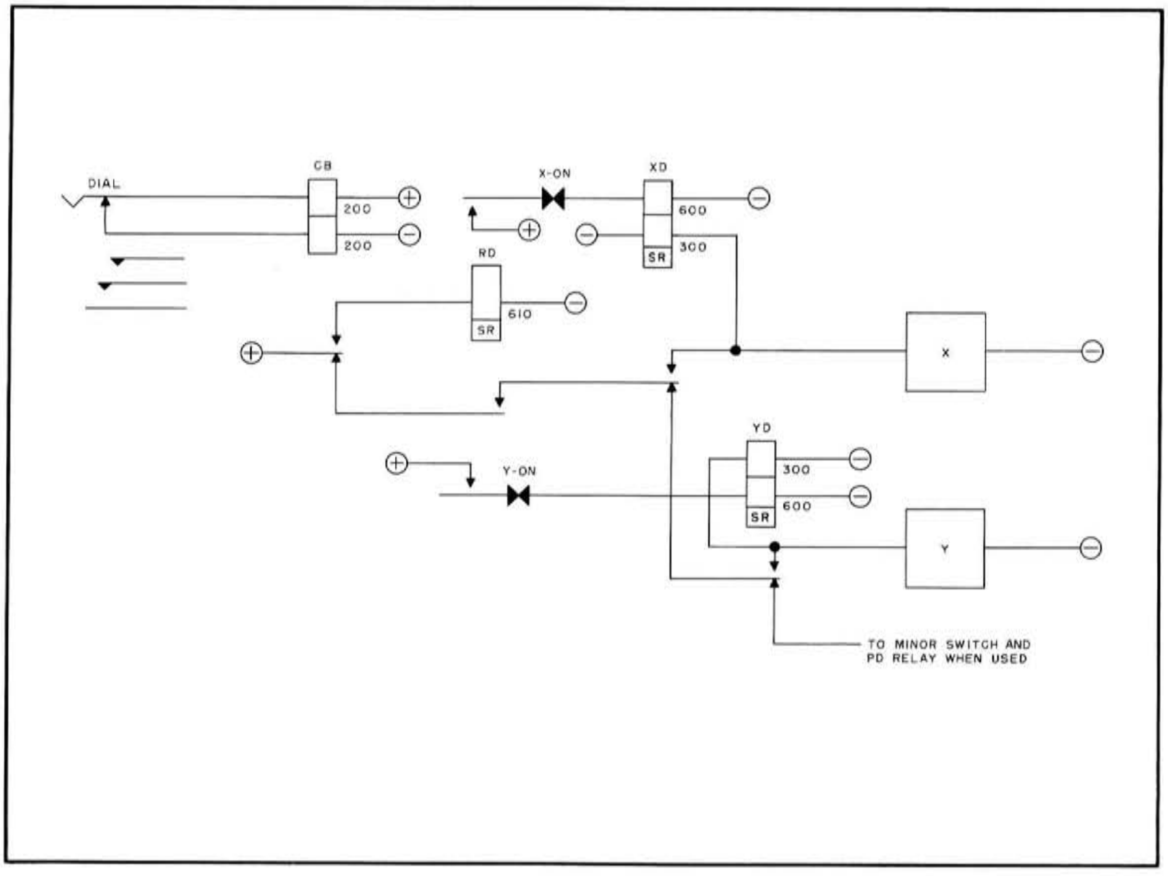


Figure 58. The Basic Impulsing Circuit

The operation of this circuit is as follows: When the Calling Bridge (CB) relay is operated by a bridge on Tip and Ring, the Release Delay (RD), X-Delay (XD), and Y-Delay (YD) relays all operate, the XD and YD relays operating on their respective 600 ohm windings in series with the X and Y off-normal (X-ON, Y-ON) contacts. The last three of these relays are slow to release and will remain operated even though the path which operates them is momentarily opened as it will be when the dial, shown connected to Tip and Ring, is returned to normal, thus opening the circuit to the CB relay the number of times indicated by the number to which the dial has been pulled.

During the first open period, as the dial returns to normal, the CB relay releases. A path is then established to pulse the X-magnet once and to move the cog-roller and carriage assembly on the XY Universal Switch one step in the X direction. The RD relay remains operated so long as the CB relay does not remain unoperated longer than the release time of the RD (approximately 200ms). After the momentary opening of the dial contacts the contacts reclose and the CB relay reoperates, re-establishing the path to the RD relay so that it remains operated.

When the XY Universal Switch moves off normal the X off-normal contacts (X-ON) are broken. These contacts are therefore useless in maintaining the XD relay operated, even though it was through this path that the XD relay operated initially. It is therefore necessary that the CB relay release again shortly in order to hold the XD relay operated and to pulse the Switch a second step. Provided that the CB relay releases again within 100ms, the XD relay will maintain the path to the X-magnet and the Switch will be pulsed in the X direction.

During dialing, then, the RD and XD receive alternate pulses of current which cause them to remain operated and the Switch receives a pulse each time the CB relay releases.

Upon the completion of the first digit the CB relay remains operated and, because no further pulses are forthcoming from the pulsing contacts of the CB relay, the XD relay releases. The release of the XD relay establishes a path for pulsing the Y-magnet. During the registration of the second digit the same action takes place except that the YD relay is maintained operated and the Y-magnet is pulsed.

In Selectors, the release of the XD relay initiates the searching function to be described later.

In Connectors containing minor switches a similar circuit pulses the minor switch on the third digit.

Lock Pulse Operation (Fig. 59)

Telephone exchanges frequently are designed to ring 10 parties, all connected so that the ringers bridge the two sides of the line. Under this condition most impulse repeating relays distort the pulse so badly that it is impossible to step the XY Universal Switch without special circuit design.

Under these circumstances, the Lock Pulse circuit is used. Even though the percentage make of the moving and back contact of the impulse repeating relay is insufficient to step the XY Universal Switch, it is sufficient to operate a properly designed relay. This relay is arranged so that if it is once operated it cannot be released except by the complete operation of the associated magnet.

The Lock Pulse relay is locked operated until the XY Universal Switch completes its stroke and opens the interrupter, whereupon the Lock Pulse relay

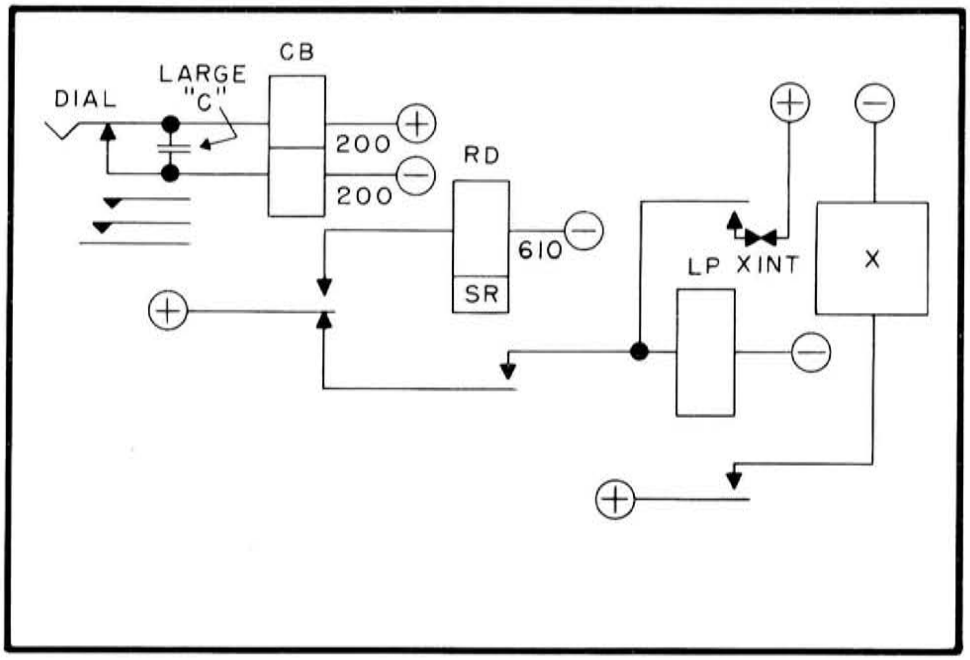


Figure 59. Lock Pulse Operation

releases and prepares to repeat the operation on the next pulse. This circuit assures that the Switch will make a complete step from a very short pulse. The Lock Pulse relay normally is designated LP.

Self Interrupt Operation (Fig. 60)

The XY Universal Switch, rotary switch, and minor switch all can be equipped with interrupter springs which open as the armature approaches the core on the downstroke. In some circuit operations, the switches will be arranged to pulse in the condition termed "Self Interrupt" operation.

This circuit is similar to that used in the electric doorbell but considerably more precise adjustment is required. As the armature approaches the core, the interrupter springs open, thus opening the circuit to the magnet. When the magnet releases as a result of this, the contacts reclose and current flow is re-established. While this has occurred electrically, the armature has moved a sufficient distance mechanically to move the wipers from one bank contact to the next through the mechanical linkage.

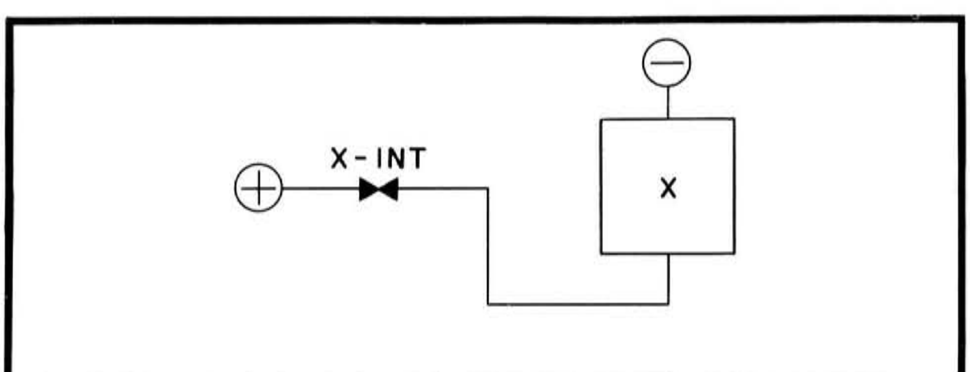


Figure 60. Self Interrupt Operation

This operation will continue until the circuit is broken by some external condition.

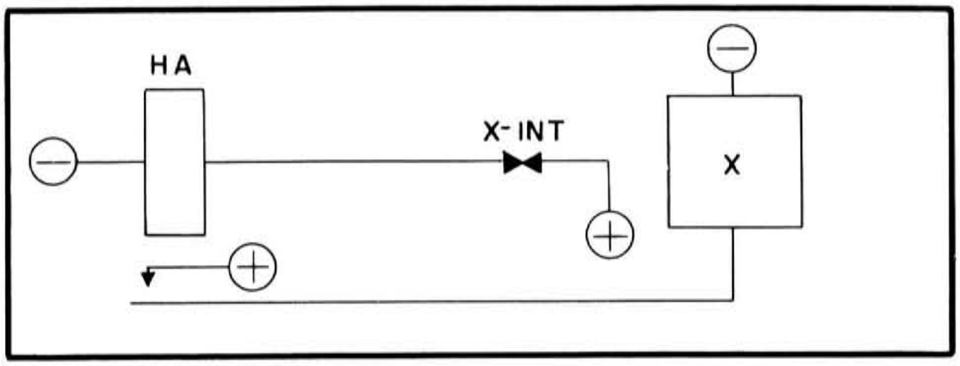


Figure 61. Pulse Assist Operation

Pulse Assist Operation (Fig. 61)

In order to stabilize the switch or slow it down, a variation of self interrupt operation is used. In this circuit a relay is included which is controlled from the interrupter contacts of the switch and the relay contacts complete the circuit to the switch magnet. In this case the relay operate and release time add to the switch operate and release time and thus reduce the speed of pulsing. This relay is normally designated the HA or PA relay.

The Shunt Relay (Fig. 62)

Certain circuits require a relay which operates from the impulsing relay when it releases on the first pulse, remains operated throughout the digit and releases when the digit is completed.

Contacts on this relay may be arranged to short windings on a repeat coil during pulsing.

This relay usually is designated the SH relay.

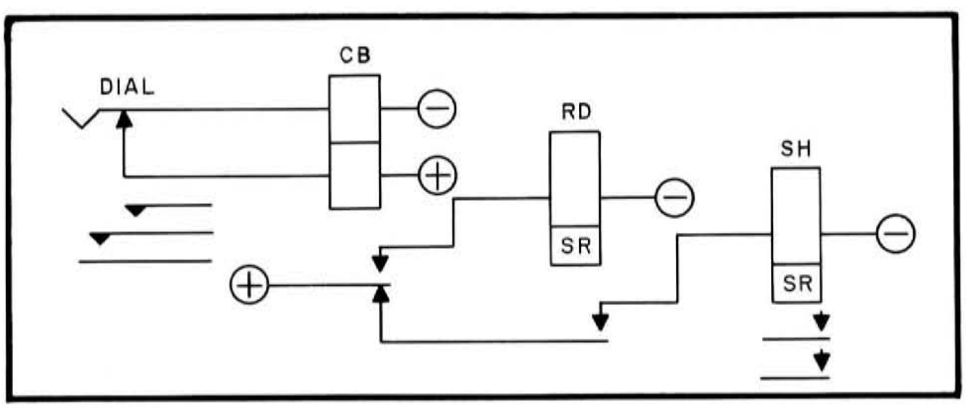


Figure 62. The Shunt Relay

Differential Relays

In certain types of circuit operation it is advantageous to connect a relay so that the magnetic field of the two windings oppose each other. Such a relay is said to be differentially connected. In order to produce differential action in a relay the magnetic fields must be opposite in each winding, or + to − on relay coil terminal "a" to relay coil terminal "c", and − to + on relay coil terminal "b" to relay coil terminal "d." An example of a differential relay is relay SR1, shown in Figure 80.

Pulsing Source

An example of a two relay pulse generating circuit is shown in Figure 63.

Rotary Switch Hunting Circuit

In some Allotters used in the XY Dial System, the rotary switches search for the idle Linefinders using the principle shown in Figure 64.

The rotary switch operates on an indirect drive principle, the movement of the wipers taking place when the armature releases. When the magnet operates as a result of the ground on step 1 of the banks, the wipers remain on step 1 and the interrupter opens the current to the magnet. When the current is broken, the magnet releases, moving the wipers to step 2 where a ground reoperates the magnet through the interrupter and the cycle repeats so long as ground is located on the next step. When the wipers reach step 8, the ground for operating the magnet is no longer present and the switch remains on that step until a ground is applied.

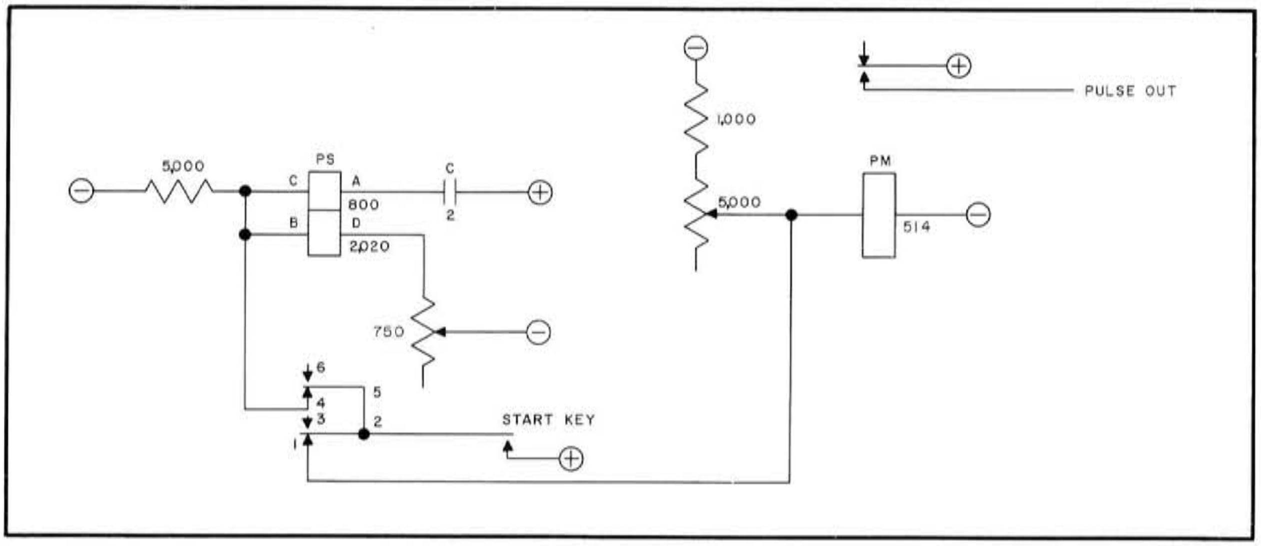


Figure 63. Pulsing Source

The wipers and banks are not designed to break or make circuits carrying heavy currents. For this reason, the wipers are designed to bridge two steps momentarily when moving from one bank terminal to another.

Biased Relay

When rapid operation of a relay is desired, it is sometimes necessary to bias the relay magnetically. Figure 65 illustrates the principle. The biasing winding is generally a high resistance winding which is wound on the relay. It may be in series with a resistor. The biasing winding and the combination are chosen so that when the winding is energized, the relay requires only small additional flux, contributed by the operating winding, in order to operate.

Electropolar Relay

Some circuits require a relay which will detect the polarity of the voltage applied to one of its windings. Where the requirements are not too severe; the electropolar relay (P) illustrated in Figure 66 is sometimes used.With the circuit as shown, relay P is connected so that the fluxes contributed by the two windings cancel each other. When the A relay is operated, the current flowing through the "a-c" winding of the P relay is reversed and the fluxes add, thus operating the P relay.

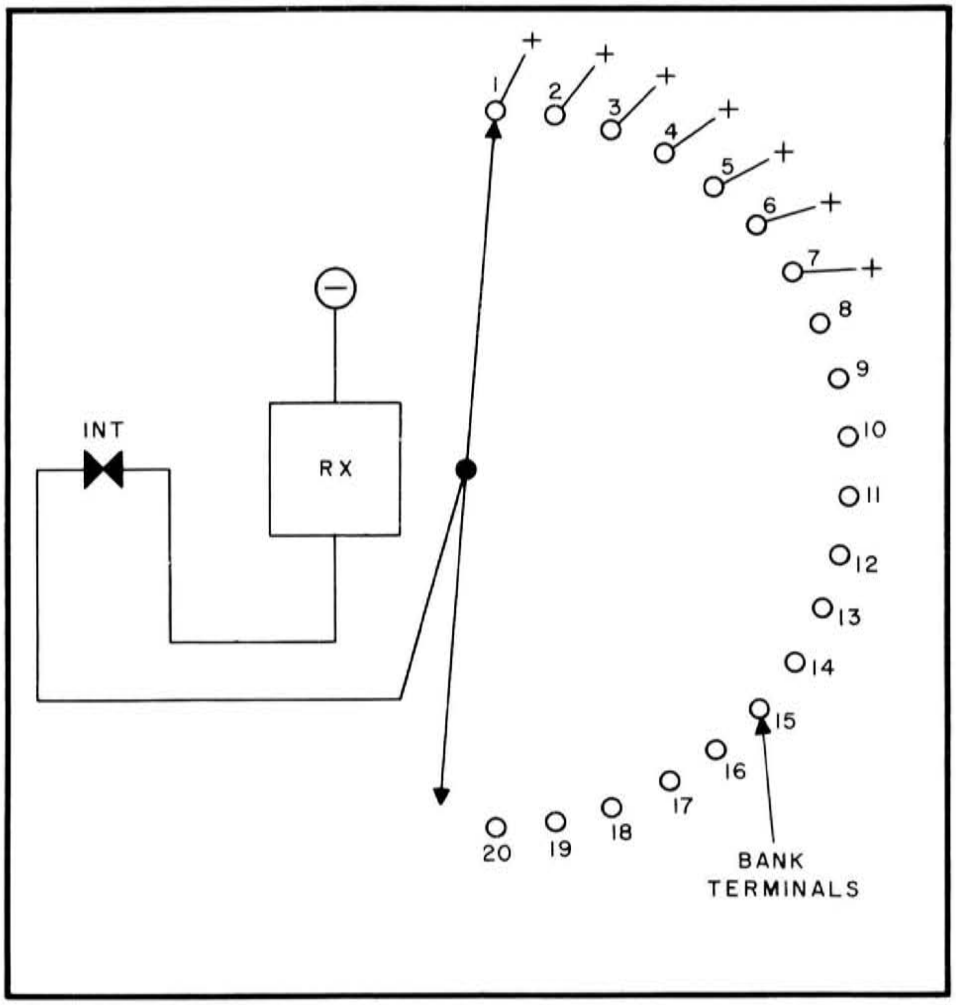


Figure 64. Rotary Switch Hunting Circuit

SELECTOR CIRCUIT PRINCIPLES, ABSENCE OF GROUND SEARCHING

Figure 67 illustrates "Absence of Ground Searching" as used in the Selectors when hunting for idle equipment in a given group. The circuit illustrated is that which functions after the X digit has been registered and the Selector is prepared to search in the selected level for idle equipment.

The control of this circuit lies in the presence or absence of ground on the Sleeve bank. If the succeeding circuit connected to any step is busy, a ground is sent back to the bank terminal to indicate to Selectors subsequently searching for idle equipment in the same level that the unit connected to that particular step is engaged. Absence of ground indicates an idle unit, and the Selector will therefore switch through to the idle equipment.

The operation of this circuit is as follows: Release of the XD relay after completion of the X digit operates the Hunt Assist (HA) relay through the Y off-normal (Y-ON) contacts. Operation of the HA relay operates the Y-magnet and advances the Y carriage and wipers one step, thus opening the Y-ON contacts. The HA relay locks itself operated through the Y-interrupter (Y-INT) contacts of the XY Universal Switch, thus maintaining the magnet operating ground until the interrupter contacts open.

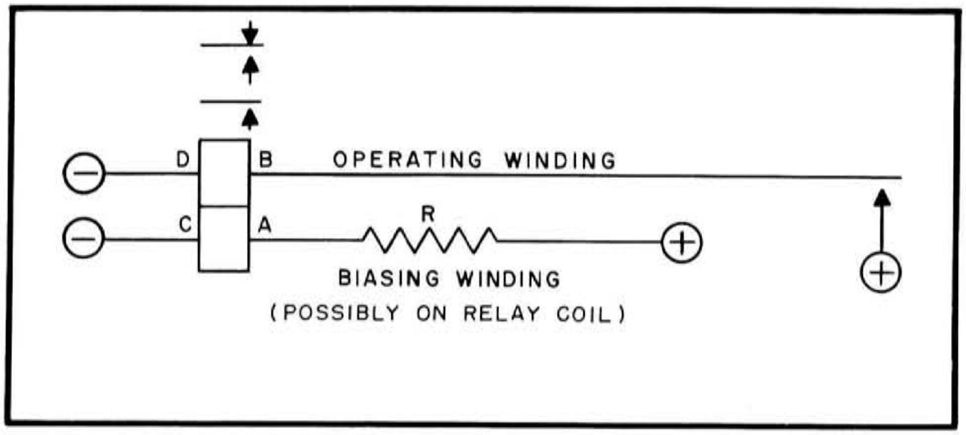


Figure 65. Biasing

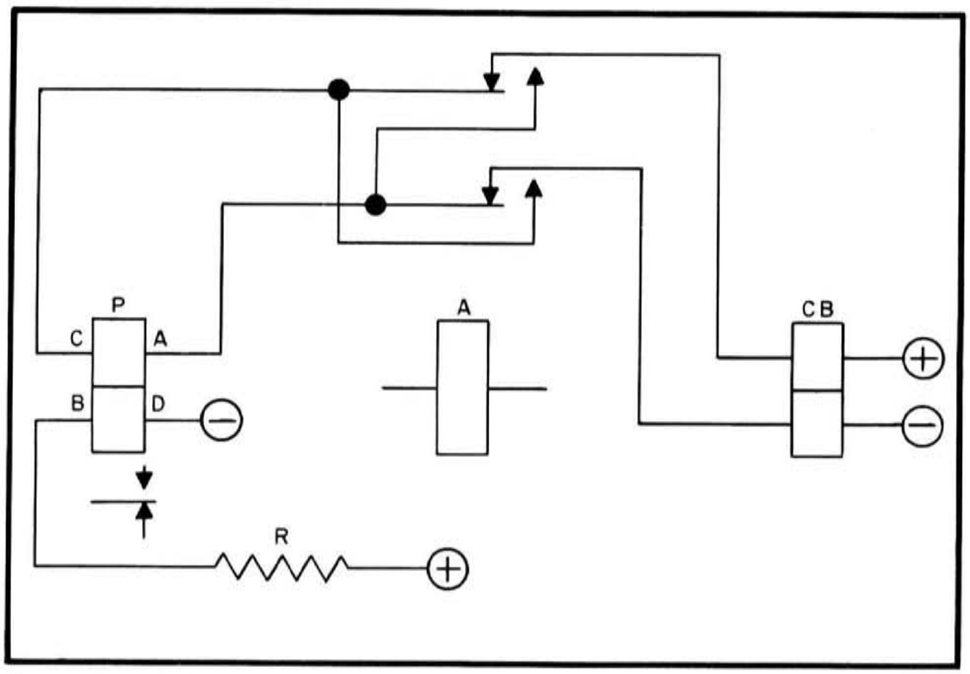


Figure 66. Polar Relay

As the Sleeve wiper advances it prepares to test the first step in the Sleeve bank to determine whether it is idle or busy. The ground which locks the HA relay operated is forwarded on the Sleeve wiper. Since the Y-interrupter contact opens when the Y-magnet operates completely, the locking path of the HA relay is broken, allowing it to release. The release of the HA relay removes ground from the Y-magnet thus allowing the Y-magnet armature to return to normal.

The Sleeve wiper is now prepared to test step one. If the first step is grounded as a result of being busy the HA relay is reoperated from the Sleeve wiper and the Switchthrough (SW) relay is prevented from operating because both sides of the winding are grounded; one ground originating at the RD relay, the other at the grounded Sleeve bank.

The operation of the HA relay reoperates the Y-magnet and also forwards a

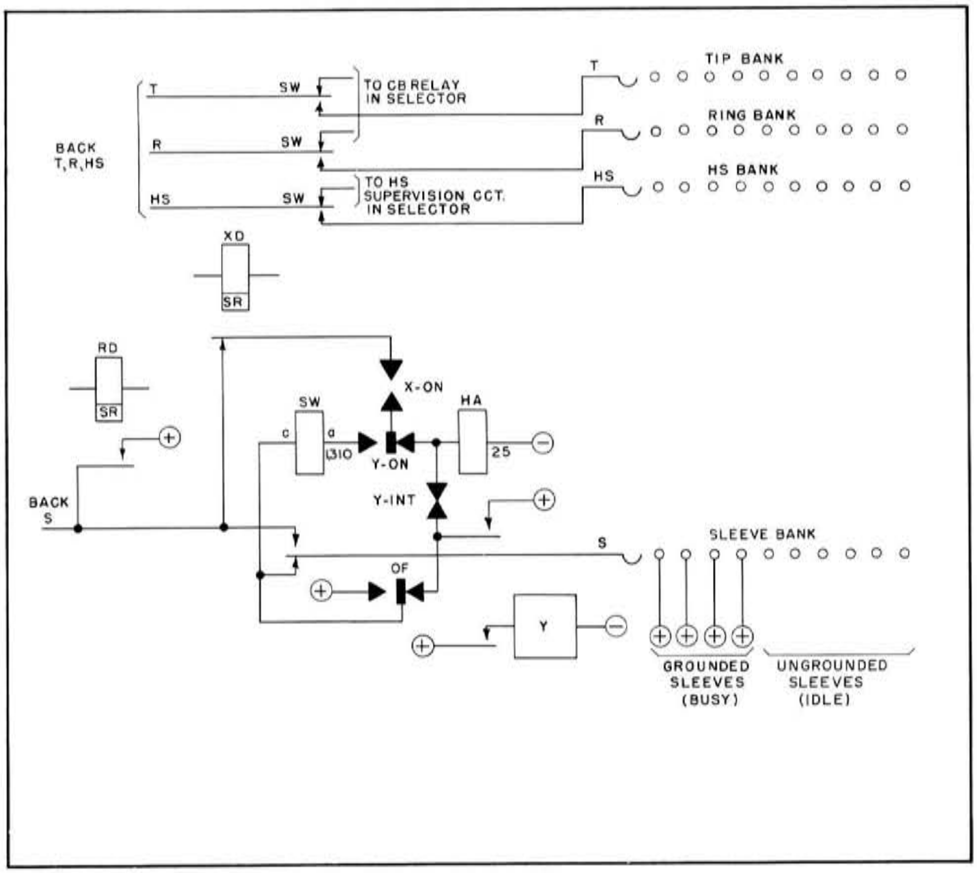


Figure 67. Absence of Ground Searching

ground on the Sleeve wiper to prevent the operation of the SW relay during the period of time occupied in moving the Sleeve wiper from step one to step two. The operation of the Y-magnet breaks the Y-interrupter contacts, thus allowing the HA relay and the Y-magnet to release. Upon the release of the HA relay the covering ground is removed from the Sleeve wiper and the wiper proceeds to test step two. If step two is busy the HA relay is reoperated and the operation again proceeds as described, advancing the wipers so long as ground is located by the Sleeve wiper on each succeeding step of the Sleeve bank.

When the Sleeve wiper encounters a step in the Sleeve bank which is not grounded, the SW relay is allowed to operate in series with the HA relay because it is no longer shunted by ground on the Sleeve wiper. The operation of the SW relay completes the path to the succeeding Switch for the Tip, Ring, Sleeve, and Helping Sleeve leads.

When the succeeding circuit is engaged, ground is returned to the Sleeve bank thus busying the step used by this Selector to all succeeding Selectors which may encounter it. The Sleeve ground returned by the succeeding circuit holds the SW relay operated in series with the HA relay, which does not operate because of its low resistance.

CONNECTOR OPERATION

Busy Testing and Switchthrough

When the Connector has moved to the position indicated by the dial it is necessary to test the called line to determine whether it is busy or idle. The

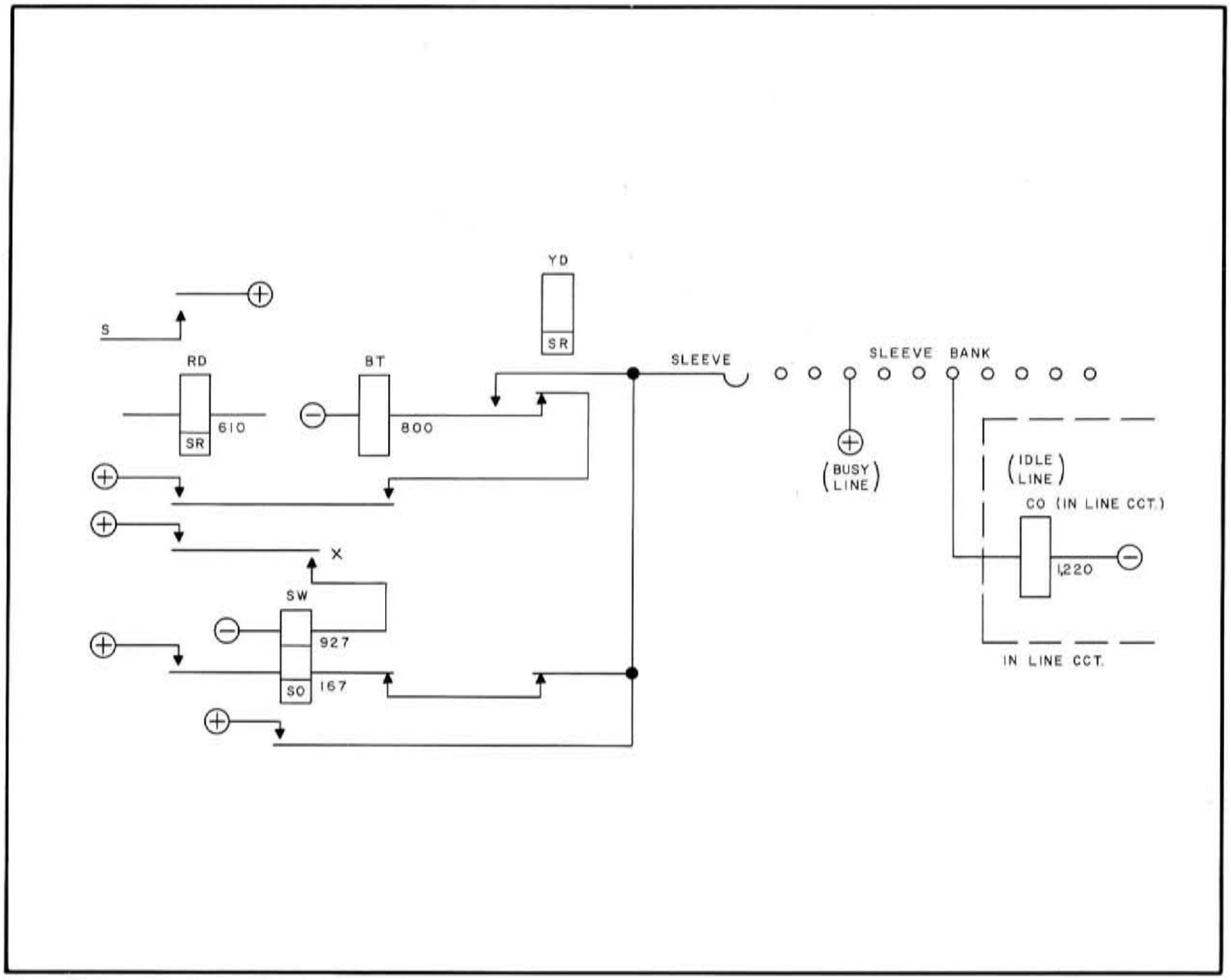


Figure 68. Busy Testing and Switchthrough

circuit illustrated in Figure 68 outlines the principles of operation of this portion of the Connector.

The operation of this circuit is as follows: At the time that the Sleeve wiper makes contact with the Sleeve bank terminal selected by the dial, the YD or PD relay (either may be used, depending upon the particular Connector) is still in the operated position. If a ground appears on the Sleeve bank terminal, indicating that the called line is busy, the Busy Test (BT) relay operates and locks itself operated through contacts on the YD (PD), BT and RD relay after the YD (PD) relay has released. Busy Tone is sent to the calling subscriber and the called line is not signalled.

If the called line is idle, 1,200 ohms battery will appear on the Sleeve terminal of the wire bank. When the Sleeve wiper encounters the 1,200 ohms Cut-off (CO) relay resistance to battery on the Sleeve bank, the BT relay is not operated; and when the YD (PD) relay has released, a path is prepared to operate the Switchthrough (SW) relay so that the called line may be signalled. The SW relay operates in series with the CO relay, which operates first, and locks itself operated to ground through contacts on the RD relay. Upon operation of the SW relay, a ground is forwarded on the Sleeve wiper to ground the bank terminal so that succeeding Connectors testing the same called line will be given a busy indication. The operation of the SW relay switches Tip and Ring through to the called line and prepares the circuit for signalling and ultimate conversation if the called line is answered.

Ringing Trip Circuits

After the called line has been tested and found idle by the Connector, the SW relay operates to start ringing the called station. When the called station is answered, it is necessary to stop the ringing instantaneously, and to connect the talking path (Tip and Ring) through, so that conversation may begin. The circuits illustrated in Figure 69 accomplish this.

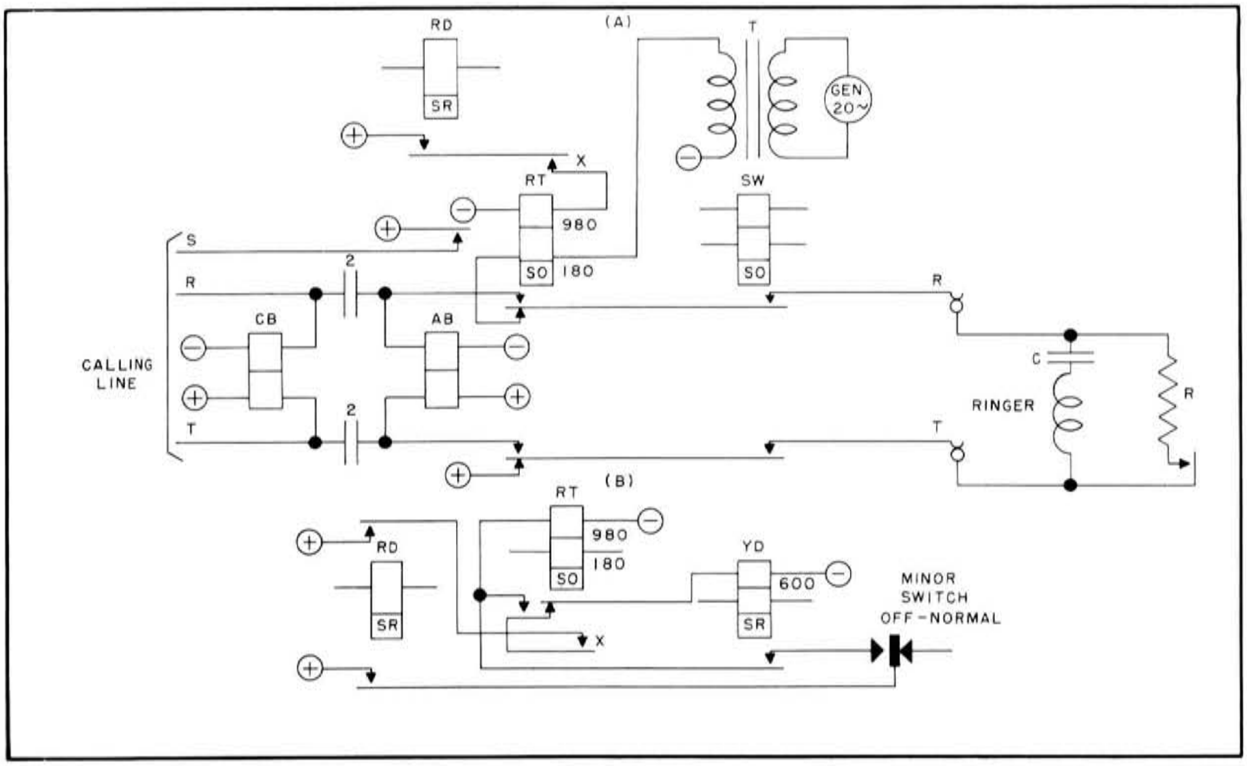


Figure 69. Ringing Trip Circuits

There are two versions of this circuit in use. The sketch shown in Figure 69(A) is used in single party Connectors and that shown in Kigure 69(B) is used in multiple party line Connectors.

During the ringing interval, only the telephone ringer is across the line, in series with the ringer capacitor. When the telephone is answered, the transmitter places a resistance bridge across the line.

The ringing voltage is superimposed on the D.C. exchange voltage by means of the transformer (T).

When the SW relay operates, superimposed ringing is sent out to the called station. The design of the coil used on the Ringing Trip (RT) relay is such that this relay will not respond to alternating current and consequently does not operate when ringing current flows through the coil.

When the called subscriber answers, the RT relay operates in response to the direct current flow caused by the resistance bridge of the telephone. When the X contact on the RT relay closes, the RT relay locks operated to the ground forwarded from contacts on the RD relay.

When the RT relay operates, the called T and R is transferred to the windings of the Answering Bridge (AB) relay, thus establishing the talking path.

Figure 69(B) is used for party line Connectors because of the additional capacitance across T and R of the called party line. Under certain circumstances, the additional capacitance may result in large charging currents when ringing is first applied to the line. The charging currents have the same effect on the RT relay as direct current and it is therefore necessary to guard against premature operation of the RT relay.

The sketch in Figure 69(B) shows only the locking path for the RT relay. The ringing path is the same as is shown in Figure 69(A). When the called subscriber answers, the X contact on the RT relay closes, operating the YD (being re-used). When the YD operates, ground from the RD relay energizes the high resistance winding of the RT through contacts on the YD relay and the minor switch off-normal (operated) contacts. When the RT operates completely, the YD releases and the RT locks to ground from the RD relay through its own X and D contacts.

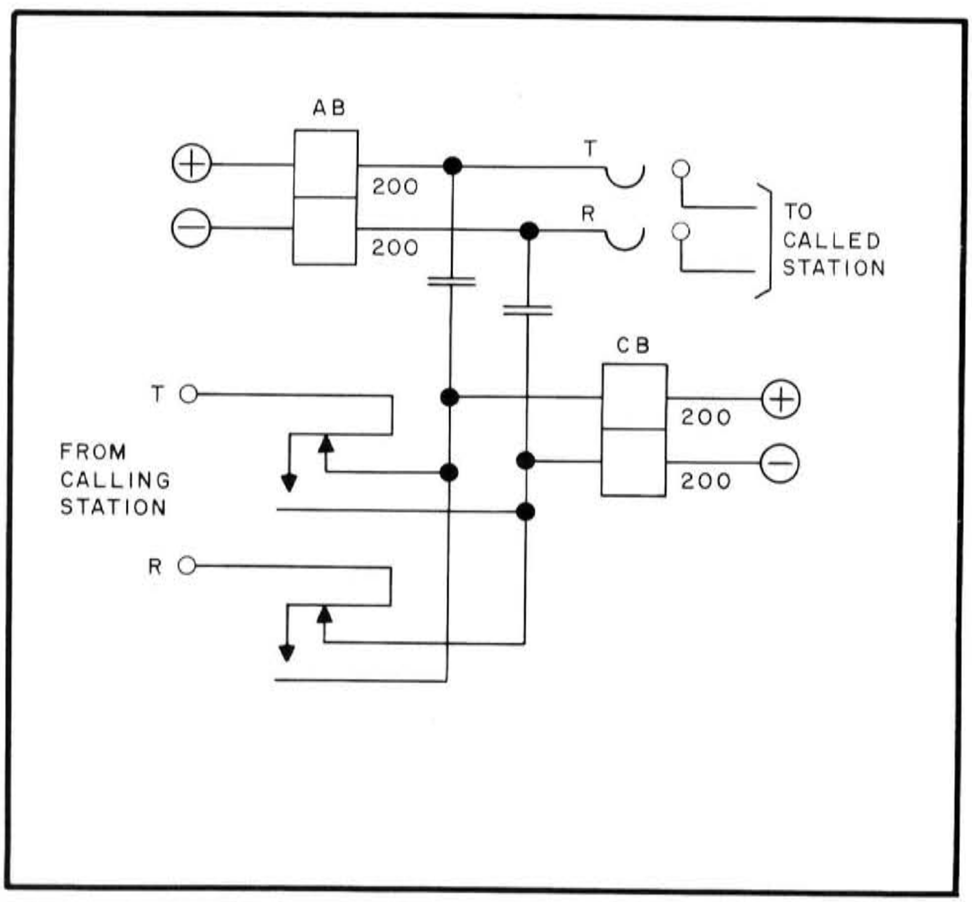


Figure 70. Reversal of Battery

Reversal of Battery

Connectors of the XY Dial System reverse the potential applied to the Tip and Ring conductors when the called station lifts the handset from the cradle. This reversal of potential is a means of indicating that the called station has answered and is used to provide supervision on certain trunk circuits and to control paystation magnets and message registers if required.

Figure 70 illustrates Battery Reversal. The operation of the circuit is as follows: In the circuit as shown the Tip conductor is connected to positive, and the Ring conductor to negative through the windings of the CB relay.

When the call is completed the Answering Battery Feed (AB) relay operates as a result of the called station bridge and reverses the potential applied to Tip and Ring.

Trunk Hunting

Trunk circuits leading to an XY-PBX normally are terminated on Line Circuits in the CDO or MDO. Where more than one line is involved, as is usually the case, the lines are grouped consecutively in a given level and become what is known as a "Consecutive Number" or "Trunk Hunting" group. It is the normal practice to list only the lowest number of the group in the telephone directory so that all Connectors will test the lowest number first. If this number is busy the Connector will automatically step to the next possible path located on the succeeding terminal and will test the line. If this line is idle the Connector will switch through and signal the PBX operator. If the line is busy the Connector will again step forward in an attempt to locate an idle line in the group, stopping only when it has either located an idle line or advanced to the last line in the group, in which case Busy Tone is sent to the calling subscriber.

From two to ten lines may be involved in a Consecutive Number Group and the quantity used may be changed conveniently by the operating company.

The circuit which controls the Trunk Hunting Operation is illustrated in Figure 71 and operates as follows:

The S and HS lead of all lines but the last in the Consecutive Number Group have been strapped together (lines L2, L3, L4, L5 and L6). Lines L2, L3 and L4 are busy (ground on Sleeve bank) and lines L5 and L6 are idle.

The seizure of the Connector has operated the PH, PD, and RD relays. The XY Universal Switch has been stepped to the second step in the Y direction, and the BT relay is operated because line L2 is busy.

When the registration of the third digit is completed, the PD relay releases, closing contacts 1 and 2. The ground from the Sleeve bank also appears on the HS bank and operates the HA relay through contacts on the BT, PH and PD relays and the XY Universal Switch Y-magnet interrupter. The HA relay locks itself operated through its own contacts (1 and 2) and contacts 10 and 11 on the PH relay.

The Y-magnet operates from ground through contacts on the PH and HA relays, and the sleeve and HS wipers are stepped forward, the BT relay releasing and reoperating if the next terminal is busy. Simultaneously the HA relay releases because the Y-magnet interrupter has opened as the armature approaches the core, thus opening the path to the Y-magnet and the locking

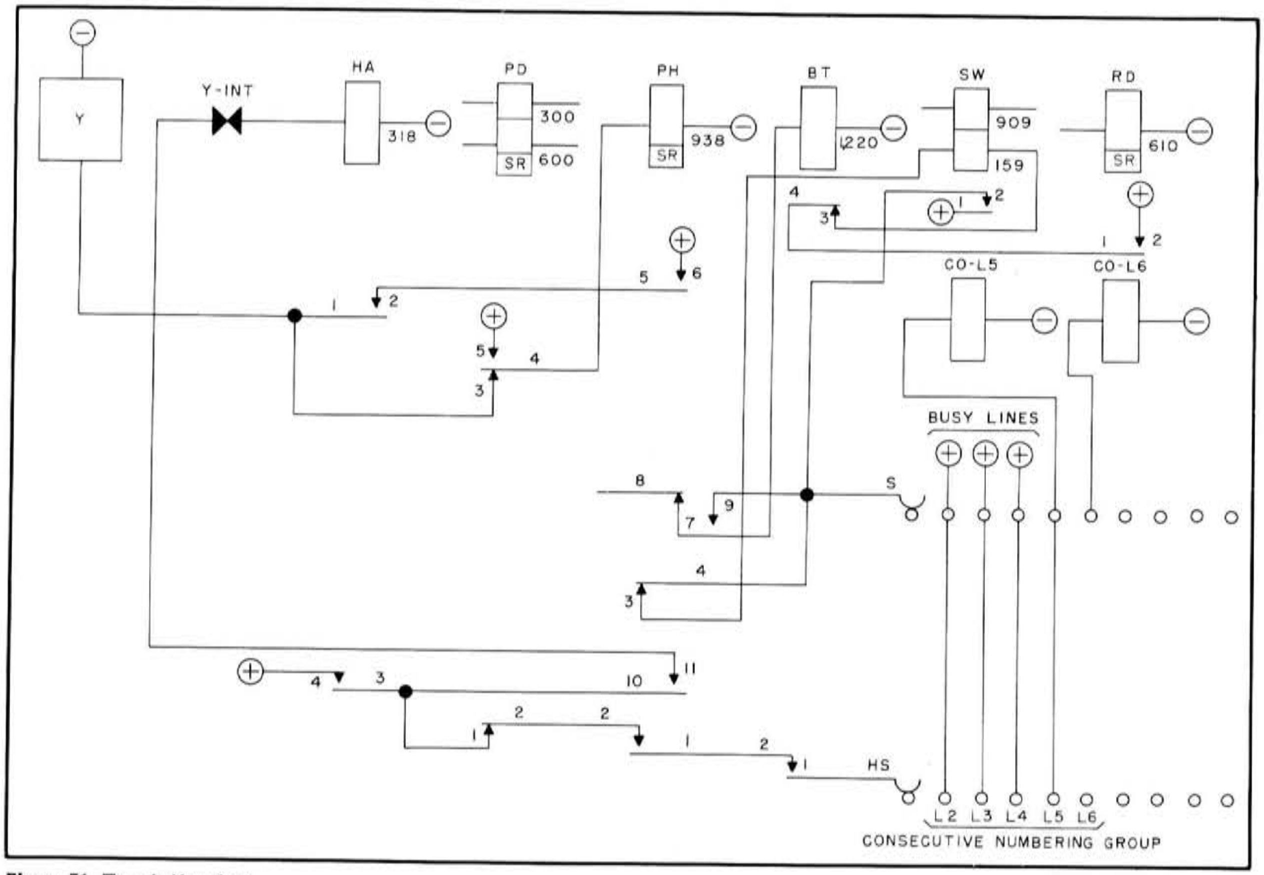


Figure 71. Trunk Hunting

path of the HA relay.

If the next step is busy, the BT reoperates and ground from sleeve reoperates the HA relay and the cycle repeats so long as the sleeve of the succeeding step is grounded. The PH relay remains operated on the pulses forwarded to the Y-magnet during the hunting interval.

When an idle line is encountered, the BT relay does not reoperate and the path to reoperate the HA relay no longer exists. The PH relay then releases and switchthrough takes place in the normal manner. (See "Busy Testing and Switchthrough")

If all lines in the Consecutive Number Group are busy, the operation stops because the strap between the S and HS banks is not present in the last terminal and hence there is no way to reoperate the HA relay.

While this circuit has proved to be reliable in operation, it is critical in several respects as follows:

a. The BT relay must release rapidly.
b. The PH relay must remain operated during the hunting interval.
c. The Y-interrupter must be adjusted for reliable stepping of the Y-magnet.

Trunk Hunting with Night Service

The previous section has described trunk hunting into an XY-PBX, however, if a specific line in the PBX is desired, the night service feature allows dialing and testing of that line, without hunting over the other busy lines. This may be accomplished as long as the line called is not the first line in the group. If the first number in the group is dialed, the Connector will hunt in the previously described manner.

The Transmission Bridge Circuit (Fig. 72)

The Connector in the XY System provides the transmission circuit (or bridge) between the calling and called telephones on a local call and the transmission bridge to the called telephone on inward toll calls. The transmission bridge consists of two inductances (relay windings of special design) and two capacitors. Transmission battery is supplied individually to the calling and called telephones through the balanced windings of these inductances. The two transmission battery circuits are coupled through a pair of capacitors in series with the line wires. This circuit is basically a high pass filter which provides increased transmission efficiency as the frequency is increased.

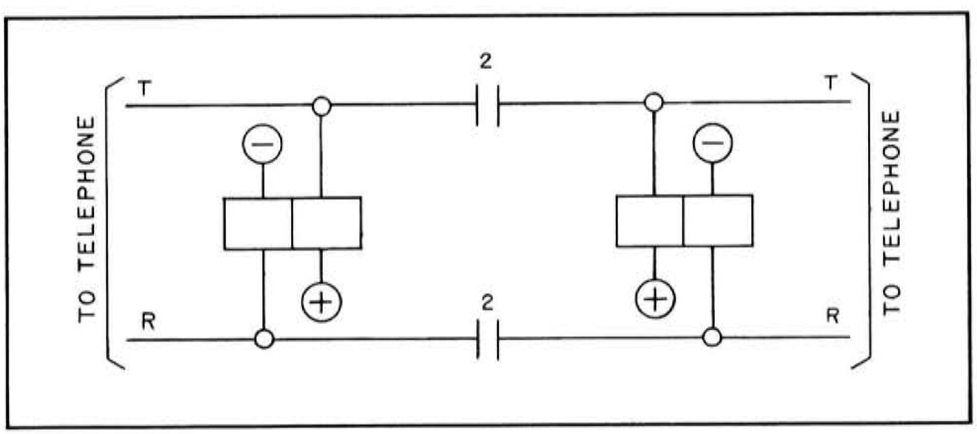
The following characteristics are desirable in transmission bridge relays when considered from the standpoint of supplying current to the subscriber's transmitter.

a. The total impedance should be as large as possible under all conditions.

b. The self impedance of the two windings should be as nearly equal as possible under all conditions.

d. The resistance of each of the windings should approximate 200 ohms (for a 50V office) and they should be as nearly equal as possible.

In order to follow dial pulses properly over all line conditions the impedance is limited for the calling bridge (CB) relay, since an increased number of turns means increased resistance as well as inductance, and the operate time of the relay is extended without affecting the release time appreciably. A compromise which will allow satisfactory repetition of dial pulses and still not introduce excessive bridging loss on a 600 ohms line is therefore necessary.



Reverting Call

A call from one party on a line to another party on the same line is called a Reverting Call.

There are three basic types of Reverting Call circuits commonly used in XY Dial Systems.

- Reverting Call by Directory Number
- Reverting Call by Directory Number with a Prefix Code
- Reverting Call by Code Number ending with the ringing digits of called and calling parties.

The choice of system used depends upon several factors including, size of exchange, type of ringing and type of Line Circuit employed.

The Completed Call in the XY Universal Switch Train. Reverting Call by Directory Number appears, on the surface, to be the most complicated, but in reality is found to be quite simple if the functions of each circuit in an XY Universal Switch Train are understood.

Figure 73 shows the talking pair and control leads in an XY Universal Switch Train. Note particularly that from the Line Circuit there are T, R, S and SN leads. The T and R are connected to both Linefinder and Connector wire banks. This permits a line either to originate or receive a call. However, the S lead is separate from SN. The S lead goes to the finder banks and the SN to the Connector banks.

After the Connector is seized, the RD relay applies a ground to its own Back Sleeve, thereby holding the SW relays of Selector and finder as well as CO of Line Circuit operated. With the LR relay normal, and CO relay operated, the SN and S leads are connected together. Consequently the ground applied by the Connector on the Back Sleeve also appears on the SN lead going to the Connector bank.

Thus, if a Reverting Call is being made, it means that the Connector is stepped, by dialing, in such a manner that the T and R wipers are connected to the T and R of the line originating the call. This S wiper will encounter a ground, which is the usual signal that the called line is busy. However, by virtue of the fact that a reverting call is being made, the "busy ground" which the S wiper encountered originated within the Connector. Note the circuit from the S wiper of the Connector out of the Connector through normal contacts of LR and operated contacts of CO relay to S lead at the Line Circuit, then through the switch train into the Connector on the Back Sleeve lead.

The Connector Circuit may now be used for Reverting Calls by Directory Number by merely adding an RC (Reverting Call) relay to the Connector. The RC will test the "busy ground" found by the Front Sleeve and determine if it originates within the Connector. If the "busy ground" is from the Connector, the RC relay will be shunted down, keeping it from operating, thus indicating to the Connector that the call is a Reverting Call and to ring on the

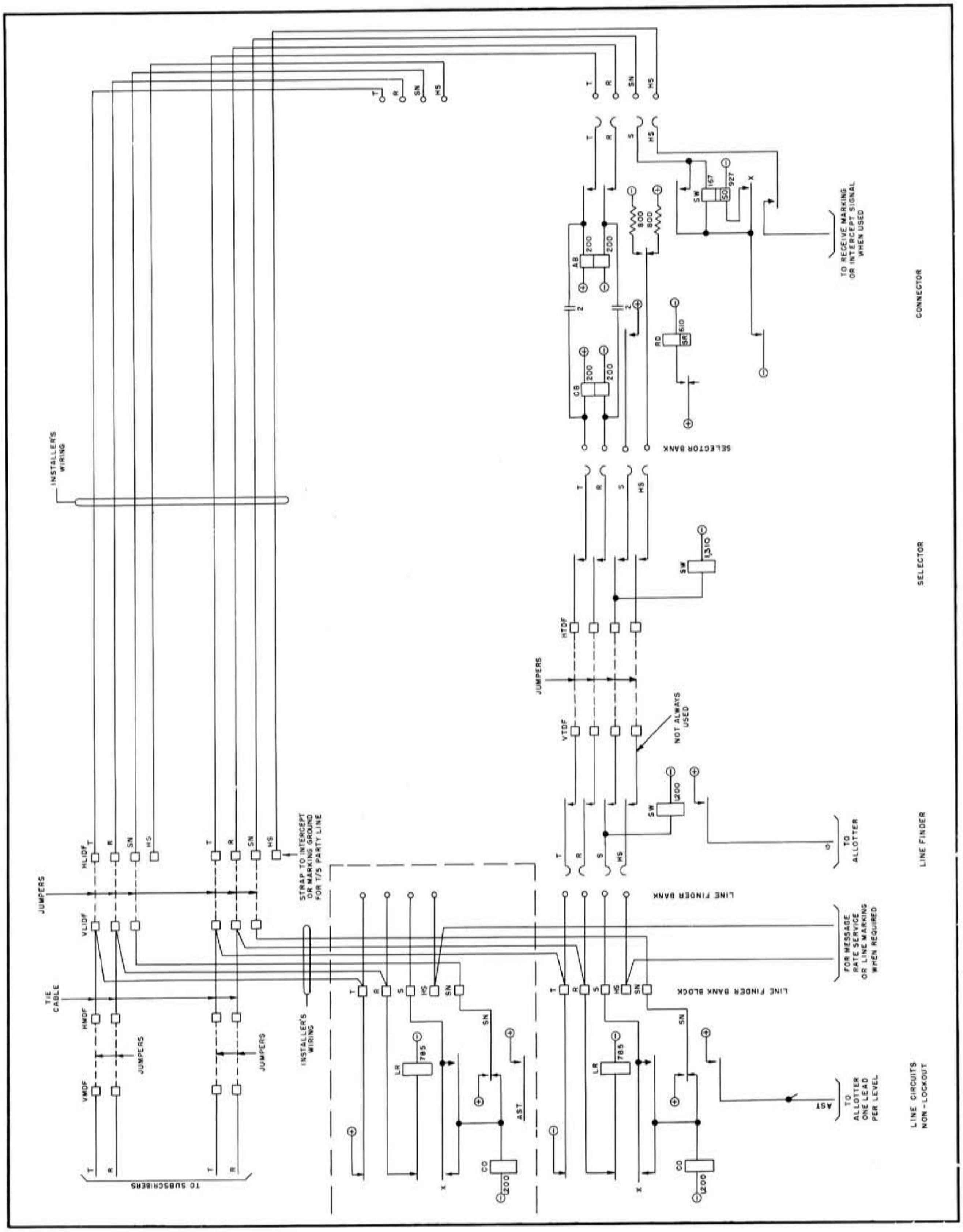


Figure 73. Talking Pair and Control Leads in an XY Universal Switch Train

line when the calling party hangs up.

a. *Reverting Call by Directory Number.* Figure 74 shows the essential parts of a Connector equipped for Reverting Call by Directory Number. When the Connector is first seized, CB and RD operate and, as usual, RD applies ground to the Connector Back Sleeve. But in this case the path from ground on RD contacts to the Back Sleeve is through break contacts on BT which shunt a low resistance winding of RC. In addition, a DD relay is operated. When a Connector is used for a Reverting Call it has been stepped to the line originating the call. The BT relay will operate before PD releases (see Figure 68). Reference to Figure 73 and the above paragraphs show that the ground which operated BT originated within this Connector. Operation of BT removed the shunt from the RC relay. Since the call is Reverting, the Front and Back Sleeves of the Connector are connected as shown in Figure 73, and explained above.

Consequently, the RC relay has ground on its "a" terminal directly from RD contacts, while the "c" terminal is connected to the back S and thus through the switch train to the Front Sleeve into the Connector, through operated contacts of BT (which shunt a winding of SW) and normal contacts of RC to ground on operated contacts of RD. With ground on both the "a" and "c" terminals, RC will not operate.

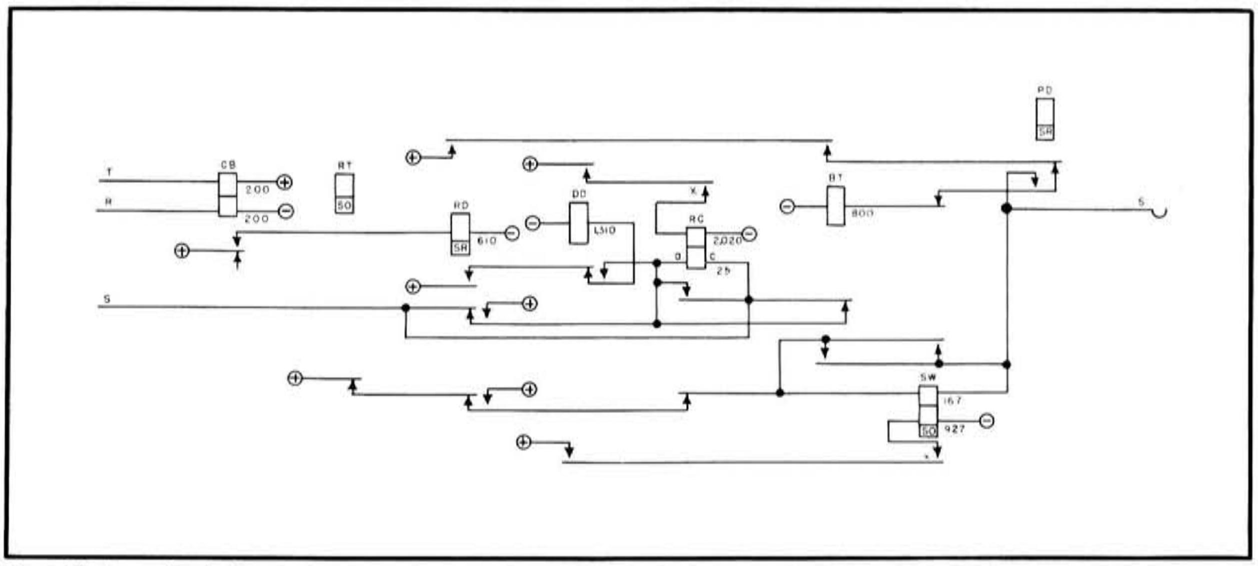


Figure 74. Reverting Call

Had a busy line, other than its own, been called, the Front and Back Sleeve would not have been connected and RC would have operated with ground on the "a" terminal and battery in series with the SW relays of the Selector and finder.

Had an idle line been called, SW would have operated (Fig. 68).

Operation of the BT relay sends Busy Tone to the calling subscriber, who then hangs up, releasing CB and RD relays. The DD relay remains operated, the holding path being from the DD coil through its own make before break contacts, released RD contacts to the Back Sleeve, through the switch train to the Front Sleeve wiper, operated contacts of BT, normal RC, RD and RT contacts to ground. However, with RD released, BT will release, thereby removing the shunt from SW and permitting SW to operate in series with DD.

With SW operated, automatic ringing will start. When any party on the line answers, ringing will be tripped as shown in Figure 69. Operation of RT will release DD, thereby releasing the Connector and causing the Line Circuit to go into Lockout.

During conversation, with this type of Reverting Call, no equipment other than the Line Circuit, which is in Lockout, is held operated.

b. *Reverting Call by Directory Number with Prefix Code.* Reverting Call by Directory Number with a prefix code uses a special Reverting Call trunk, regular switch train, and makes use of the Controlled Ringing features of the Connector. If Lockout-type Line Circuits are not used, the Connector (but no other circuits) are held during conversation.

c. *Reverting Call by Code Number and Ringing Digits.* Reverting call by code number ending with ringing digits of called and calling parties uses a special Reverting Call trunk, into which the ringing digits are dialed. The trunk will then alternately ring the calling and called party. This is particularly suitable for Harmonic ringing, as the calling party can tell when the called party answers, since both phones will stop ringing. If Lockout-type Line Circuits are not used, this trunk is held during conversations.

TERMINAL PER STATION EXCHANGES

The "terminal-per-station" method of operation offers many advantages. The inherent advantages in flexibility lie in that a subscriber may be changed to a different cable pair or moved from one party line to another without changing his directory number. Also, service can be up-graded or down-graded (multiparty to single party service and vice versa) without number changes. In areas where a great deal of moving around occurs, this facility is very useful.

It was with the idea of making the "terminal-per-station" method of operation even more efficient and flexible that the Stromberg-Carlson "Frequency Marking" (Fig. 75) scheme was developed. If any party line station could be assigned to any terminal in any Connector group, a much more uniform fill of the Connector groups could be maintained and a subscribers ringing frequency could even be changed without changing his directory number. By means of the inherent 4th wire of the XY Dial System, each Connector terminal can be marked individually for the frequency with which it is to be rung. Thus, by simple changes in strapping, practically all subscriber shifts within the office area can be handled without changes in directory number and a very efficient fill of Connector terminals can be maintained. As a result of this, more uniform traffic distribution, and fewer Connector circuits are necessary to serve each group of Connector terminals.

Operation

Common ringing relays (Fig. 75 ❼) are provided on the power board which serve to place in time sequence, the five ringing generator frequencies onto generator leads serving the Connectors. All five generators appear in time sequences on each lead. One lead is furnished for each five Connector shelves (1st through 5th Connector groups; 6th through 10th Connector groups, etc.). Marking leads (M1A, M1B, M2, M3, M4, M5) are also grounded in sequence which serve to energize strapped sections on the Connector terminal or bunching blocks which correspond to the ringing generator frequencies. In this manner, the strapped section of the Connector terminal or bunching block (Fig. 75 5-5A) corresponding to generator 5 is grounded at the same time that generator 5 appears on the common generator lead. Cams on the machine interrupter drive the ringing relays and in turn ground marking leads M1A, M1B, M2, M3, M4 and M5 while the corresponding generator appears in sequence on the common generator lead. The actual time position of any particular generator is different on the common generator leads to each of the thousands groups of Connectors and the corresponding marking leads are slipped in the same manner in order to distribute the ringing load uniformly over the whole office. For example, while generator 5 is being rung on the Connectors of the 1st thousands group and M5 is grounded to the generator marking block of the 1st thousands group terminals, generator 4 is being rung on the Connectors of the 2nd thousands group and M4 is grounded to the generator marking block of the 2nd thousands group terminals, generator 3 and M3 to the third thousands group, etc. If a particular Connector terminal is to be rung with generator 5, a generator marking jumper is placed from the HS contact of that terminal to the strapped section corresponding to generator 5 (Fig. 75 5A). Thus, when a Connector Switch cuts through to that terminal, the BT relay (Fig. 75 4) will be operated by the ground appearing on the MS lead during the same period that generator 5 is appearing on the generator lead. The proper generator will be sent through the tripping relay (RT) out to the line.

It can be seen that by simply moving the generator marking strap or jumper, the terminal can be rung with any one of the 5 generators.

If a subscriber moves within the office area, and there is any unused frequency on the new line to which he will be connected, he can be given service immediately without changing his directory number by changing the generator marking strap or jumper and the Connector terminal-to-bunching block jumper (Fig. 75 5-5A-9).

By the use of specially coded marking pulses and a modified Connector circuit, one and two-ring service may also be provided.

It should be pointed out that although the industry has come to know this method of operation as "Frequency Marking" it is not limited to frequency ringing. Superimposed and code ringing may also be used with this system and the same flexibility, efficiency and economy can be obtained.

An alarm system is normally furnished consisting of a marking panel (Fig. 75 6) on which are mounted 5 alarm lamps and associated toggle switches, for each 100 Connector terminal group and a common set of alarm relays (Fig. 75 8). If a foreign ground or cross occurs on an HS lead or a marking lead, the alarm lamp corresponding to the generator in the one hundreds group, in which the fault is located, will light. This lamp lights in series with an alarm relay which locks up a second relay to send a major alarm.

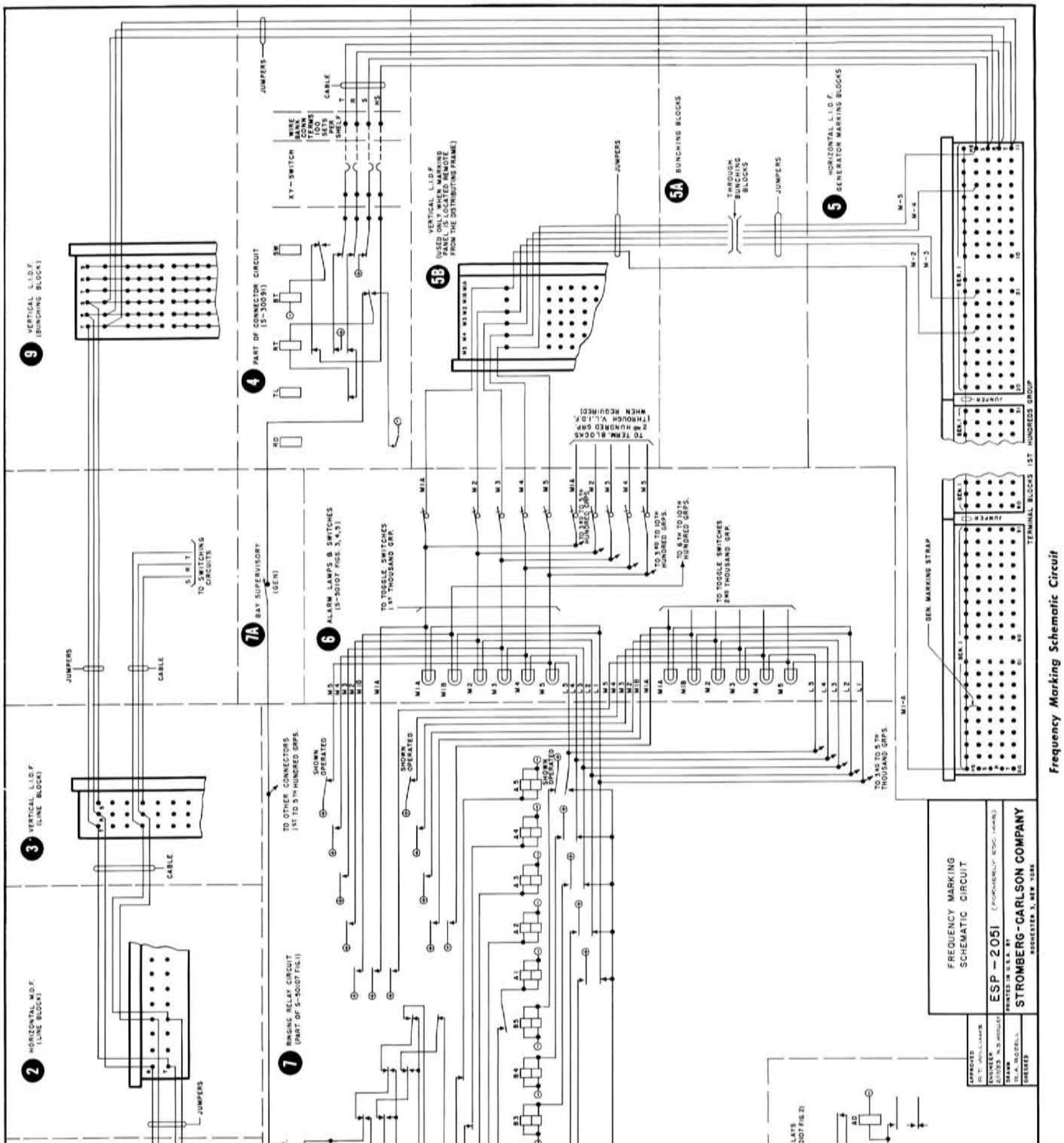


Figure 75. Frequency Marking Schematic Circuit

By operating each of the toggle switches associated with the lighted marking lamp, the lamp will be extinguished by the toggle switch associated with Connector hundred group at fault. This also isolates the fault from the other Connector hundred groups. By operating the generator toggle switch at the Connector bay for the affected shelf the generator will be cutoff to that shelf if so desired.

When the trouble is found and cleared, the toggle switches are restored and normal operation resumes.

THE HS LEAD

The switching circuits of the XY Dial System are designed to handle both local and toll traffic. On calls from a toll switchboard it is the practice to arrange the circuits to operate somewhat differently than they do on a local call. It is necessary, therefore, that some means of discriminating between a local and toll call be provided. The HS lead serves as a path for discriminating signals and the differential duplex circuit shown in Figure 76 accomplishes the required discrimination.

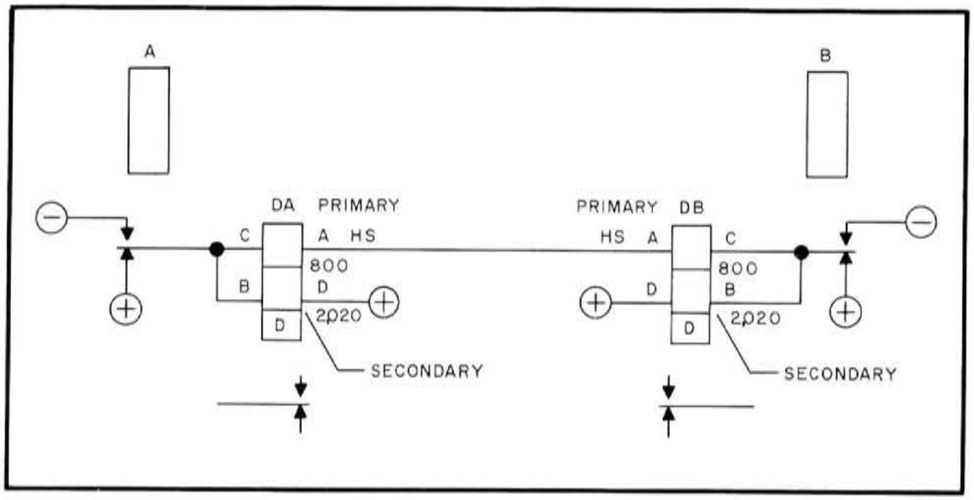


Figure 76. HS Supervision

The operation of this circuit is as follows: With the conditions as shown, no current flows through DA and DB and no relays are operated.

If A is operated, current will flow through DA and DB, but DA will not operate because the flux contributed by either of the two windings is cancelled by the other, the total flux being approximately zero. Since no opposing flux is set up by the secondary winding of DB, DB operates. If B is then operated, DB will remain operated over its local circuit (secondary) and DA will operate over its local circuit because the primary flux disappears as a result of no current flow in the primary winding of the DA and DB relays.

If A is then released, DB will release because the net flux becomes approximately zero (flux from primary and secondary windings opposing) and DA will remain operated as a result of current flowing in the primary.

The release of B allows the DA to release and the circuit has returned to normal.

This circuit allows, in effect, the sending of signals in two directions over a single wire.

For use in a switching circuit, relays A and DA are located in the toll board trunks and B and DB are located in the Connectors. By operation of the A relay the operator indicates that the call is originating in a toll board and the DB relay arranges the Connector for toll operation. When the subscriber answers, the B relay operates, providing answering supervision over the same wire back to the DA relay and the toll operator. Flash busy signals are returned over the same path when required.

The Simplexed Circuit

The Simplexed Circuit is shown in Figure 77. This circuit isolates the talking and signalling by the use of two Repeat Coils (transformers) RC, one at each end of the circuit. Windings "a-b" and "b-c" of each of the two repeat coils must be as nearly equal as possible in both resistance and inductance and normally are "parallel" wound, using special insulation on the wire. The careful balance of these windings enables the circuit to operate satisfactorily.

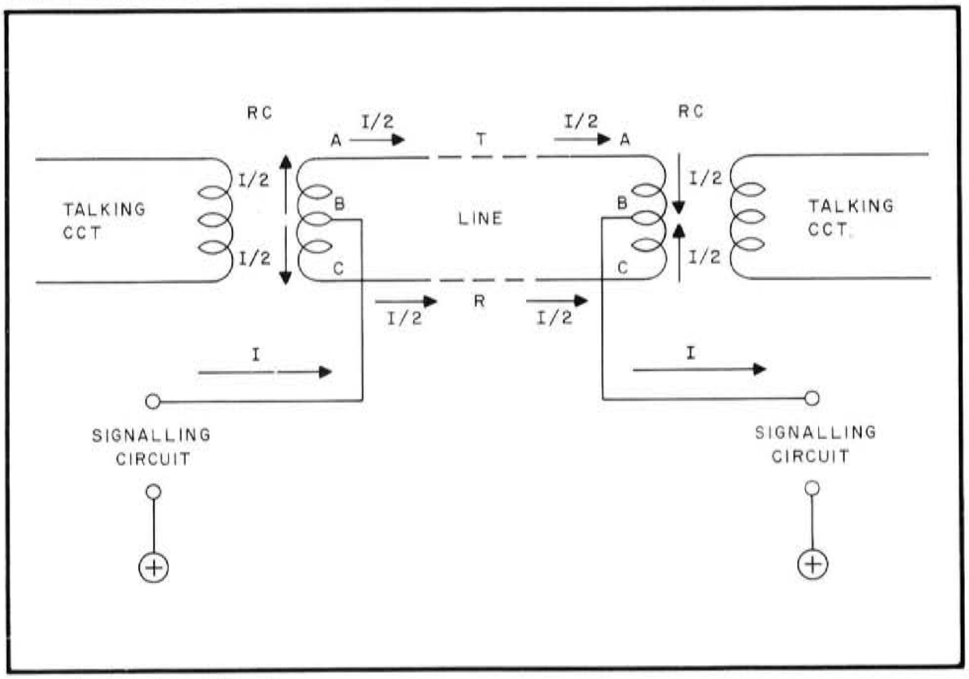


Figure 77. Simplexed Circuit

The circuit operates as follows: If the current in the signalling circuit is assumed to be flowing in accordance with the arrows and changing, it will split into two equal parts provided that the impedance of the "b-a" (left), T, "a-b" (right) path is equal to that of the "b-c" (left), R, and "c-b" (right) path. The fact that the current divides into two equal parts and flows in opposite directions through the windings of the balanced repeat coil assures that there will be no voltage induced in the secondary of either repeat coil and consequently no mutual interference between the talking and signalling circuits.

In the practical case, some unbalance usually is present because of the manufacturing tolerances of the "a-b," "b-c" windings and the lack of exactly equal electrical characteristics of the two line wires, T and R. The usual Simplexed Circuit will provide at least 60 db attenuation between the signalling and talking circuits. The Simplexed Circuit may be used with Polar Duplex, Differential Duplex, Positive-Negative and Ringdown signalling, and associated types of supervision.

The Composited Circuit

The Composited Circuit is illustrated in Figure 78.

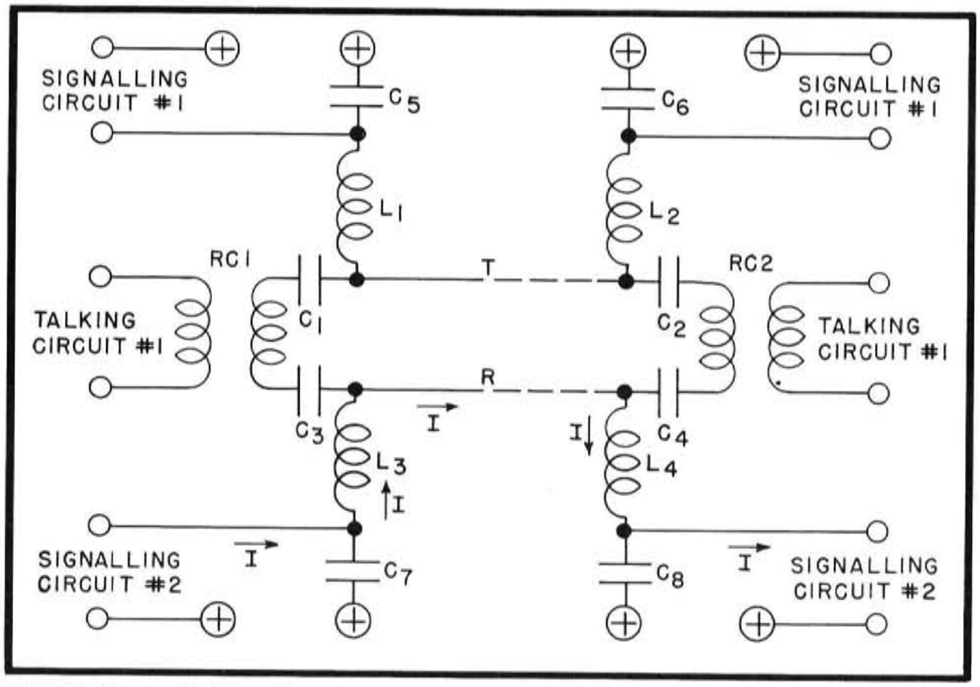


Figure 78. Composited Circuit

This circuit, like the Simplexed Circuit, isolates the talking and signalling paths so as to prevent mutual interference. The signalling current (I) in signalling circuit #2 contains primarily low frequency (below 200 cycles per second) components. A signalling current, therefore, travelling in accordance with the arrows, sees a high impedance to ground (C7), a low impedance to the R wire (L3), a high impedance to RC1 (C3), a low impedance along the R wire, a high impedance to RC2 (C4), a low impedance (L4), a high impedance to ground (C8) and a low impedance into the signalling equipment.

The majority of the low frequency energy of the signalling current follows the signalling path and very little appears in the talking circuits.

The relatively high frequency talking current (300-3,000 cycles) see a different set of conditions with the capacitors C1, C2, C3 and C4 representing practically zero impedance with respect to that of L1, L2, L3 and L4. Thus the talking currents are confined to the loop path.

As was pointed out in the case of the Simplexed Circuit, there is some mutual interference. Sharply rising wavefronts in the signalling current can produce audible clicks in the talking circuit. The signalling equipment must be designed to avoid this condition. In the 10-50 and 1,000-3,000 cycle per second ranges of frequencies there is probably 50 db attenuation between the signalling and talking circuits. Since the talking currents ordinarily can cause no difficulty with the signalling apparatus, the lower range of the frequencies is the important one.

RC1 and RC2 are usually center-tapped for use in a Composited Group, and C1 and C3, and L1 and L3 must be carefully balanced. C2 and C4 and L2 and L4 also must be carefully balanced but not necessarily equal to C1, and C3 or L1, and L3.

The Composited Group

In order to realize the most value from the Composited Circuit, it usually is found in conjunction with another Composited Circuit in the form of a Composited Group as illustrated in Figure 79. This arrangement allows four wires to carry three independent conversations and four independent signalling paths.

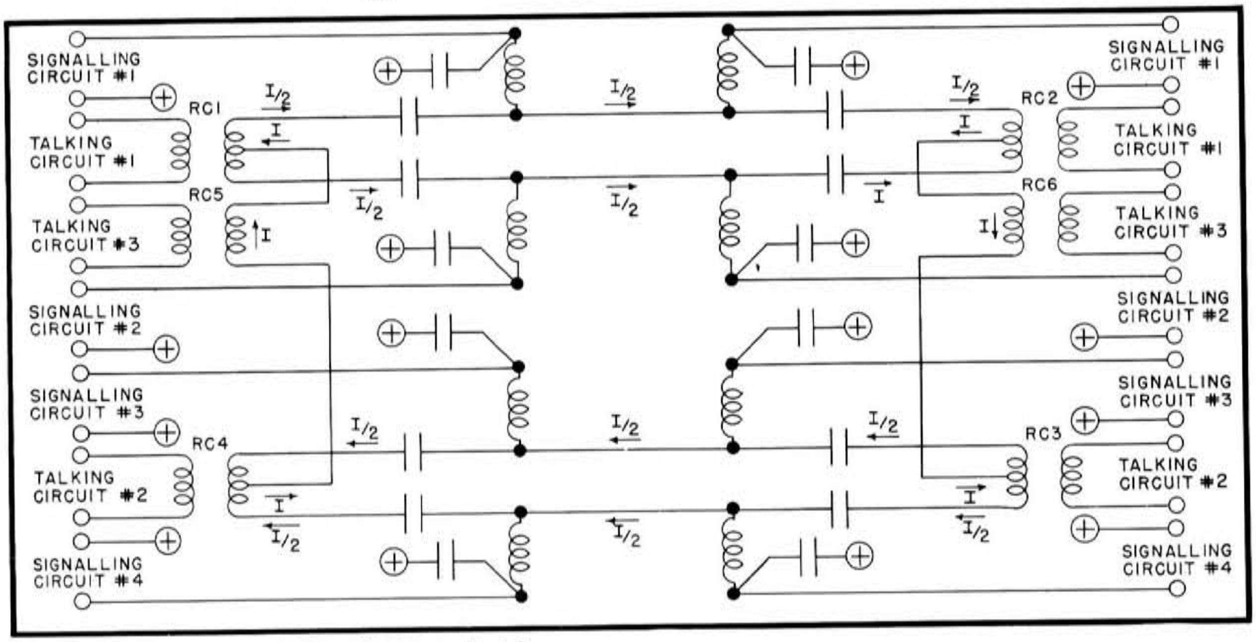


Figure 79. Composited Group

So far as talking circuits 1 and 3 are concerned, the operation is the same as described in the Composited Circuit. The careful balance of the line side of repeat coils RC 1-4 allows the use of a third talking circuit, known as the "phantom" with repeat coils RC5 and 6. The talking currents involved in the "phantom" follow the path illustrated by the arrows and are isolated in the same manner as are the signalling currents in a Simplexed Circuit. The attenuation between the phantom circuits and the other two talking circuits is of the order of 60 db. The two Composited Circuits are called "Side 1" and "Side 2."

DIAL INTER-OFFICE TRUNK CIRCUITS

A complete discussion of inter-office trunk circuits is properly the subject of a separate bulletin. The purpose of the following is to introduce only the basic principles of inter-office trunk operation, which are divided into several types: Positive-Negative, Polar Duplex, and Loop.

Introduction

Dial Trunk Circuits consist principally of relays which repeat the pulses originating in one office to the switching equipment located in another office. They also repeat supervisory signals which indicate the conditions present in the terminating office as the switching progresses.

Trunk circuits are used between offices for three main reasons:

a. The need for a third wire (sleeve lead) is eliminated, thereby reducing the investment in outside plant wire facilities. The trunk circuit places a ground on its Back Sleeve lead upon seizure, thus holding the preceding switches engaged.

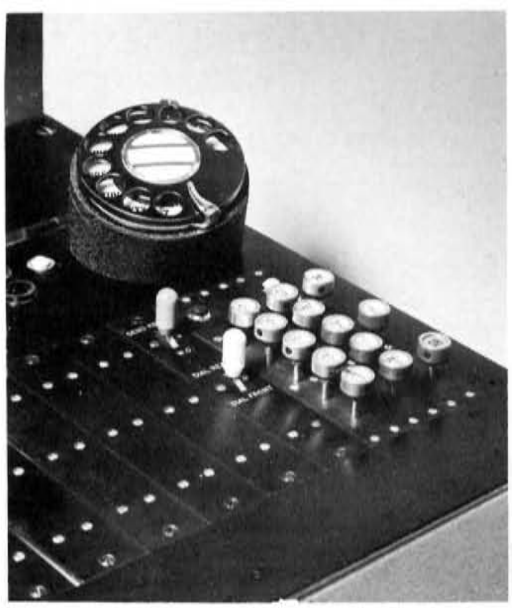
b. Since the efficiency of the telephone transmitter is dependent upon the amount of direct-current supplied, it is desirable to restrict the distance over which transmission current is supplied. This is accomplished on inter-office calls by having the trunk circuit in the originating office (instead of the Connector in the terminating office) supply current for the calling telephone.

c. There is a practical limitation to the loop resistance over which impulse repeating relays will function properly. In the trunk circuit, the impulses are repeated thus allowing a new source of impulsing current to be introduced. This results in more satisfactory pulse repetition.

Keysenders

The design of the Keysender took place concurrently with the development of the new No. 3 Toll Board. Both were designed to function together as integral parts of the nationwide intertoll dialing network.

The features of the Keysender include speed in sending digits, automatic start of ringing, complete erasure of mistakes in dialing, ability of operator to disconnect while Keysender is still functioning, without interrupting its operation and numerous supervisory functions.



The length of this text prohibits a complete study of the Keysender, and its applications, however, the literature on the No. 3 Toll Board contains a complete description of the Keysender and its operation. Bulletins are available through Telecommunication Division Sales Department.

Methods of Seizure, Pulsing and Supervision, Using a Two Wire Trunk Circuit

Loop Seizure, Loop Pulsing, Reverse Battery Supervision. Figure 80(A) illustrates the basic seizure and pulsing method used in this type of trunk. When the CB relay is seized in the originating office, the CB1 relay operates over the trunk loop, closing the loop to the incoming switch. The CB relay then follows the pulses of the CB1 relay.

When the call is answered in the terminating office, the circuit shown in Figure 80(C) is effective. Operation of the AB relay in the Connector reverses the battery potential on the trunk T and R, which causes the polar supervisory relay (SR) to operate. The SR relay operates the SY relay which repeats the battery reversal to the originating office equipment. When required, HS supervision is also given.

Battery Pulsing. In order to increase the operating range of trunks, the Battery pulsing scheme shown in Figure 80(B) is sometimes used. Seizure generally takes place in the same manner as in an ordinary loop pulsing trunk. In the Battery pulsing circuit, the two exchange batteries are effectively in series, thus increasing the range of operation. Supervision usually is accomplished as shown in Figure 80(C).

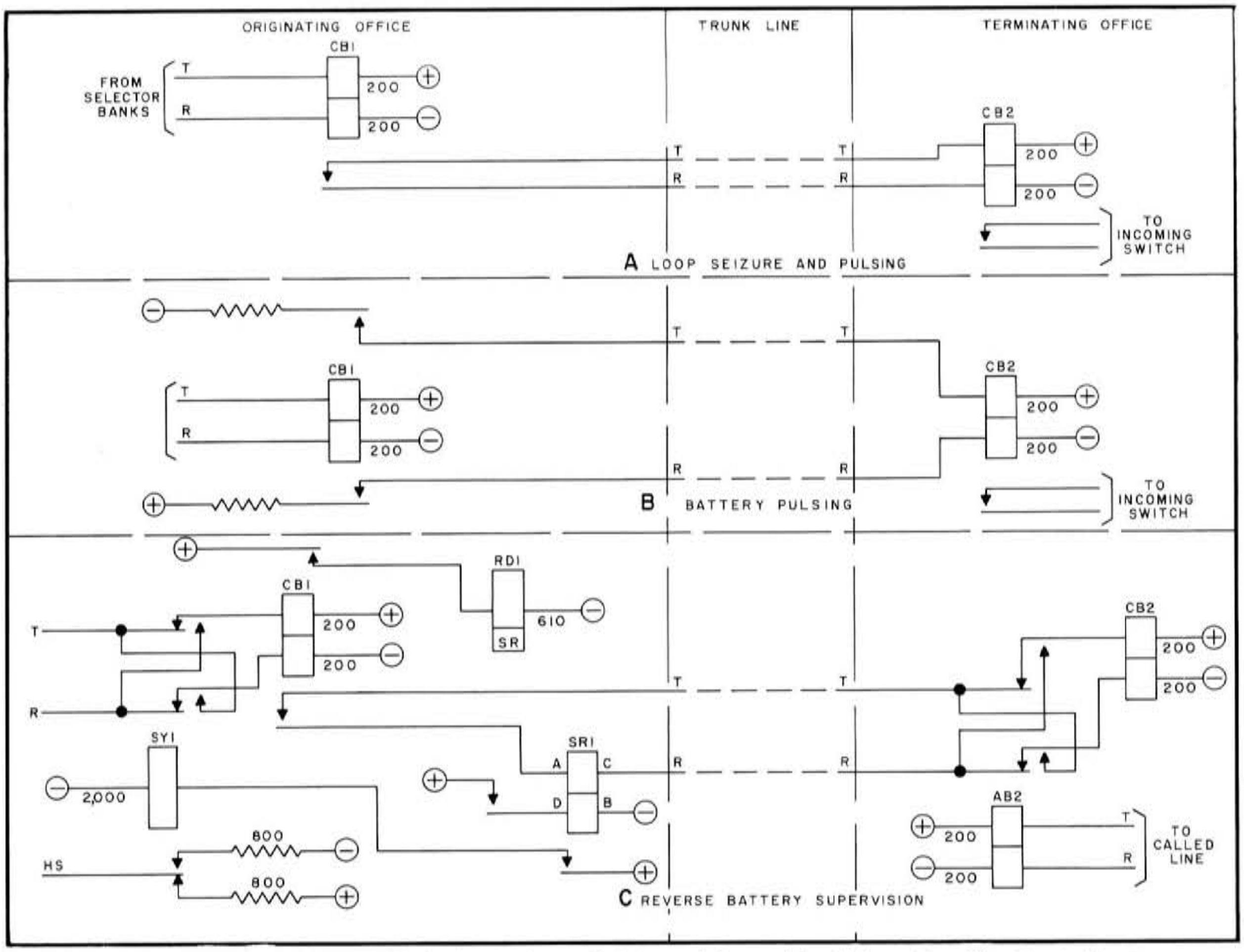


Figure 80. Methods of Seizure, Pulsing and Supervision Using a Two Wire Trunk Circuit

Methods of Dial to Dial Trunk Operation Using Composited and Simplexed Circuits

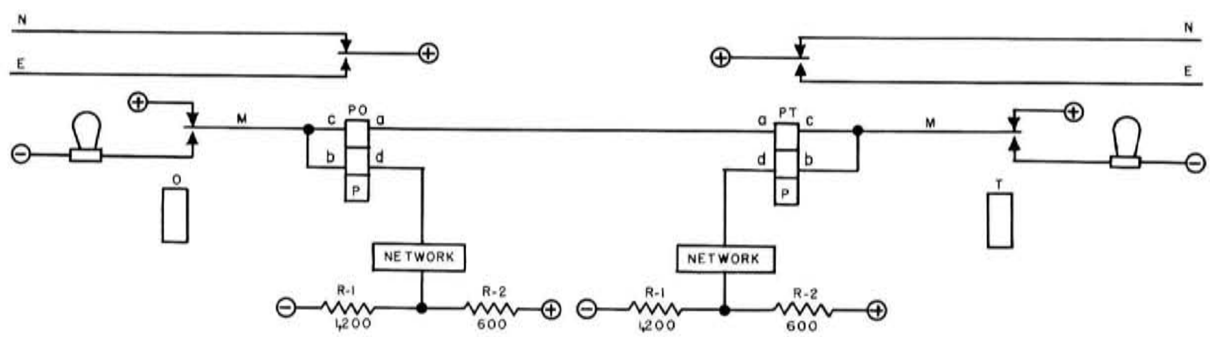
Composited and Simplexed trunks make use of the following signalling systems: Polar Duplex . . . . Positive—Negative

a. *Polar Duplex Signalling.*

1. THE POLAR RELAY—Polar Duplex Signalling requires the use of polar relays. Because of its design principles, the polar relay is responsive to both the magnitude and the direction of current flow and is more sensitive than relays of conventional design. In Polar Duplex Signalling, both of these features are used, the first providing proper operation and the second giving

extended range.

2. POLAR DUPLEX SIGNALLING—Figure 81 illustrates the principles of Polar Duplex Signalling. Relays PO and PT are polar relays, each having two equal low resistance parallel wound coils, connected differentially. For illustration, the polar relay associated with the originating end is labeled PO, while the polar relay associated with the terminating end is designated PT. O and T are conventional relays which activate their respective polar relays.



CASE	CONDITION OF "O" AND "T" RELAYS		CONDITION OF PO RELAY				CONDITION OF PT RELAY			
			UNITS & DIRECTION OF FLUX IN WINDING		NET UNITS OF FLUX	GROUND ON	UNITS & DIRECTION OF FLUX IN WINDING		NET UNITS OF FLUX	GROUND ON
	O	T	b-d	c-a			b-d	c-a		
1	RLS	RLS	1 ↑	0	1 ↑	N	1 ↑	0	1 ↑	N
2	OP	RLS	2 ↓	4 ↑	2 ↑	N	1 ↑	4 ↓	3 ↓	E
3	OP	OP	2 ↓	0	2 ↓	E	2 ↓	0	2 ↓	E
4	RLS	OP	1 ↑	4 ↓	3 ↓	E	2 ↓	4 ↑	2 ↑	N

Figure 81. Polar Duplex Signalling

The polar relays carry only a "C" combination which serves as a means of repeating signals.

Resistors R1 and R2 are unequal and serve to bias the PO and PT relays so that ground is on the N lead while the circuit is idle.

Polar Duplex operation is a method used for two way (duplex) signalling and dialing over a single metallic leg. The operation is easily understood if it is kept in mind that if one end wants to signal the other, the polar relay at the distant end must be operated, but there is no need to operate the polar relay at the sending end. Signals are sent by changing the potential on the M lead; and received by the appearance, or removal, of ground on the E or N leads. In practice the N lead from the polar relay contact is seldom used. It should be remembered that either end may signal the other regardless of what signals have been previously sent. With the circuit normal, released, ground is on the M leads while the E leads are open. Battery to energize the polar relays on the M lead is usually supplied through a resistance lamp.

These facts may be clarified by reference to the accompanying chart. Since the polar relays are polarity sensitive, the following conventions will be used:

(a) Current flowing through a coil from + to − in alphabetical sequence tends to operate the relay such that + is removed from the E lead. Conversely, current from + to − in reverse alphabetical sequence tends to operate the relay such that + is on the E lead.

(b) On the chart, an arrow pointing upwards indicates the direction of the flux (magnetic pull) in that winding, such as to cause ground to be removed from the E lead. Conversely, an arrow pointing downward indicates the direction of the flux in that winding, such as to cause the ground to be placed on the E lead.

(c) The "Units of flux" indicate relative magnitude only.

Case 1. Normal conditions, circuits idle.—Ground is on the M lead at both ends, while the E lead is open. Current flows from + to − in the "b-d" winding, creating a flux (upwards) which keeps ground off the E lead.

Case 2. Originating end signals terminating end.—Although the flux in the "d-b" winding of PO reverses as a result of O relay operating, the "a-c" winding flux overcomes the "d-b" winding flux and the direction of the net flux is unchanged. However, in the PT relay, the flux in the "c-a" winding overcomes the flux in the "b-d" winding, and PT operates and places a ground on the E lead to signal the terminating end.

Case 3. Terminating end answers the signal.—The terminating end answers by operating the T relay which places resistance battery on the M lead. The flux in the "a-c" winding of both polar relays becomes zero as both M leads are now connected to battery, and no current flows over the dial leg. Consequently, the flux in the "d-b" winding of PO causes PO to operate and place a ground on its E lead to signal the originating end. Although the direction of flux in the "d-b" winding of PT was reversed, the loss of flux in the "a-c" winding left the net direction unchanged, so PT, as expected, remained operated.

Case 4. Originating end resignals terminating end.—The O relay is released, causing the direction of flux in the "b-d" winding of PO to reverse, but simultaneously a flux in the "a-c" winding of both polar relays is created. As seen from the table, PO will not change (remain operated, thus holding ground on the E lead) while PT will change (release, thus removing ground from its E lead).

In the actual Polar Duplex Signalling circuit, the network shown in Figure 81 causes the rate of rise and fall of current in the "d-b" winding to equal the rate of rise and fall of current on the dial leg and "a-c" winding, thus maintaining dynamic balance in the system. In addition, this network contains resistors which are strapped in or out as required to balance the dial leg resistance.

The typical polar relay for use in a Polar Duplex Signalling circuit is equipped with a third winding which is used to compensate for ground potential differences between offices. It is not required in order to explain the principles of operation of the circuit and hence has not been shown in Figure 81.

b. *Positive-Negative Signalling.*

Positive-Negative Signalling uses either SX or CX equipment to connect the two offices together. The signalling is accomplished by applying either a resistance battery or resistance ground to the signalling circuit (dial leg). With the circuit normal, the dial leg is connected to resistance ground in both offices, and consequently no current flows. In practice these trunks are frequently two way devices, but for purposes of illustration only the relays required for one way operation are shown. Equipment marked with "-1" is in the originating end, while equipment marked with "-2" is in the terminating end. The principles of Positive-Negative signalling are shown in Figure 82. Figure 82(A) shows the basic circuit. Operation of the CB-1 relay operates both the SR-1 and the PL-2, which closes the loop to the incoming switch. Supervision is accomplished by operating the SR-2 relay in the terminating office, thus releasing the SR-1, which may repeat the supervisory signal. Release of CB-1 will allow BY-1 to operate for other supervisory purposes. For several reasons, practical trunk circuits using this principle become rather intricate in their design. With reference to Figure 82(A) it is obvious that some means must be found to hold the PL-2 relay during supervision so as to avoid the release of the incoming switch train. The BY-1 relay shunts the PL-2 relay during pulsing, increasing its release time and distorting the pulse to the incoming switch. In addition, it is generally undesirable for the SR-1 relay to follow pulses even though it is supplying pulsing current to the PL-2 relay. For these reasons the simple principle shown in Figure 82(A) is hardly perceptible in a typical Positive-Negative trunk. A simplified version is shown in Figure 82(B). Relays having the same designation in both Figures 82(A) and 82(B) have the same function.

Figure 82(B) operates as follows:

1. SEIZURE—When the Selector switches through to the originating end of the trunk, CB-1 relay operates from the bridge on T1 and R1. Operation of CB-1 energizes RD1-1 and prepares a path to operate SR-1. RD1-1 operates, energizes SR-1 and SR1-1 places a ground on the sleeve to hold the originating switch train and busy the circuit to other Selectors. (SR-1 is energized by ground supplied through the PL-2 relay at the terminating office.) Operation of RD1-1 prepares a path to operate SH-1 when the CB-1 relay releases during pulsing.

SR-1 and PL-2 operate in series over the dial leg. (SR1-1 does not operate because SR-1 operates, breaking the circuit to SR1-1 by opening contacts 3 and 4. (SR1-1 is slow to operate.)

Operation of PL-2 prepares a bath to close the loop to the Incoming Selector (contacts 1 and 2) and energizes RD2-2. RD2-2 operates, closes the path to seize the Incoming Selector, prepares a path to operate the SH-2 when the PL-2 releases during dialing (contacts 5 and 6), prepares a path to hold the PL-2 during supervision (contacts 23 and 24) and biases the supervisory relay, SR-2 (contacts 21 and 22). SR-2 is differentially energized at this time.

2. DIALING—When the dial is returned to normal, CB-1 follows the dial pulses. The pulsing of contacts 1 and 2 of CB-1 opens and closes the dial leg, causing the PL-2 to pulse and transmit the dial pulses to the Incoming Selector. When the CB-1 releases on the first pulse, the SH-1 operates, shorting winding T1 to A1 of repeat coil RC1 to prevent pulse distortion. SH-1 remains

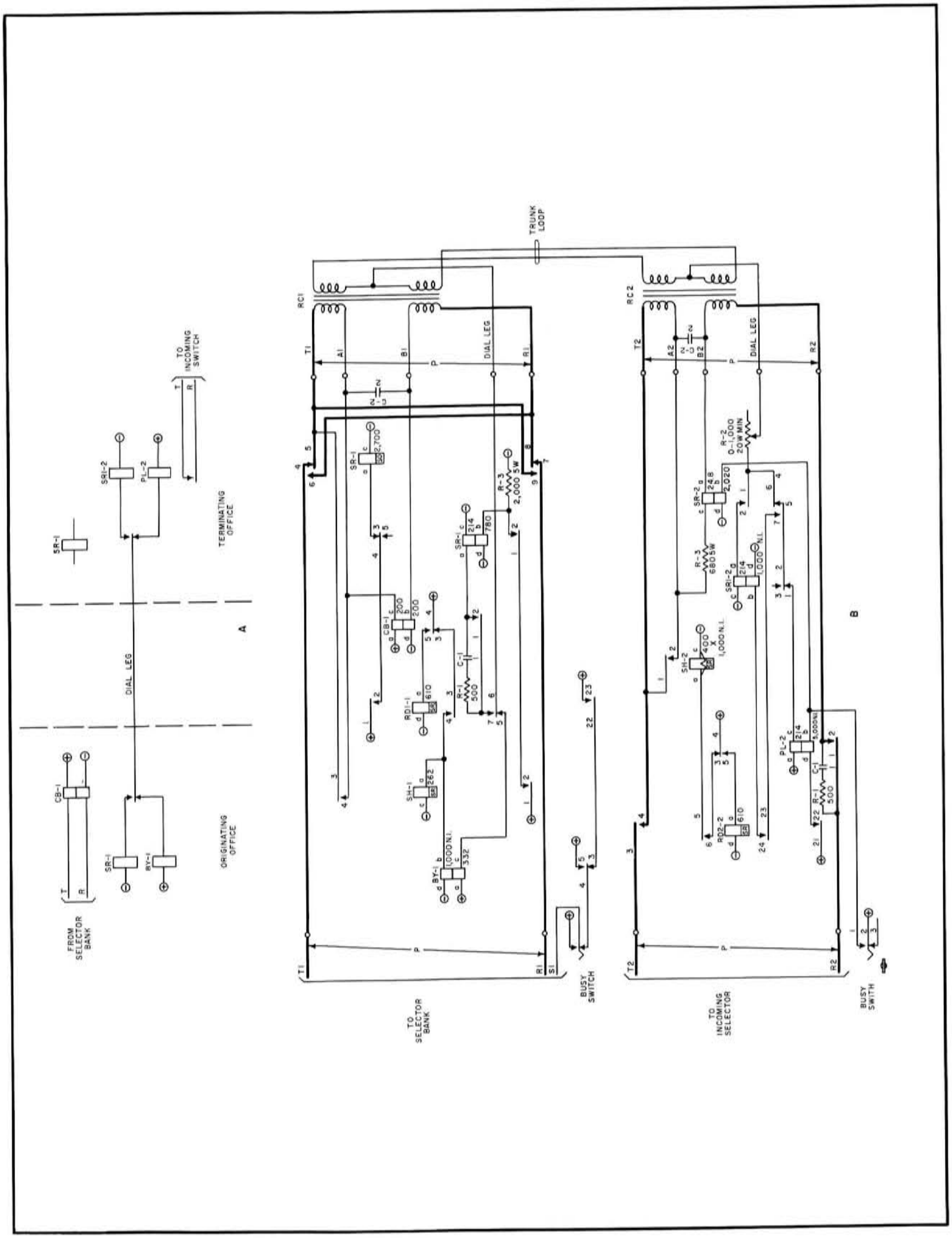


Figure 82. Positive-Negative Signalling

operated during each digit and falls at the completion of each digit. Contacts 1 and 2 of SH-1 hold the SR-1 to prevent it from following dial pulses.

When the PL-2 releases on the first pulse, the SH-2 operates, shorting the winding T1 to A1 of repeat coil RC2 to prevent pulse distortion. SH-2 remains operated during each digit and falls at the completion of each digit.

These conditions are repeated for all succeeding digits.

3. SUPERVISION—When the call is answered in the terminating office, battery is reversed to the T2 and R2 leads, operating the supervisory relay SR-2 which is no longer differentially energized. SR-2 operates, removes the PL-2 from the dial leg and replaces it with the battery-connected "a-c" winding of SR1-2. PL-2 is held operated through contacts 1 and 2 of SR1-2, 5 and 7 of SR-2, 23 and 24 of RD2-2 and the 1,000 ohm NI resistance on SR1-2 of battery, thus preventing release of the incoming switch train. SR1-2 does not operate (battery connected dial leg at both offices.)

The transfer of the dial leg in the terminating office from ground to battery releases the SR-1, operating the SR1-1. Operation of SR1-1 reverses the battery on T1 and R1 in the originating office providing answer supervision.

4. DISCONNECT

(a) *Originating party disconnects first.* When the originating party disconnects, the release of CB-1 opens the path to RD1-1 and opens the dial leg. RD1-1 releases, connecting the BY-1 to the dial leg. BY-1 operates over the dial leg if the terminating party has not disconnected, thus replacing the ground on the sleeve to prevent seizure of the circuit by another Selector.

SR1-2 operates over the dial leg, releasing the PL-2 which releases the incoming switch train and opens the circuit to RD2-2. RD2-2 releases, releasing SR-2. Release of SR-2 releases SR1-2 and places the "a-c" winding of PL-2 on the dial leg. When the ground-connected PL-2 relay is connected to the dial leg, the BY-1 releases, and the busying sleeve ground is removed. Both circuits have returned to normal.

(b) *Terminating Party Disconnects First.* When the terminating party disconnects first, battery on Tip and Ring is returned to normal, releasing the SR-2 relay by energizing it differentially.

Release of SR-2 opens the circuit to SR1-2 and transfers the dial leg to the ground-connected "a-c" winding of PL-2. PL-2 remains operated. SR-1 reoperates, opening the circuit to SR1-1, which returns normal battery to the Selector T1 and R1 leads providing disconnect supervision. When the originating party disconnects, the release of CB-1 releases SR-1, opens the dial leg, and opens the path to RD1-1. RD1-1 releases, placing the ground-connected "a-c" winding of BY-1 on the dial leg, allowing PL-2 to release and removes busy ground from the Selector sleeve, releasing the originating switch train. Release of PL-2 opens the path to the RD2-2, and opens the T2 and R2 loop, releasing the incoming switch train. RD2-2 releases and the circuit is returned to normal.

NO. 3 TOLL SWITCHBOARD

The Stromberg-Carlson No. 3 Toll Switchboard is characterized by having supervisory relays in the line and trunk circuits, rather than the cord circuits, thereby affording unlimited flexibility in trunk features and individual circuit arrangements to meet varying conditions in the connecting equipment.

All No. 3 Toll Switchboards are wired for Keysenders as well as dials. The maximum cord circuit capacity of this switchboard is 14, but 6 equipped and 8 wired is the quantity usually provided for CLR positions, and 12 equipped and 14 wired for inward positions. The ultimate multiple capacity depends upon multiple layouts of 3, 4 or 5 panels, whether the 203 or 204 section is used, and whether 10- or 20-Jacks per strip are used.

The large number of features, and the various circuits involved in the No. 3 Toll Switchboard prevents a complete description of the switchboard, however, a composite drawing is used to illustrate the major features. (Fig. 83) The designation of relays and leads duplicate those used on the standard circuit drawings. Letters shown below the components designate the circuit in which the equipment appears, and for simplification certain keys and relay contacts have been omitted.

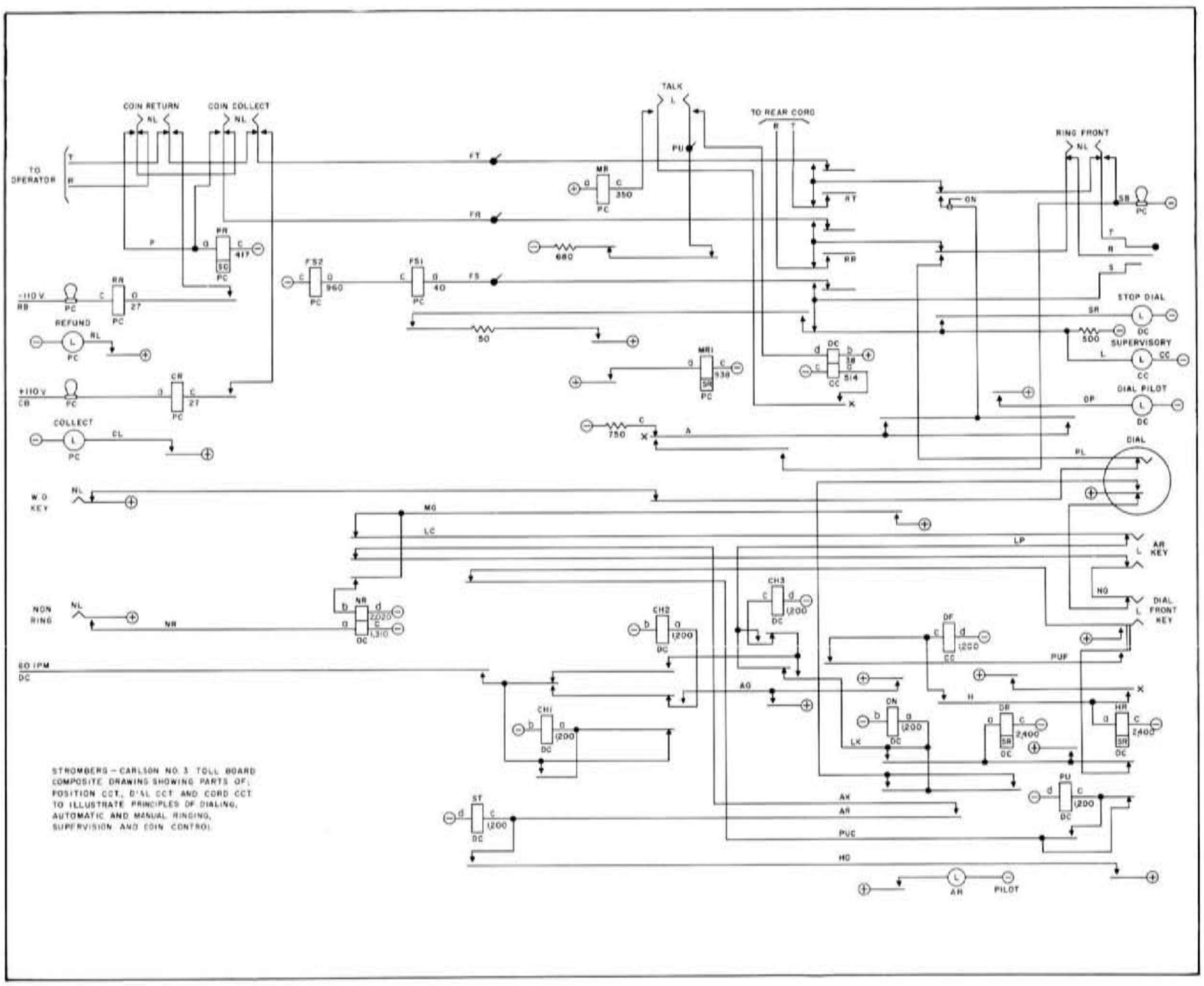


Figure 83. Composite Drawing No. 3 Toll Board

a. *Relays.*

Position Circuit
RR Refund relay, CR collect relay
PR Prepares (prepares trunk to receive coin control)
FS1 Front Sleeve relay 1 (operates on low resistance, on hook supervision)
FS2 Front Sleeve relay 2
MR Marking MR1 slave of MR

Dial Circuit
ON off-normal (of dial: Locks 750-ohm battery on T without dial key operated)
PU Pick up (when the dial key is operated)
DR Dialing relay
HR Hold relay (holds DF or DR relay of cord circuit while dialing)
NR Nonring (stops automatic ringing when NR key is pressed)
ST start (starts automatic ringing)
CH1 Chain #1
CH2 Chain #2
CH3 Chain #3

Cord Circuit
DR Dial Rear (not shown on Fig. 83)
OC Operators cut-in
DF Dial Front
Several lead designations should be clarified:
PUC Pick up cord
AR Automatic Ringing
SB Signal Battery (shown Twice)
LK Locking
RT Rear Tip
RR Rear Ring
CL Collect lamp

Operation of the circuits is not on a loop basis, as local switching circuits. Instead the functions are accomplished in the following manner:
b. *Seize.* Ground on R
750^{ω} battery on T
500^{ω} battery on S

c. *Dialing.* The ground on R is pulsed

d. *Ringing.* After 750^{ω} battery is removed from T and after ground is removed from R, signal battery (48V exchange battery through 110V protecting lamp) is placed on tip

Operate talk front key, OC operates to make "X" contact (two OC relays cannot operate at once because their parallel resistance in series with 680^{ω} limits current so neither will operate). MR operates in series with OC through "X" contact, MR1 operates as a slave to MR. Plug the cord into the trunk jack, which returns low resistance ground on the sleeve and, $1{,}000^{\omega}$ battery on S load seizing the trunk. Seizure

FS2 operates in series with high resistance ground of the SL relay in the

trunk (removes idle line termination from operators circuit)
FS1 operates when the trunk returns low resistance (50$^{\omega}$) ground (on hook).
FS1 will release on high resistance ground (off hook)
Supervisory lamp on and controlled by FS1

Operate Dial Front Key PU operates, sending ground to the DR relay, which operates, lighting the dial pilot lamp.
DF operates from ground supplied by PU through the dial front key and made contacts on OC. Operation of DF connects stop dial lamp for supervision, HR operates in parallel with DF, and locks through its "X" contact, under control of DR.
Front T now has 750$^{\omega}$ battery and front R has ground.
Pull Dial Off Normal
ON operates through contacts on operated DR
HR locked up by DR
DF held in parallel with HR
DR locked up to ground from PU.
PU controlled by the dial key, all the others controlled by the dial, independent of the dial key.
Dial impulse springs interrupt ground on the front ring lead. The wipe out key would open this ground to release succeeding circuits in case of an error in dialing.

End of Dialing Dial key may be restored at any time after the dial is pulled off normal for the last digit.

Automatic Ringing ON remains operated when the dial and the dial key are normal, provided the AR (automatic ring) and NR (nonring keys) have not been operated. DR, HR, and DF remain operated. PU releases when the dial key is restored. ST operates as soon as the dial restores to normal.
CH1 operates when 60 IPM ground pulse comes in, CH1 locks to pulse CH2, operates from 60 IPM pulse, locks to ON. CH2 removes 750$^{\omega}$ battery from T with its "X" contact, then removes ground from R. This sequence prevents a false pulse getting to succeeding equipment. CH1 releases at the end of the 60 IPM ground pulse.
CH3 operates from the next pulse of 60 IPM. CH3 locks under control of ON, signal battery is now placed on the tip, ON is now held by the 60 IPM pulse. Signal battery on the tip causes the succeeding equipment to prepare for automatic ringing. ON in the out dial trunk operates, putting 800$^{\omega}$ battery on the HS lead to the Connector. TL operates in the Connector. RT of the Connector releases. ON in the toll board releases at the end of the 60 IPM pulse.

DR, DF, CH3, CH2, HR, ST, release in that order.

OC releases when the talk key is restored, which may be with, or any time after the dial key is restored.
MR and MR1 release.
Supervisory lamp associated with the cord used gives supervision.

Coin Collect and Refund The collect and refund equipment is associated with the desired cord by operation of the talk key which operates the OC relay. OC operates when the talk key is operated. Operate the desired coin collect or refund key. The PR relay is connected to the R lead, CR in the out dial trunk operates. PR, a slow operate relay, applying plus or minus 110 volts to the tip, operating the coin magnet in the pay telephone.

Manual Ringing

Should the operator desire to delay ringing, or for any reason not have automatic ringing, it may be permanently stopped by operating the AR key. With this key operated the ST relay can't operate, thus preventing any automatic ringing, or if automatic ringing is to be stopped on a few calls only, the AR key is left normal, but momentary pressing of the NR key any time after the dial key is operated and before the dial key is resorted at end of digits, will lock up the NR relay, which again opens the circuit to the ST relay.

When the operator is ready to ring on this call, or re-ring on any call, it may be done by operation of the ringing key, which places signal battery on tip. Ringing in succeeding circuits does not start until after signal battery is removed from tip.

The preceding statements cover only a small portion of the No. 3 toll switchboard circuitry. They are intended to explain the basic operations which occur in the switchboard during normal operation. Information on the various circuits, not covered in this section, may be obtained by writing General Dynamics|Electronics, Telecommunication Division Sales Department.

CONCLUSION

This book has been written to provide a general introduction to the XY Dial System and its components, its features, and their practical application to the independent telephone operating company's problems.

The accuracy of the written material has undergone exhaustive checks, however, development in the General Dynamics|Electronics, Telecommunication Division is always progressing and certain procedures and methods may be superseded with new developments.

Several sections of this publication deal with subjects which are extremely complex, and actually require extensive literature for their complete explanation. These subjects are mentioned only in an introductory manner, and more information is available through General Dynamics|Electronics, Telecommunication Division Sales Department, Rochester 3, New York.

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