Community

Automatic Exchanges

BULLETIN 819

August 1941

AUTOMATIC ELECTRIC

MAKERS OF TELEPHONE, SIGNALING AND COMMUNICATION APPARATUS
ELECTRICAL ENGINEERS, DESIGNERS AND CONSULTANTS

1033 W. Van Buren St., Chicago, U. S. A.

TABLE OF CONTENTS

FIG. 1. A SMALL CITY EXCHANGE OF 450 LINES AT MORTON, ILLINOIS

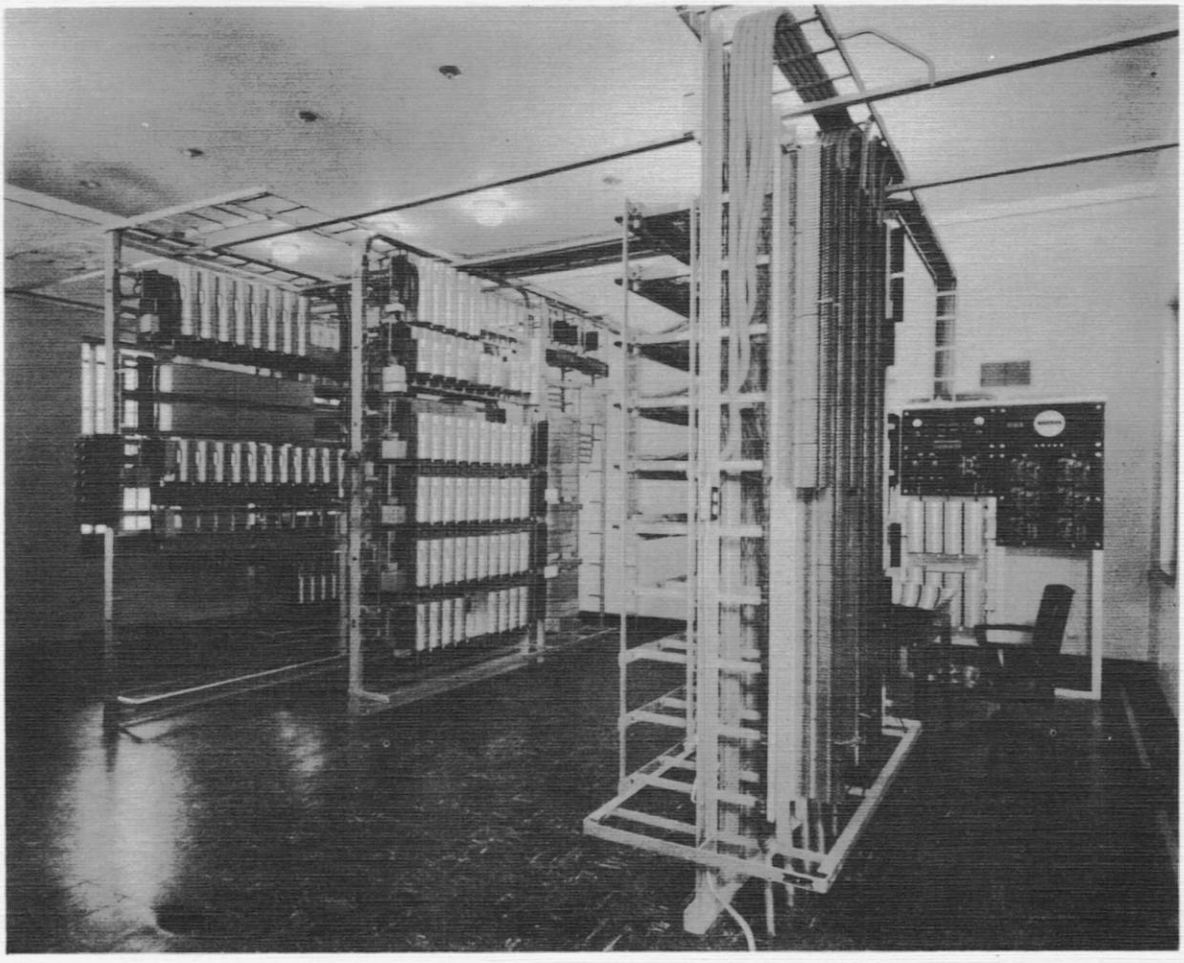


FIG. 2. INTERIOR OF THE MORTON EXCHANGE.

COMMUNITY AUTOMATIC EXCHANGES

1. INTRODUCTION

In recent years, there has been a definite trend toward the replacement of manual switchboards in small towns and rural communities with Strowger Automatic systems. One reason for this is that Automatic equipment stands ready to operate at full capacity twenty-four hours per day. The exchange itself may be locked up and left unattended. Should a subscriber desire the services of an operator, he dials a number, usually "0," and obtains an operator in the nearest attended exchange. This operator is prepared to render the subscriber any desired service.

A number of outlying small exchanges may be grouped so as to all be served by one toll center where an operator will always be in attendance. Ordinarily, the subscriber sets up his own local connection by operating his dial. However, should he desire some special service, e.g., toll or information, he may dial a digit, usually "0," for the operator. In addition, this operator is always available should an emergency arise. Frequently, operators in more than one attended exchange can be reached from the automatic exchange by dialing appropriate numbers.

Automatic subscribers in a network may dial directly from one community to another without the intervention of an operator unless a toll charge is made. Sometimes a method of automatic toll ticketing is adopted so that on a toll call, the charge is automatically entered on a ticket together with the calling and called person's telephone number. Thus, the charge may be later billed to the subscriber.

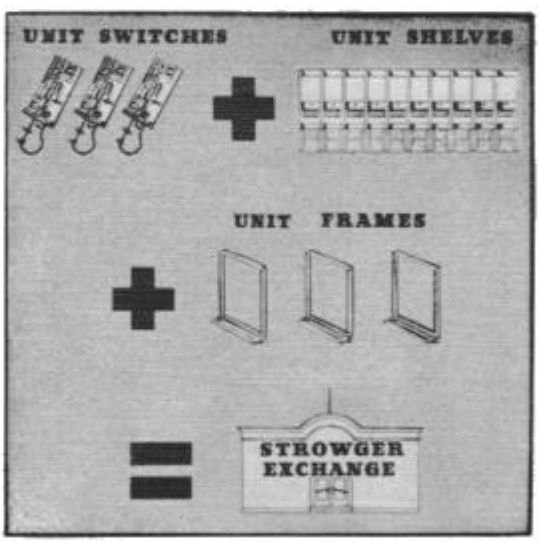


FIG. 3. THE INTERCHANGEABLE COMPONENTS OF A STROWGER EXCHANGE.

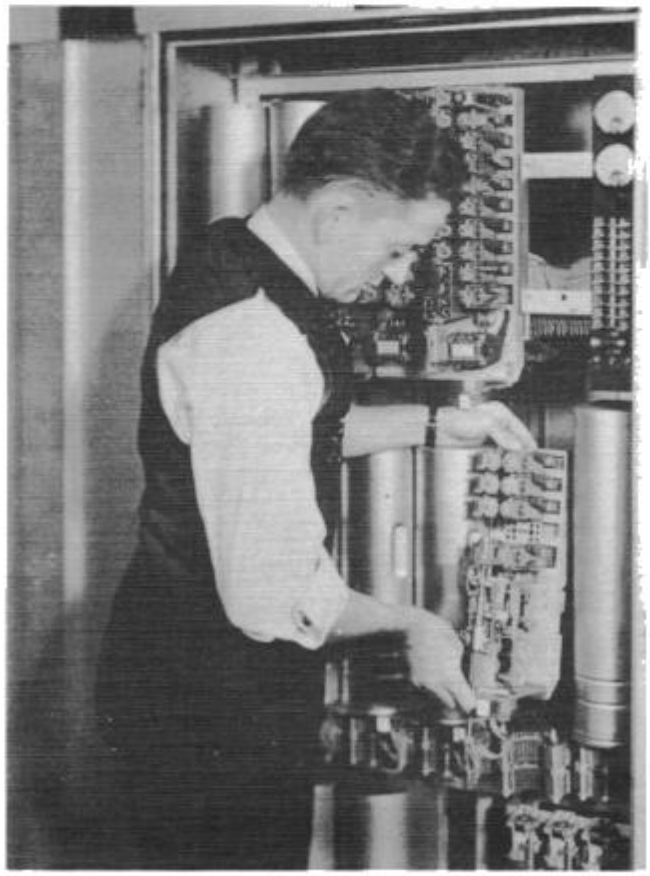


FIG. 4. JACKING IN A CONNECTOR SWITCH.

2. FLEXIBILITY OF STROWGER EQUIPMENT

Strowger automatic equipment is flexible. An automatic exchange in the Strowger System is made up of standard switches which can be jacked in or out of standard shelves. The shelves, each containing, say, 10 switches, are bolted to unit frames. The exchange may consist of one or more frames with only sufficient switches mounted to care for the traffic in the exchange. Should more traffic develop, more switches (which are the mechanical "operators" of the system) may be added at anytime. Thus an exchange may be altered as necessary to meet changed traffic conditions. In addition Strowger Automatic equipment is economical in operation. In fact, operation cost is almost negligible. The switches and relays are rugged, requiring little maintenance. Electrical power is used sparingly and is usually obtained from commercial sources. A battery eliminator may be employed, or power may be stored in batteries for emergency use.

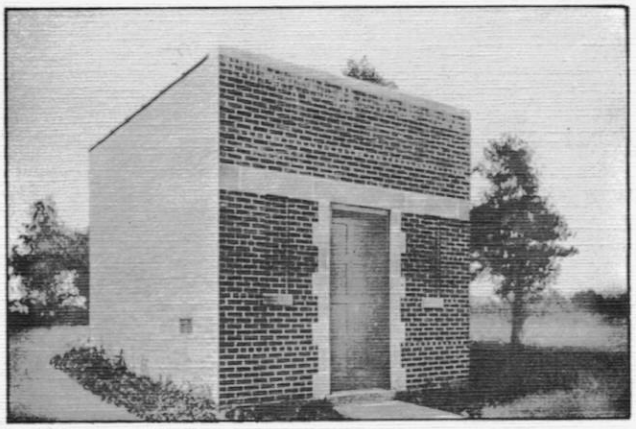


FIG. 5. A COMMUNITY AUTOMATIC EXCHANGE.

3. SWITCHES EMPLOYED IN C-A-X SWITCHBOARDS

Connections in Strowger Automatic exchanges are established by standard types of switches. Three general types used are the rotary (11, 16, 25, 50 points), the two-motion Strowger switch (100, 200 points), and the plunger line switch (10 points). In addition a minor switch (10 point) is sometimes employed to perform certain miscellaneous functions.

4. SWITCH TRAIN OF A C-A-X

The simplest possible arrangement is shown in Figure 7. Here each subscriber's line terminates in a connector. Since a connector switch is the mechanical operator of the automatic system, each line is able to directly connect with every other line in the exchange. Unfortunately this method is expensive, because it wastes connector switches. At any given moment, a majority of the connector switches are idle just as would be the case with operators in a manual exchange if there were one operator for every line coming into the exchange. Therefore it is not economical to use this arrangement except in exchanges of only a few lines.

In a manual exchange, to continue the analogy, one operator serves a number of lines. When a subscriber removes his handset to make a call, a signal lamp lights. The operator finds the calling line jack and plugs into it, announcing that she is ready to take the wanted number by saying "Operator."

In order that a connector (a mechanical operator) may serve a number of lines, it is necessary that the connector be able to find and connect with a calling line. To accomplish this, a second switch (Figure 8) is joined with the connector. The second switch is called a "finder." It looks toward the calling lines and when a subscriber removes his handset, the finder begins rotating its wipers over the bank contacts searching for the calling line. When the calling line is found, the finder returns dial tone to the calling subscriber, indicating that it is ready to receive the dialed number.

In Figure 8, the finder switch is of the rotary type having 25 contacts. It may thus search over 25 lines. In Figure 9, the finder is of the Strowger two-motion type of switch which normally hunts over 100 lines but may also include a second one hundred as in Figure 18. The 200-point Strowger linefinder starts stepping vertically immediately upon a subscriber removing his handset. At each vertical step, the linefinder tests two groups of ten lines. In order to test 100 lines, the finder need only make five steps. The finders are in two groups with reversed bank multiples, so each finder ordinarily hunts over but five levels, one taking lines 211 to 250 and 111 to 150; the other, lines 200 to 260 and 100 to 160. In case either group of finders become busy, the opposite group will hunt over all 200 lines.

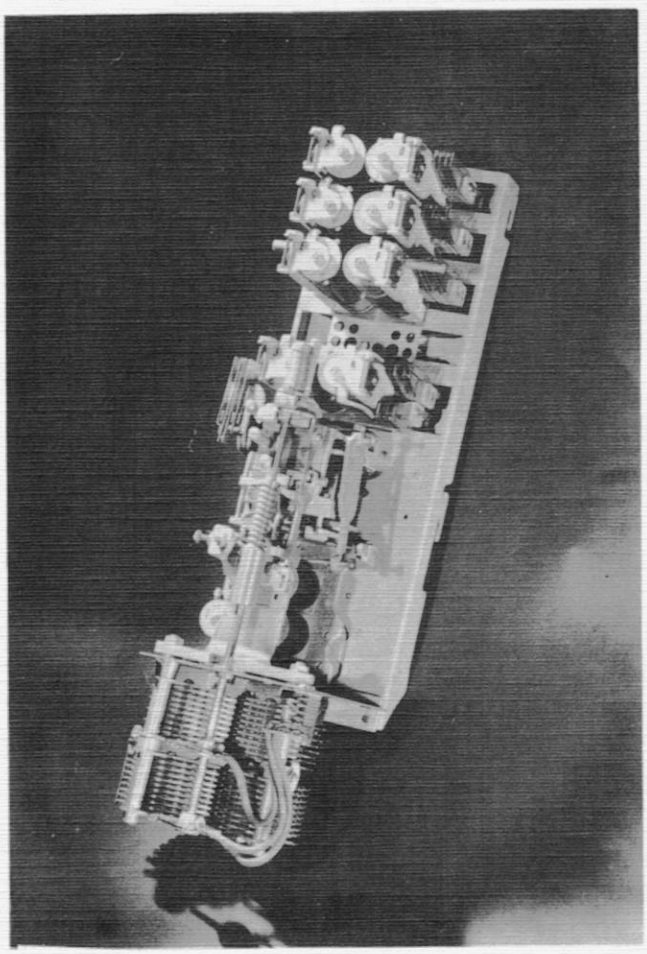


FIG. 6. A STROWGER CONNECTOR SWITCH.

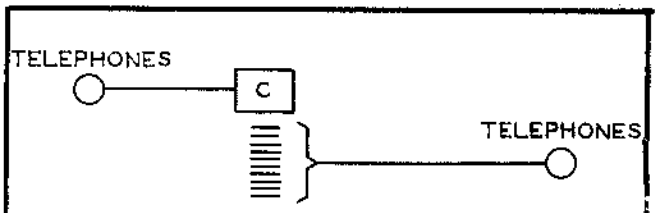


FIG. 7. A CONNECTOR SWITCH PER LINE

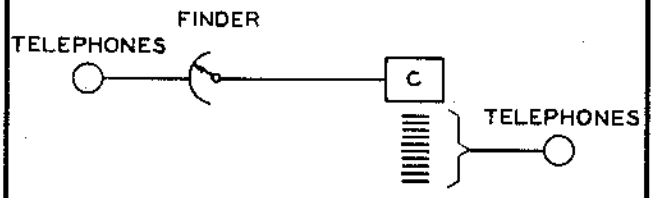


FIG. 8. A ROTARY LINEFINDER PERMITTING ONE CONNECTOR TO SERVE A NUMBER OF LINES.

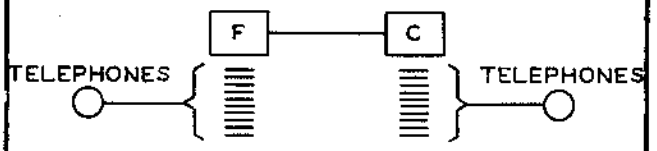


FIG. 9. STROWGER LINEFINDER AND CONNECTOR

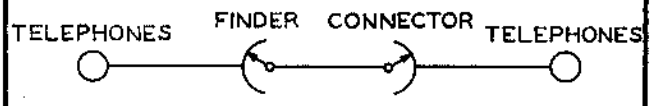


FIG. 10. ROTARY FINDER AND ROTARY CONNECTOR 50-LINE SYSTEM.

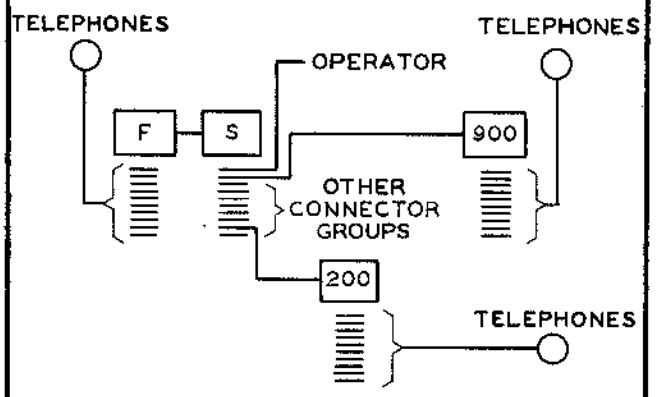


FIG. 11. 1000-LINE SYSTEM.

FIGS. 7-11. SWITCH COMBINATIONS.

The switch train of Figure 8 will find but 25 lines although it will connect with 100. For this reason, there will need to be four groups of such finder-connector links for a full 100 lines. In each group able to search over 25 lines, there may be more than one link. The number of finder-connector units determines the number of simultaneous conversations which may be carried on in the exchange. In practice two groups of 50-point rotary switches would be used for linefinders under the conditions mentioned.

Figure 10 shows a switch arrangement consisting of a rotary linefinder and a rotary connector. This combination is employed in small exchanges having 10 to 19 lines, with up to 3 trunks and 4 of the finder-connector links shown. Successive calls seize the finder-connector links in rotation as determined by the distributor.

Figure 9 shows a 100-line system using Strowger two-motion linefinders and connectors.

Figure 11 illustrates a larger system such as the Type 35E97. The capacity of that shown is up to 800 lines. An 800-line exchange would require eight groups of connectors, each group of connectors handling 100 lines. The linefinders are of the 200-point type though under normal traffic each linefinder hunts over but 100 lines. Each linefinder is permanently associated with a selector.

The selector is a two-motion switch very similar to a connector but responsive to only one dialed digit, the first. The first digit of a called number usually determines the hundreds group in which the called line is located. In the analogy, the selector serves as the first or "A" operator who must select a second "free" operator able to reach the called line.

The selector accordingly steps its wipers up to the level on which the desired group of connectors is located. Its wipers then rotate automatically over the bank contacts until an idle connector in the group is found. The second and third digits then cause the idle connector to seize the called line as described previously. If there is more than one party on the called line, it may be necessary on some types to dial additional digits in order to ring the wanted party.

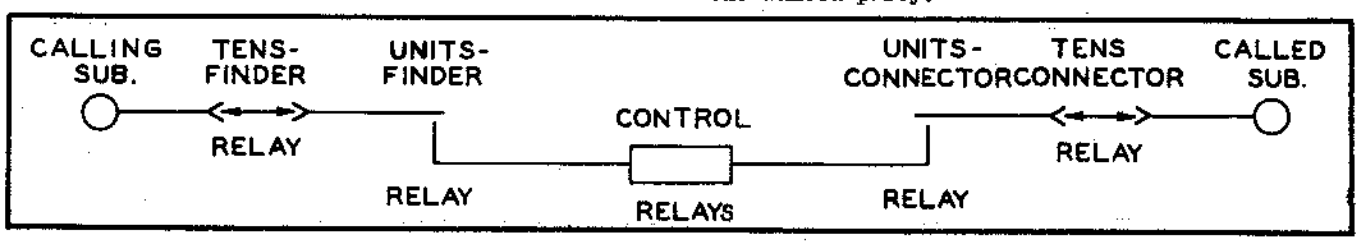


FIG. 12. CONNECTION THROUGH A ROTOR RELAY FINDER - CONNECTOR LINK.

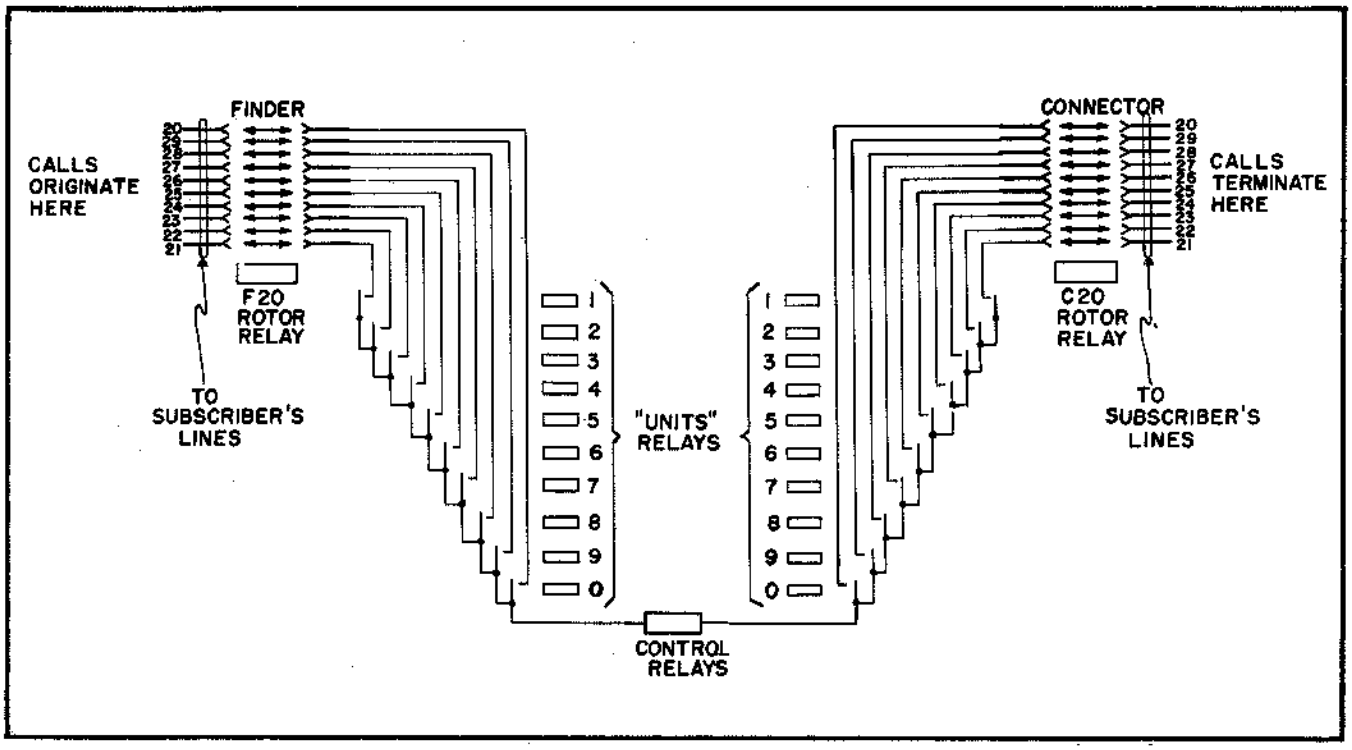


FIG. 13. COMPLETE FINDER - CONNECTOR LINK OF A ROTOR RELAY SWITCHBOARD.

5. RELAY SWITCHING

There are other ways in which one calling line from a number of lines may be connected to the wanted line among another group of lines. One of these employs only relays to complete all connections.

Naturally a great number of relays must be employed in an all-relay exchange. To keep this number to a minimum, Automatic Electric has developed a special rotor relay which has more than sufficient contact springs to simultaneously close connections to ten three-conductor lines. In a rotor relay exchange, all conducting paths from every station to every other station are permanently wired, but they remain open until closed by the operation of certain relays.

Figure 12 is a one-line diagram illustrating the basic switching principles underlying relay systems. The calling line is found by the finder half of a free finder-connector link. A link may be compared to a manual operator's cord in that it finds the calling line on one end and the called party's line on its outgoing end and connects the two.

In Figure 13, only the ten lines in the 20's group are shown. Each group of ten lines has a 10's finder rotor relay and a 10's connector rotor relay. In practice, the vertical conductors of the Figure would be extended to form a multiple to which any 10's rotor relay could connect its group of ten lines. The units relays in the center would then choose the one line of the ten to be switched through.

Consider the following example. Upon any subscriber in the 20's group lifting his handset, the F20 10's-rotor-relay will operate connecting all ten lines in the 20's group to their corresponding "F" units-relay. Should "21" be the calling line, units-relay F-1 will operate. Now calling subscriber "21" is connected through to the control relays. The finder has now seized the calling line, and the control relays will return dial tone to the calling party.

Dial tone indicates to the calling party that his line has been found and that the control relays are ready to receive the called party's number. The subscriber dials "29." The control relays count the impulses and cause the C20 10's-rotor-relay and the C9 units-relay to operate. The connector has completed the connection between parties "21" and "29."

6. FEATURES OF C-A-X'S

6.1 Busy Test

Before a connector switches the calling party through to the called party, it tests the called line. If this line is busy, the connector returns busy tone (intermittent buzzing) to the calling party who must then replace his handset and try the call later.

6.2 Ringing The Called Party

If the called line is free, the connector will signal the called party. On a one-party line, this means that the connector places interrupted generator across the line (or between one side of the line and ground) to ring the subscriber's bell. To obtain selective ringing on a two-party line, one party has his ringers connected to ground and the negative side of the line, and the other party has his ringer connected to ground and the positive side of the line. Then to ring the first party, the connector places generator on the negative side of the line and ground; while it places generator on the positive line and ground to ring the second party. This principle is that of divided ringing.

6.21 HARMONIC RINGING

Where it is desired to have more than two parties per line and still give selective ringing, the harmonic principle is employed. Harmonic ringers, supplied subscribers, are tuned to ring only when current of one given frequency is impressed on the line. Using five frequencies, full-selective ten-party service may be given on all terminals with divided ringing; i.e., five harmonic ringers between each side of the line and ground.

Semi-selective ringing employing one and two rings may be furnished in some instances to give semi-selective service on ten-party bridged ringing lines. Grounded lines must necessarily employ this latter service.

Ringing current at the five frequencies is generated by means of vibrating converters. A harmonic ringing converter unit consists of five vibrating reed converters, one for each of the five frequencies. A converter consists of a suspended armature (reed) with an adjustable weight at its free end. By raising or lowering the weight, the natural frequency of vibration of the armature can be varied. Electrical contacts on the armature make and break so as to convert direct current to the desired frequency of alternating current.

The ringing converters produce a continuous supply of alternating current. In order that station bells will be rung with alternate periods of silence, a relay type interrupter is used. Ordinarily it merely provides single ringing intervals (one ring followed by a silent period); however, it may also produce two rings per period for the ten-party semi-selective service.

When the subscriber removes his handset, the ringing will either be cut off instantaneously or at the end of the first silent period as provided.

6.22 Code Ringing

Code ringing is commonly used on long rural lines. Magneto manual lines have long employed code ringing, and automatic switchboards have likewise continued this practice where it is desired. Simplest code is one long ring; probably next simplest is two short rings. The code rung is determined by the digits dialed. On some boards a total of 20 different codes are provided for 20-party bridged-ringing service. All telephones on the line are rung, but only the telephone corresponding to the code rung will be answered.

Divided ringing may be employed on code ringing lines so that only half the telephones on the line will be rung simultaneously. Thus five codes are available to each side of the line giving ten-party service.

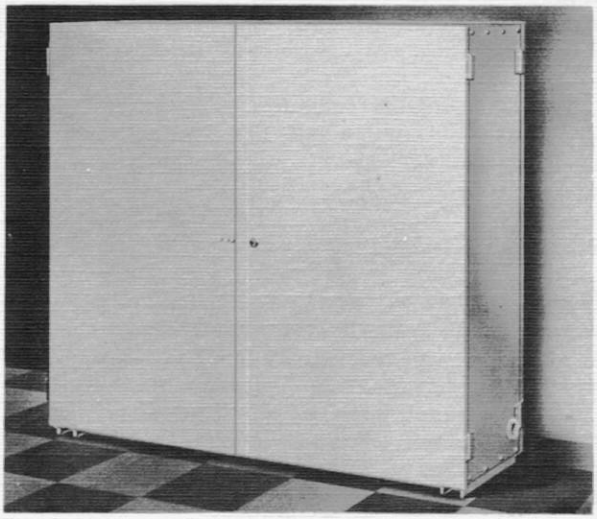
6.3 Reverting Calls

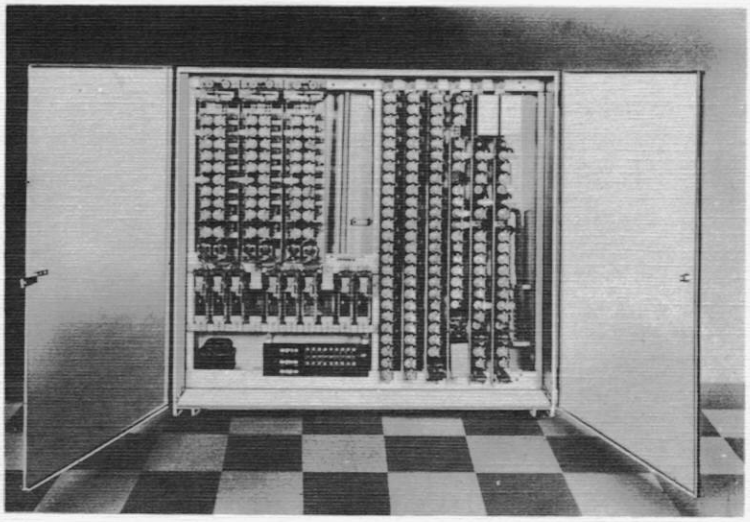
On party lines, especially rural lines where there may be 10 to 20 parties, some means must be provided for one party on the line to call another party on the same line. Since the person is calling his own line, he would ordinarily receive busy tone, and the line would not be rung. With reverting call equipment, the subscriber calls either the regular directory number of the wanted line or a special number. Busy tone is then received. Upon the calling party's replacing his handset, the called station is signaled. The calling person in some cases may be given warning rings so that he knows when the called party answers.

The called party may be given a tone upon his answering to hold him on the line until the calling party again removes his handset to find if his call has been answered.

6.4 Conversation Timing

In small exchanges and especially on party lines, it may be desired to time conversations and release the connection at the conclusion of the timing interval. A warning signal is usually given to the parties on the line shortly before disconnection.





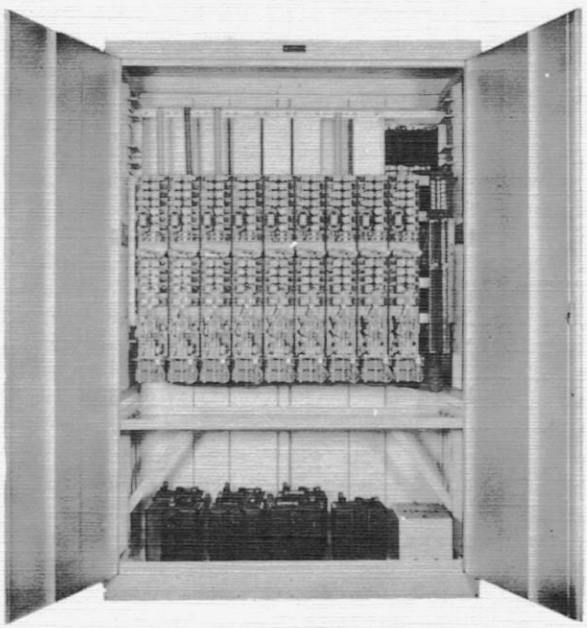


FIG. 14. TYPE 36A1 C-A-X INCLOSED IN A METAL CABINET.

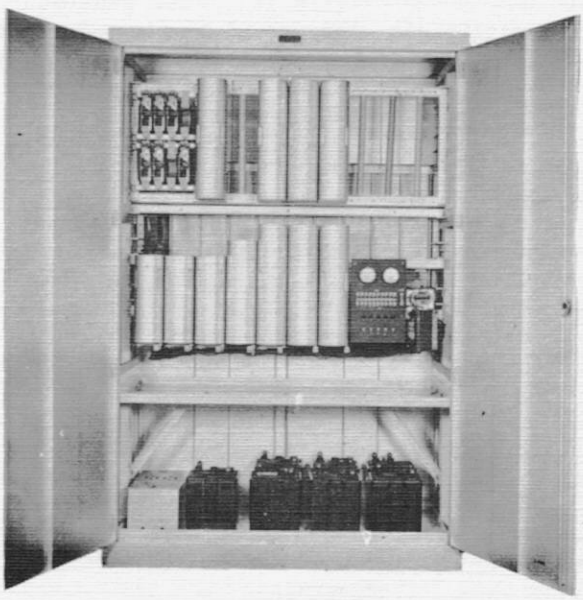


FIG. 15. TYPE 36A1 C-A-X SHOWING INTERIOR. ROTARY CONNECTORS AND FINDERS ARE AT LOWER LEFT.

FIG. 16. TYPE 32A44 C-A-X SHOWING THE CONNECTOR SIDE, INDIVIDUAL DUST COVERS REMOVED. CAPACITY IS 50 LINES WHICH MAY BE INCREASED BY ADDITION OF A SECOND UNIT TO 90 LINES.

FIG. 17. TYPE 32A44 C-A-X SHOWING LINEFINDER SIDE, SOME DUST COVERS ARE IN PLACE. ROTARY SWITCHES VISIBLE, UPPER LEFT.

6.5 Link Timing Relays

In addition to conversation timing described above, the finder-connector link may be timed under certain conditions which tend to tie up the exchange equipment. A link will be released within a given time on some C-A-X's if the calling party fails to dial, if the call is not answered, if the calling party fails to disconnect, or if a "permanent" line seizes a link.

6.6 INTERCEPTING SERVICE

Calls made to lines recently disconnected will be intercepted by an operator or be given an intercept tone.

6.7 Restricted Service

Frequently in a network of C-A-X's, it is desirable to restrict all subscribers or a group of subscribers from connecting with certain trunks such as toll lines which are accessible only to the operator.

6.8 Paystations

Generally paystations of the post-payment type are employed on small exchanges. These coin collectors require reverse battery when the called party answers. Reverse battery places a shunt on the transmitter so that a conversation cannot be carried on until a nickel has been deposited. No coin is required to talk to the operator who receives paystation tone when she

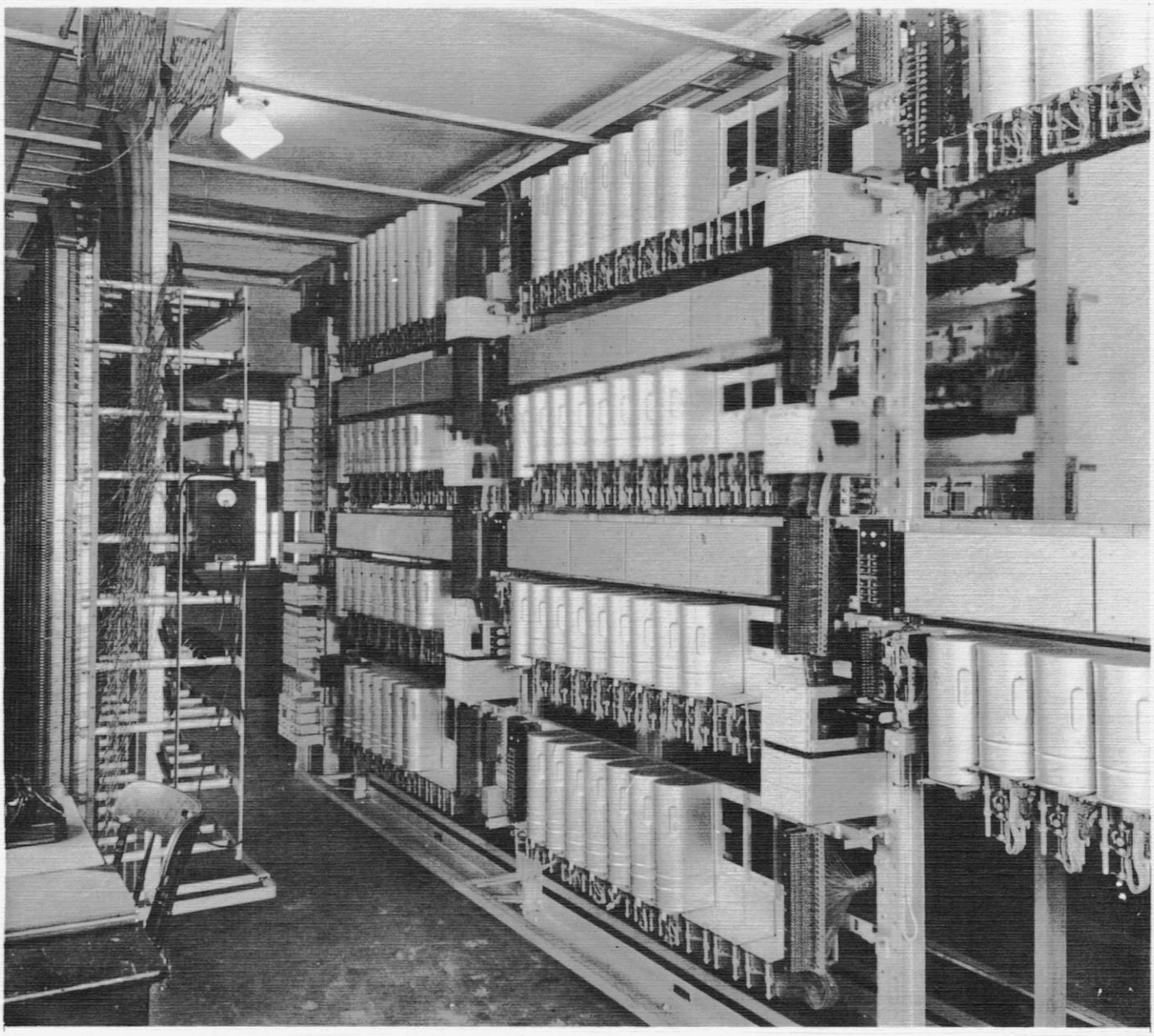


FIG. 18. TYPE 35E97 C-A-X WITH 200-POINT LINEFINDERS.

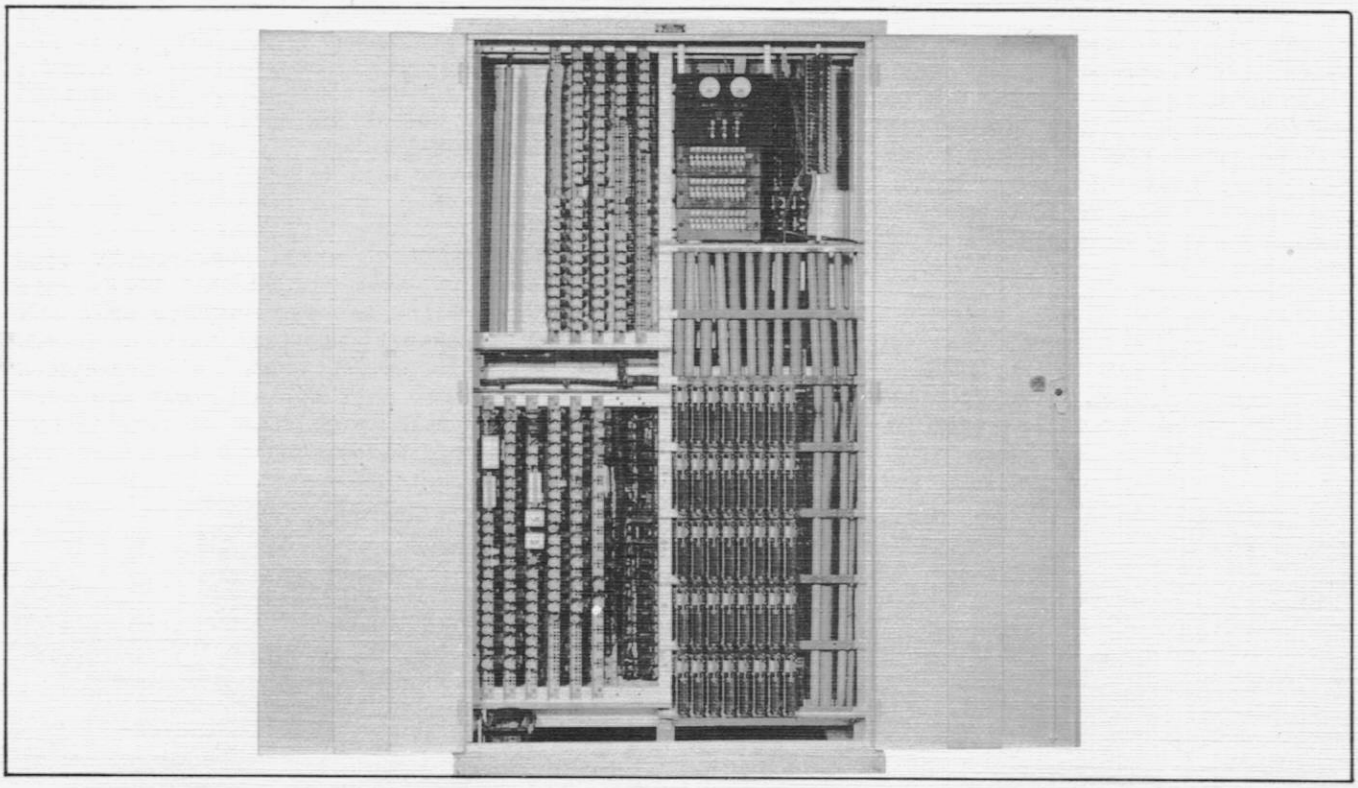


FIG. 19. TYPE 36A24 ROTOR RELAY SWITCHBOARD EQUIPPED FOR 60 LINES.

answers the call. Other types of paystations and paystation services are also employed.

6.9 Group Hunting

Where there are business houses having more than one telephone line, consecutive number or P-B-X service is provided. When the first number in a consecutive number group is busy, the connector will automatically switch subsequent calls to the next non-busy number in the particular group.

6.10 Alarms

Unattended Exchanges have an alarm checking number which the nearest toll operator may dial to check the condition of the exchange. Also if desired, alarms showing non-standard conditions within an exchange may be transmitted to the attended exchange. Visual signals are given on the switchboard indicating the condition as, for example, a charging failure, blown fuses, generator failure, blown heat coils, locked out line equipment, finder-start failure, or switch-release failure.

Should the operator at the attended exchange call the test number of the C-A-X, she will receive a tone such as ring back if there is no trouble; no tone for a major alarm, and busy tone for a minor alarm. A major alarm is usually considered as a fuse, charge, ringing machine, or finder-start alarm. The particular alarm combination varies from one type of switchboard as to another.

6.11 Traffic Registers

Meters are frequently provided to record the number of times all links are busy or to record the number of calls passing through an exchange.

6.12 Tones

There are three rather fundamental tones in use today. These are dial tone to indicate that a finder-connector link is ready to receive dial impulses, ring-back tone to indicate that the called party is being rung, and busy tone to indicate that the called line is busy. Special tones such as "tick" and "all-trunks-busy" are also employed at times. The tones above are especially for the subscriber.

When the operator at an attended exchange answers a call, she may receive certain tones such as paystation or class-of-service which tones inform her of the extent of service to be rendered.

6.13 Verification and Camp-On-Busy

A toll operator may monitor or talk on a busy line if desired. This arrangement when provided permits an operator to verify the calling station's number on requests for toll service as well as to check reported "busies."

The camp-on-busy feature is sometimes furnished the toll operator so that she may "camp" on a subscriber's line and delay ringing his bell until she has completed a toll connection. The line on which the operator is camping will test busy to other calls. If a party on the line lifts his receiver, the operator will receive answer supervision and be able to talk to the party.

7. SUBSCRIBERS' LINES

C-A-X's are normally wired for common battery and local battery lines using automatic telephones. Converted magneto telephones should not receive reverse battery; therefore provision must be made on the switchboard when such telephones are used.

Ground return lines may be employed on many boards. Battery is not reversed on these lines, and hence, pay stations cannot be assigned to such lines.

8. LINE CONDITIONS

Automatic exchanges are usually of the common battery type; i.e., electrical current for the transmitter as well as for signaling and dial pulsing is furnished from the central office current supply.

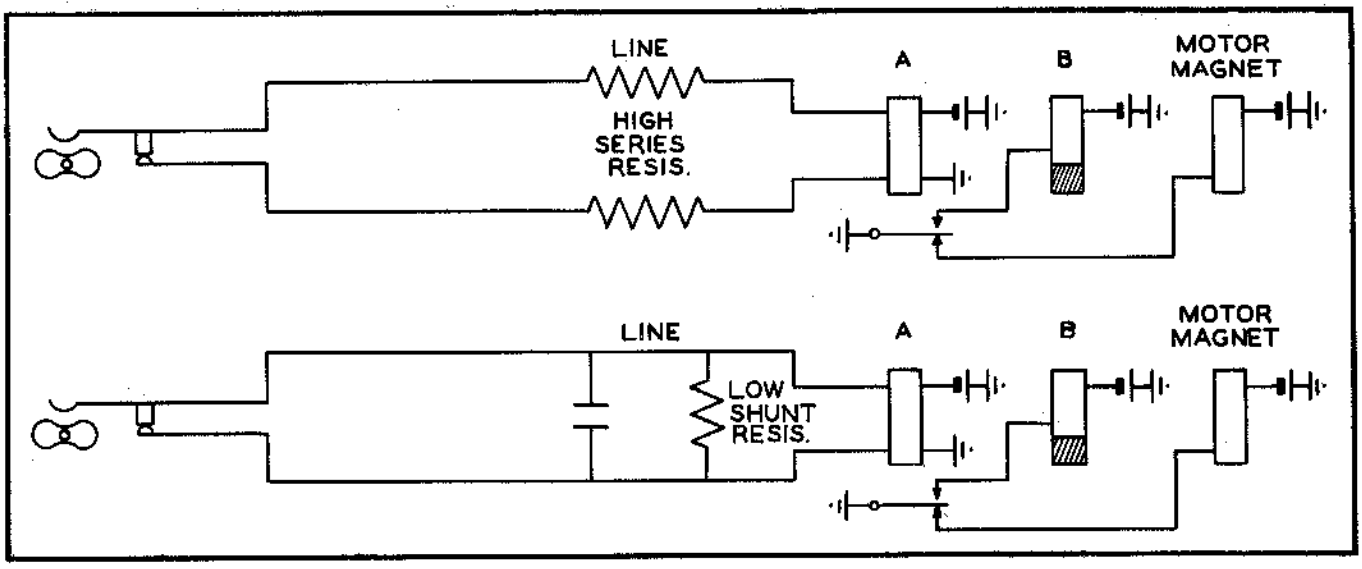
There are certain limitations which must be imposed on the subscribers' lines for successful operation of the automatic equipment.

The two line conditions which should be considered when it is desired to operate common-battery dial equipment are "line leakage" and "line loop resistance." Line leakage refers to the resistance existing through the insulation between the two wires of a line. In the case of drop wire, cracked insulation plus moisture will greatly lower this resistance and permit large currents to "leak" across the line. On the other hand, line loop resistance is the metallic resistance of the line wire (exclusive of the telephone instrument) from the exchange to the subscriber and back.

With dial speed between 8 and 12 impulses per second, a line may have a maximum non-inductive loop resistance of 1000 ohms and no leak, or 15,000 (sometimes 7,500) ohms leak resistance and no loop resistance. These two values represent extreme conditions. Intermixture of the two result in better operating conditions.

To understand, how the operating range of a two-motion switch is determined, refer to Figure 20. The subscriber's line in the Figure has no leak resistance.

If there were no line resistance, pulsing relay A would operate almost instantly when the subscriber's dial springs closed, and relay A would release almost instantly when the dial springs open on an impulse. When A closes, it sends current to the slow relay B, and when A releases, it sends a pulse of current to the motor magnet. If there is too much resistance in the line, relay A will be slow to get up and will fall away too quickly on a dial impulse because



FIGS. 20 & 21. EFFECT ON DIAL PULSES OF (TOP) HIGH SERIES RES. AND (BOT) LOW SHUNT RES.

of the low magnetic saturation and lack of a shunt. This situation gives relay B too little current to hold it up and gives the motor magnetic too long a pulse, sometimes called a "heavy" pulse.

If as in Figure 21, there should be no line loop resistance and low insulation resistance, the leakage current flowing across the line will hold A partially magnetised even when a dial impulse has opened the line circuit. A will thus operate too fast at the conclusion of a dial impulse and release too slowly at the beginning of a dial pulse. The shunt will tend to maintain A operated at break because of Lenz's Law which states that a self-induced current is in the same direction as the current which has been flowing. B will now get too much current at the expense of the motor magnet which will get too short a pulse, sometimes called too "light" a pulse.

In order that a switch may operate through as wide a range as possible, it is tested (varied) and adjusted first with a series resistance and then with a shunt resistance.

9. POWER SUPPLIES FOR C-A-X'S

The types of power supplies for C-A-X's is fully discussed in Bulletin 812 "Power and Supervisory Equipment." Generally power is obtained from a storage battery and a charging unit operating at 48 volts direct current. Some exchanges in districts having extremely reliable power supplies employ battery eliminators. However, the majority of larger exchanges have storage batteries which insure a constant supply of current, free from interruptions or large voltage variations.

9.1 Methods of Charging

The full float, constant voltage, method maintains a constant voltage across each cell of the battery. The charger normally supplies all the current required by the load, at the same time, furnishing the battery with a trickle charge. The battery "floats" in parallel with the charger. Should the battery become discharged during an emergency, the charger will bring it up to normal. When the battery voltage is up to normal, there is little or no current flow from the charger and, hence, no danger of overcharging the battery.

A second method of charging the exchange battery is the constant current system. With a charger of the constant current type, charging proceeds at a high fixed value until the battery is up to capacity. The rise in voltage which occurs when the battery reaches full charge causes a voltage sensitive relay to stop the charger. There are two methods of restarting the charger: (1) When the voltage of the cells falls from 2.05 (open circuit) to 1.75, a voltage sensitive relay releases, starting the charger or (2) the first call after the charger has been stopped restarts the charger. If the voltage is still high, indicating a fully charged battery, the charger is again stopped.

A third method of charging the exchange battery is the trickle charge method. Under this system, the charging rate is so adjusted that in a 24-hour period, the current used will just be replaced and the battery brought up to normal. During heavy loads, the battery must carry a considerable part of the load under this system. Under the "full-float" method, the battery carried no load ordinarily.

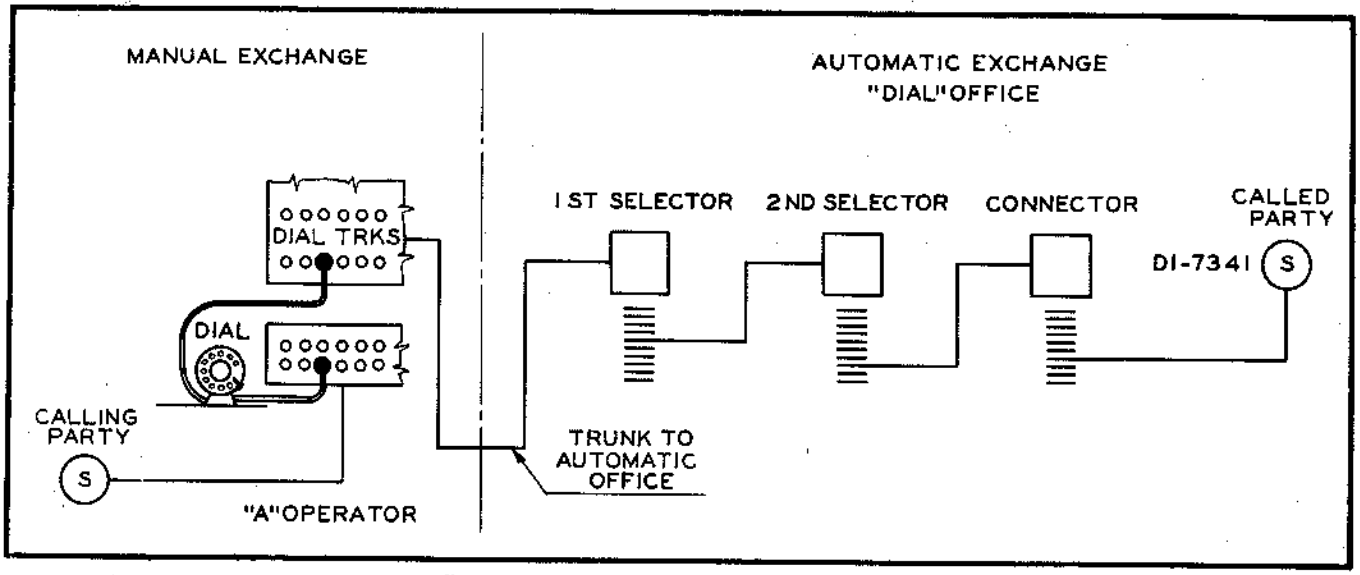


FIG. 22. MANUAL TO AUTOMATIC: MANUAL "A" OPERATOR DIALS INTO AUTOMATIC EXCHANGE FOR THE MANUAL SUBSCRIBER.

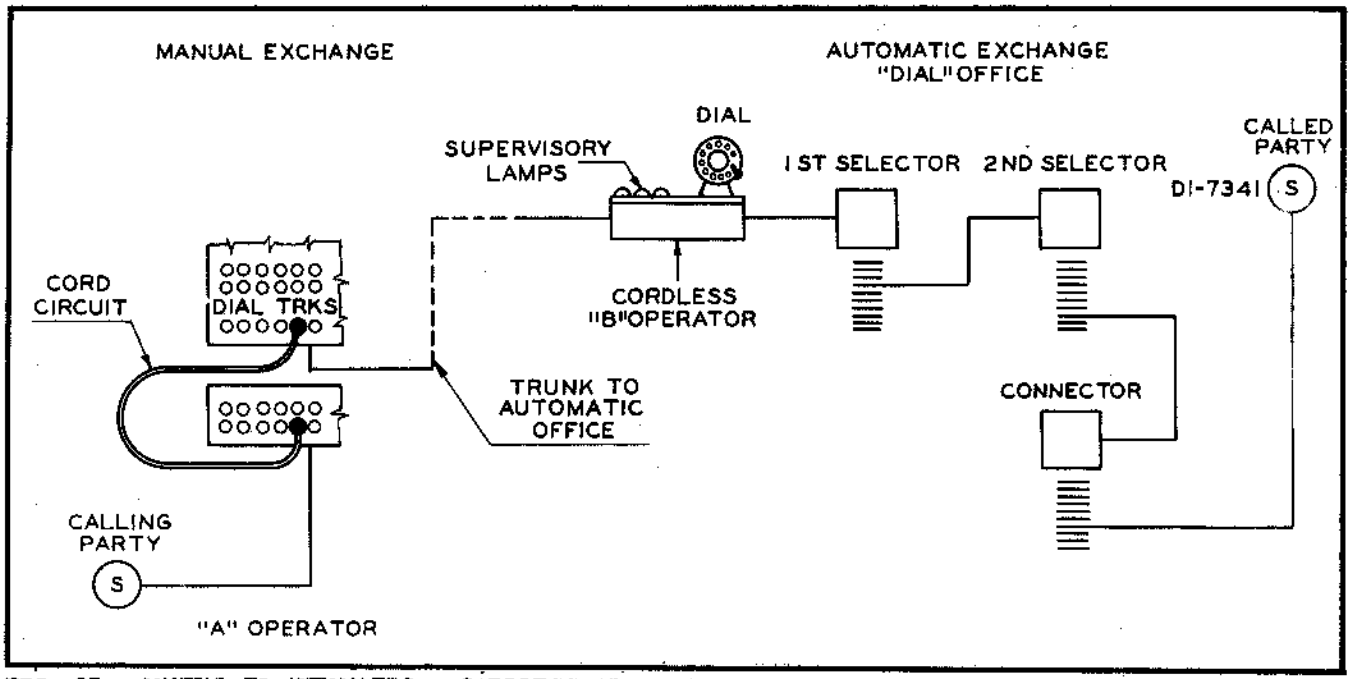


FIG. 23. MANUAL TO AUTOMATIC: CORDLESS "B" OPERATOR IN AUTOMATIC EXCHANGE SETS UP AUTOMATIC CONNECTION FOR THE MANUAL SUBSCRIBER.

9.2 Chargers

These may be of the dry-disc type, the bulb type, the motor generator type, or commercial direct current through a resistance.

10. INTERCONNECTION BETWEEN AUTOMATIC AND MANUAL

Interconnection between automatic and manual telephones is easily accomplished in several ways. Generally speaking it may be said that an operator is placed between the two systems so that she may dial into the automatic exchange for the manual subscribers and plug up connections to the manual exchange for the automatic subscribers. In areas of highly concentrated service the above duties are divided between two groups of operators, one handling all calls automatic to manual and the other all calls in the direction manual to automatic.

10.1 Manual to Automatic (Figures 22, 23)

There are two ways of handling calls from manual subscribers to automatic subscribers. In the first method (Figure 22), the regular "A" manual operator is equipped with a dial. When a call lamp from a manual subscriber lights, the "A" operator plugs into the calling jack with her "answer" cord. Ascertaining that the subscriber wants a number in an automatic exchange, she plugs the "calling" end of the cord into a free trunk to the automatic office and operates her "dial" key. She then dials the wanted number into the automatic exchange.

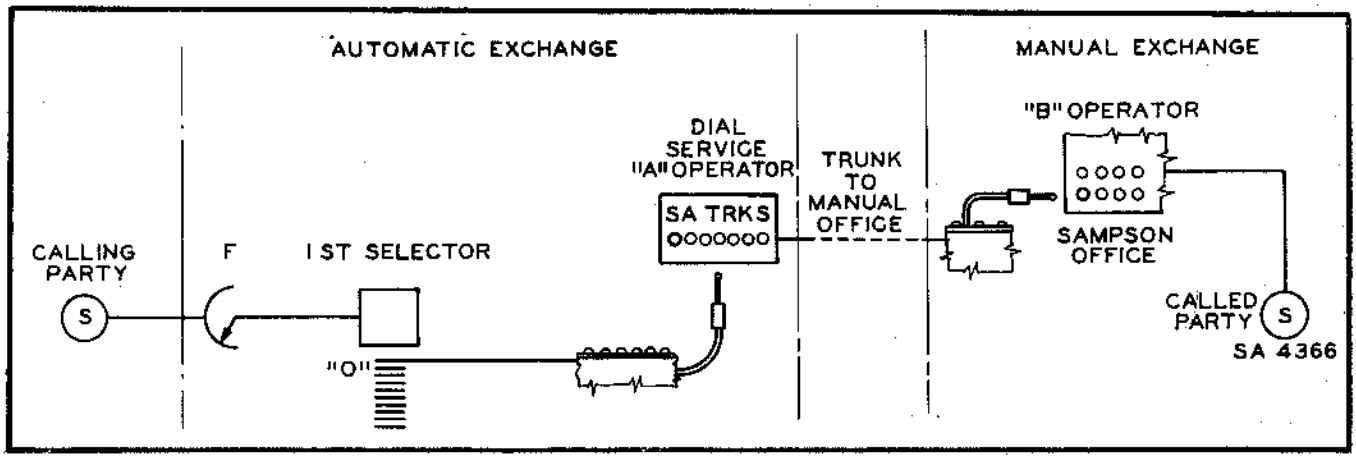


FIG. 24. AUTOMATIC TO MANUAL: DIAL SERVICE "A" OPERATOR IN AUTOMATIC EXCHANGE PASSES WANTED NUMBER TO MANUAL OPERATOR.

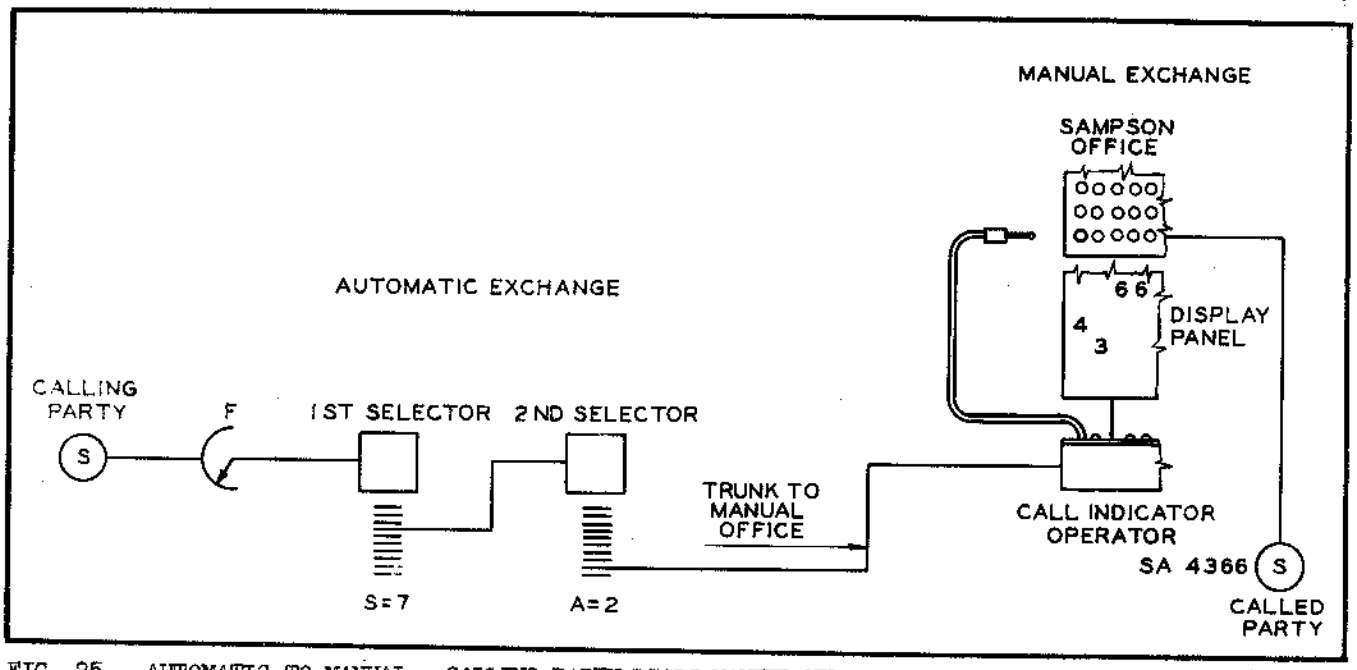


FIG. 25. AUTOMATIC TO MANUAL: CALLING PARTY DIALS WANTED NUMBER WHICH APPEARS ON A DISPLAY PANEL BEFORE MANUAL OPERATOR WHO PLUGS UP THE CONNECTION.

A second method (Figure 23) is used where operators are stationed at the automatic exchanges. The "A" operator at the manual exchange upon receiving a request for a number in the automatic office plugs the "calling" cord into a free jack to the automatic office. A "zip zip" tone is returned to her when a "B" operator is seized, and the manual A operator then passes the wanted number to the "B" operator at the automatic office. This latter operator has a cordless board equipped with either dial or a push key sender. She receives all her instructions from "A" operators in manual exchanges and without replying sets up the automatic connections. The original "A" operator receives answer supervision when the called party answers. The trunk to the automatic office and the equipment therein are released when the "A" operator withdraws the calling plug from the jack.

10.2 Automatic to Manual (Figures 24, 25)

As in the previous Section, there are also two ways of handling calls from automatic exchanges to manual exchanges. In city networks, both methods are used. The first method (Figure 24) involves Dial Service "A" operators in the automatic exchange. These are usually reached by dialing "0." The dial service "A" operators pass the calls to "B" operators in manual exchanges who plug up the connections. Normally the D.S. "A" operators handle short toll calls.

The second general method (Figure 25) requires call indicator boards each with an operator. The call indicator boards are located in the manual offices. Subscribers dial the listed number, just as if they were calling a number in an automatic exchange. Thus, the call indicator makes for uniform service.

The operator sitting before a call indicator sees the call number appear on a display panel before her. She picks up the trunk plug designated to her by a glowing of the associated trunk assignment lamp. The operator has a complete multiple of all subscribers in the manual exchange before her and may, therefore, plug up the connection after testing for a possible busy line condition.

When the connection has been established, the display panel is darkened as is the trunk assignment lamp. When the conversation on a connection has terminated and the calling party has replaced his handset, the call indicator operator is advised of this fact by the glowing of the disconnect lamp associated with the plug ended trunk circuit. The call indicator operator does not talk to the calling party at any time.

11. NETWORKS OF SMALL AUTOMATIC EXCHANGES

Figure 26 shows a number of rural communities grouped about towns E and F. E is a manual exchange furnishing toll service to the small magneto manual system at G and to a 22 line automatic system at A.

F is an attended main automatic exchange of 10,000 line capacity. F furnishes toll service directly to subscribers at B, C and D, as well as the operator at E.

B is an automatic exchange of 1,000 lines ultimate capacity. C is a still smaller exchange having fewer than 50 lines but capable of expansion to 90 lines. Exchange D has a capacity of 60 lines.

Subscribers in exchanges B, F and C may dial freely among themselves. Likewise subscribers in D may dial with free service among F, C and D. Service B to D and vice versa must pass through the toll operator at F. Subscribers at exchanges A, E and G have free service among themselves but are assessed toll charges by the operator on calls to B, C, D or F.

Figure 32 shows the switch trains at the various exchanges and the trunk connections between them. Exchange A has an automatic switchboard similar to the Type 36-A-1 with rotary linefinders and rotary connector switches. Figure 15 shows the switchboard. The rotary switches are of the 25-point type providing facilities for 19 subscribers' lines and 3 trunks to other offices such as E. The board is equipped with four links, one pair of which is shown in Figure 32. Thus, on the complete board, four conversations may take place simultaneously. To get the operator at E, a subscriber in A will dial "00." The operator at E, which is a common-battery manual exchange, will be signaled and will assist the subscriber as required. The operator at E may manually complete the connection in her area or extend the call to the magneto operator at G who will complete the connection. E may also dial directly into B, thus setting up a connection in that exchange, or she may signal the operator at F for service in F, C, D, or the tolls lines beyond.

A subscriber in the magneto-manual exchange G will give his magneto a few turns to signal the G operator. The G operator will either complete the connection locally (Bul. 820 "Manual Exchanges") or signal the E operator who will complete the connection as she would for a subscriber in the E area. This operator may extend the call to A by dialing directly into the exchange.

B is a C-A-X of the 35-E-97 Type with 1st selectors. It, therefore, has a capacity of 1,000 lines of which 500 are actually used for subscribers. Of the ten selector levels, the "0" level handles trunk calls to the operator at F. The "9" level permits direct dialing into F. The "8" level handles trunk calls to the operator at E. Since each level could normally have carried connectors for 100 subscribers' lines, the capacity of the switchboard has been reduced by 300 lines. Figure 18 illustrates a 35-E-97.

A subscriber in B dials three digits to seize the desired line plus a fourth digit to select the ringing code of the wanted party on the line. The ringing code is automatically sent over the called line until the called party answers or the calling party abandons the call.

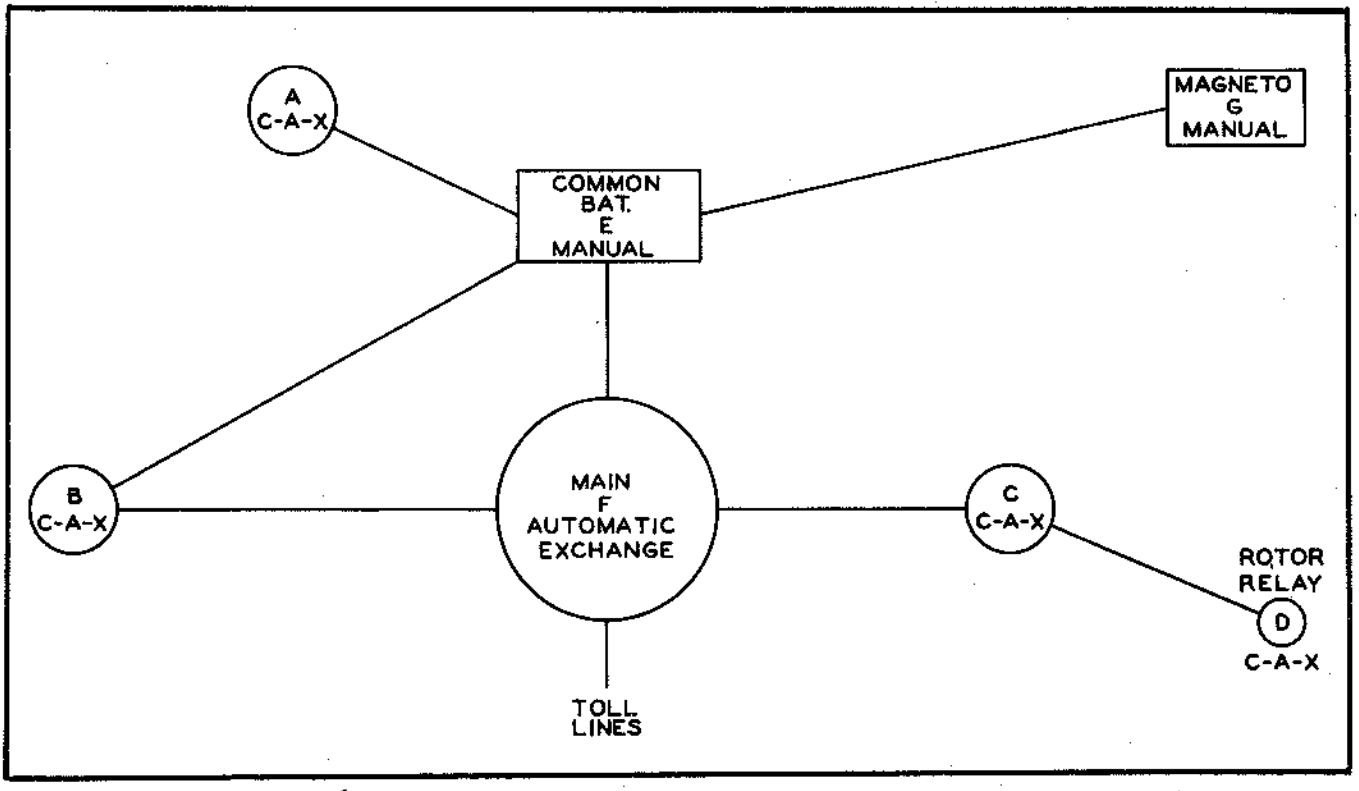


FIG. 26. NETWORK OF COMMUNITY EXCHANGE, MANUAL AS WELL AS AUTOMATIC.

Should a subscriber in B desire to call a subscriber in F, the calling party in B removes his handset, listens for dial tone, and dials 9. The wipers of the local selector rise to the ninth level connecting him to an incoming first selector in F. He now dials the regular directory number of the wanted party in F.

Should a subscriber in B desire to call a subscriber in C to which free service is also available, he first dials 9 as before which takes him to an incoming (1st) selector in F; then he dials 8 which takes him from the 8th level of the "F" incoming selector to the "Two-way repeater" on the trunk line to C. The "two-way repeater" places an unbalance on the trunk to C which causes the incoming connector to restrict B from calling into D. But B wanted a party in C; so he now dials the directory number of the wanted party at C. The connection to the wanted party is set up on an incoming connector.

If a party in F had dialed an "8" to seize the "two-way repeater" to C, the repeater would not have placed an unbalance on the trunk to C, because the repeater would have been seized from a local 1st selector instead of from the incoming selector which causes the repeater to apply the restrictive unbalance to the trunk line.

A party in F may, therefore, dial 89 to reach the rotor relay exchange at D. The rotor relay exchange will thereupon return dial tone to the calling party; trunk calls being handled by the regular finders. The calling party at F now dials the regular directory number of the wanted party in D.

Subscribers in F may dial directly into C with prefix 8; into D with the prefix 89; and into B, prefix 9. Dialing of "0" makes connection with the operator. The operator at F may dial 7 to reach the operator at E as the toll switch train is shown. The toll switch train includes switches under the operator's control. These switches provide her with special facilities such as "delayed ringing." The operator may also dial "0" for backward service over the B-F toll trunk. By dialing 08, the operator at F can reach E by a second route. A truly Automatic Toll Board is shown in Figure 27.

Subscribers at F are connected to the regular switch train by lineswitches. A lineswitch is individual to a line, and when a party on the line removes his handset to make a call, the lineswitch hunts for an idle 1st selector in the regular group of first selectors.

C represents an automatic exchange on the order of a Type 32-A-32 with rotary linefinders and two-motion connectors. The exchange has an ultimate capacity of 90 lines but at the moment is loaded somewhat under 50 lines; however, should additional line terminals be required, an additional 40-line unit can be added. The linefinder at C is of the 50-point rotary type. Should there be more than 50 lines, a second group of linefinders would be employed. A connector switch is permanently associated with each finder. Subscribers dial three digits for local service; the first two select the line; the third one determines the ringing code and side of line. Photograph of a 32-A-44 similar to a 32-A-32 is shown in Figure 16.

A subscriber in C may dial 9 for free service to D; 0 for free service to F, 00 for the operator at F, 09 for free service to B. The regularly listed directory number of the wanted party follows the above prefixes. Note that only one trunk group was provided from C to F while two trunk groups were employed from B to F. This latter arrangement permitted a single "0" at B to reach the operator.

D represents a rotor relay exchange along the lines of a Type 36-A-24. All connections are established by the opening and closing of relay contacts as described in Section 5. The exchange has a capacity for 60 lines including trunks and has seven finder-connector links, so that seven simultaneous conversations may take place. A Type 36-A-24 is illustrated in Figure 19.

Subscribers in D must dial "000" for the operator at F unless there are special trunking arrangements around C. The first "0" seizes the trunk to C. The second "0" causes an incoming connector at C to seize the trunk to F. The third "0" causes the incoming selector at F to connect with the operator. For calls within the D exchange area, four digits are dialed. The first and fourth digits determine the ringing code or harmonic frequency while the second and third select the line.

Subscribers in D may not dial beyond F into B. When the "two-way" repeater at C, connecting to the C-F trunk, is seized from D incoming connector, an unbalance is placed on the C-F trunk which acts at F to prevent the incoming selector from connecting with its ninth level leading to B. The unbalance placed on the C-F trunk is in the form of a direct current potential on one side of the line.

FIG. 27. AN AUTOMATIC TOLL BOARD. NOTE THE ABSENCE OF CORDS AND PLUGS.

12. SUB-OFFICES (See "Switching Selector Repeater" Bul. 817)

Sometimes a comparatively small office is located on the outskirts of an exchange area to secure a more economical outside plant layout than could be secured by connecting the local lines directly to the nearest central office. This small unit will operate as a satellite or suboffice with trunks to the one associated exchange. The suboffice first selectors will be located in the central exchange so that trunks to other offices can be selected from the suboffice by dialing the first digit.

Should the called subscriber be located in the suboffice, a switching selector repeater (described in Bulletin 817) can be employed so that the trunk and selector in the central office will be automatically released.

13. UNIVERSAL NUMBERING AND DIGIT ABSORPTION

In some networks, a universal numbering scheme is desired so that subscribers in all exchanges dial directory numbers to reach any subscriber whether in the calling party's exchange or in some other. Universal schemes are sometimes objectionable for they may require the user to dial more digits on a local call than are necessary for local service. Thus the first digit on a five-exchange network would select the exchange to which a call is to be routed.

When there are only two exchanges involved, it would ordinarily be wasteful of facilities to devote a selector rank to the selection of exchanges unless several selector levels were used for special services. Such a selector rank may be replaced by digit absorbing springs on the second selectors, if sufficient vacant selector levels are available on the second selectors to care for trunks to connecting exchanges and for special services. The second selectors would then serve as both first and second selectors but would be called first selector.

A digit absorbing selector operates like any selector except when a digit to be absorbed is dialed. The selector raises its shaft to the dialed level, but at that point a cam operates causing the selector to release. Subsequent digits dialed including the one just absorbed will cause the selector to operate in the standard manner.

Figure 28 shows two exchanges, Number 4 and Number 5, of say 400 lines each. Exchange No. 5 may dial into Exchange No. 4 by prefixing the digit "9" to the regular directory number. Subscribers

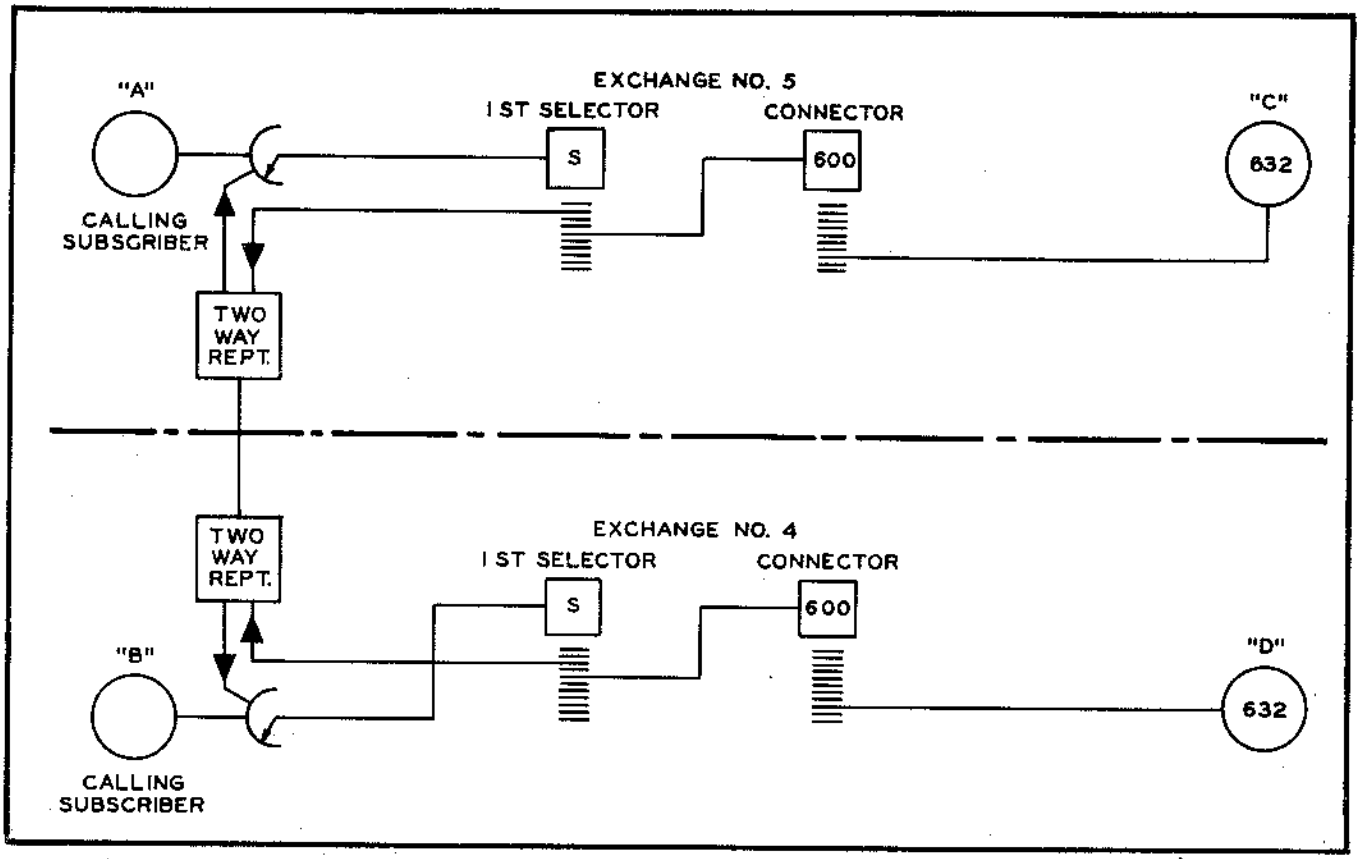


FIG. 28. A SIMPLE NETWORK OF TWO EXCHANGES. "A" IN DIALING "B" MUST PREFIX A "9" TO "B's" REGULAR NUMBER. "B" IN DIALING "A" PREFIXES AN "8."

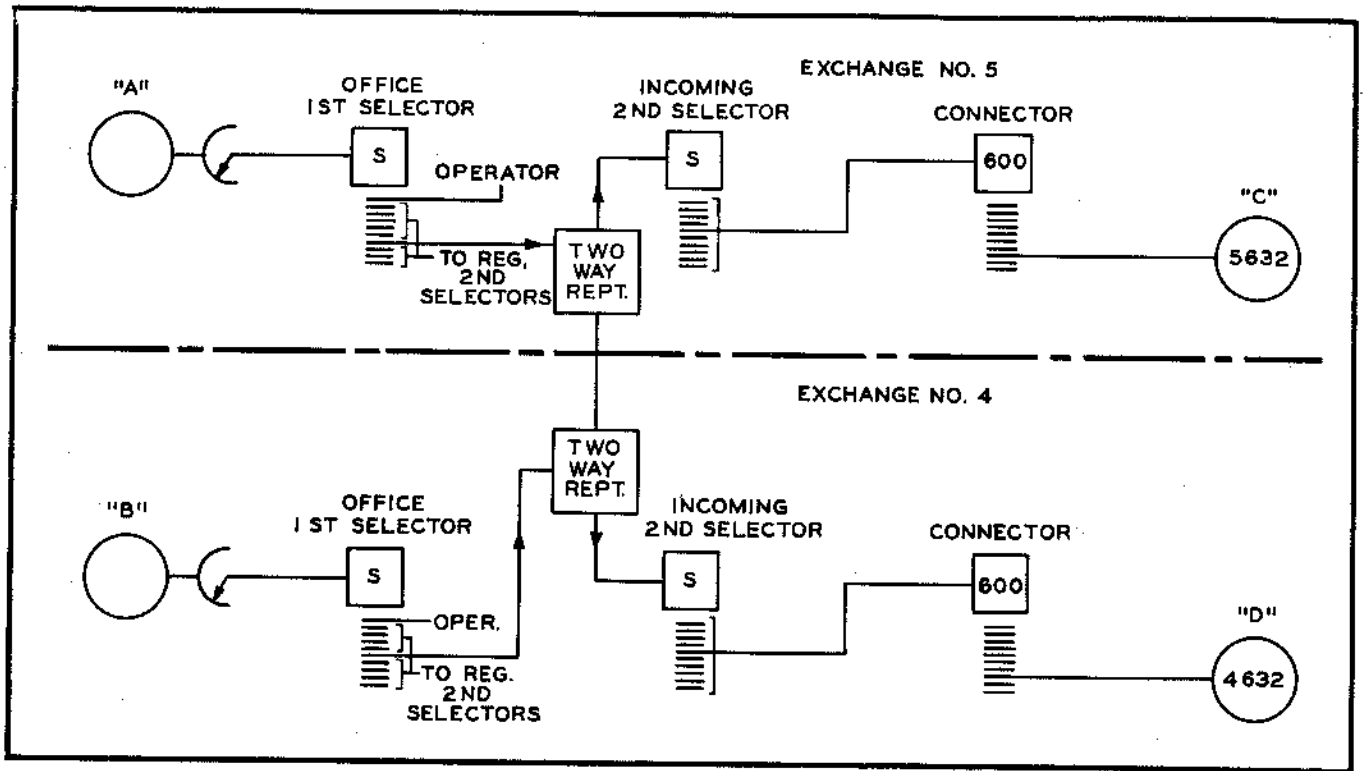


FIG. 29. SAME NETWORK ARRANGED FOR UNIVERSAL NUMBERING BY THE ADDITION OF A SECOND SELECTOR BANK. THE FIRST DIGIT OF THE REGULAR DIRECTORY NUMBER SELECTS THE EXCHANGE. NOW FOUR DIGITS MUST BE DIALED ON ALL CALLS.

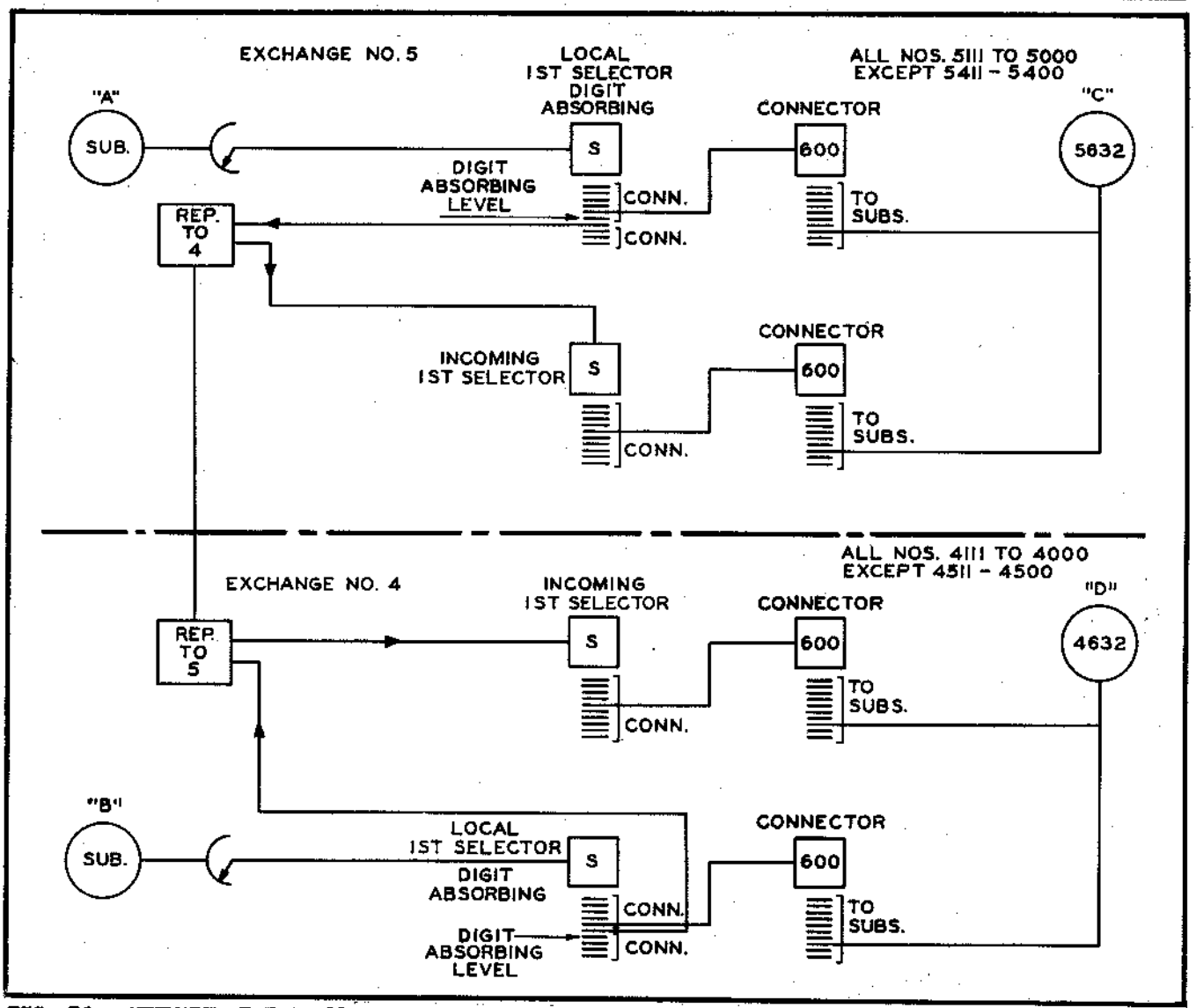


FIG. 30. NETWORK OF FIG. 29 WITH DIGIT-ABSORBING SELECTORS IN PLACE OF TWO SELECTOR BANKS. SAME FOUR-DIGIT NUMBERING SYSTEM IS NEEDED.

in Exchange No. 4 must prefix an "8" to the directory number of called parties in 5. This means that one additional digit must be dialed for interoffice calls. If a large number of such calls are made, it would be desirable to have a uniform numbering system.

One method of obtaining a uniform numbering system is shown in Figure 29. An additional rank of selectors is added. The new rank now called the 1st selectors are for the purpose of selecting the called office. The second selectors continue to select the wanted connector rank. Where only two offices are involved, office selectors (1st) are usually superfluous unless several levels are needed for special services.

If digit-absorbing selectors are used in place of the second selectors as in Figure 30, the first selector may be eliminated, and the uniform numbering of Figure 29 maintained. Notice that subscribers C and D have the same numbers in Figure 29 as in Figure 30. When subscriber B in Figure 30 dials subscriber D, both of whom are in the same exchange, the local 1st selector (digit absorbing) steps to the fourth level. The digit absorbing cam springs are operated to release the switch since the call is identified as being for the local office (No. 4). When the next digit, 6, is dialed, the local 1st selector will again step up to select a free connector in the 600 group. Digits 3 and 2 of the called number will step the connector to the calling line.

Should subscriber B in Exchange No. 4 dial 5632 to reach C in Exchange No. 5, the local 1st selector at 4 will step to the fifth level and cut in on a free trunk to Exchange No. 5. The digit-absorbing springs are not operated when the call is destined for another office. Thus, three digits remain to drive the regular switch

train in the No. 5 office. Digit 6 will cause the incoming selector to step to the 6th level and select a free connector in the 600 group. Digits 32 will step the connector to the wanted party's line.

Note that since a local 1st selector with the digit absorbing feature combines both the functions of an office selector and those of the next regular selector ranks, the 1st selector (digit absorbing) will combine the levels of the two switches. Since the total number of levels cannot exceed 10, it is obvious that there is a limit to the application when the number of subscribers is such that close to 9 levels are needed for connection to local trunks or services (e.g., next switch ranks) as one level in the selector is required for each outside office. The digit absorbing feature need be applied only to local 1st selectors and not to incoming 1st selectors, because the latter receive no extra pulses, at least in Figure 30.

Another method of universal numbering is shown in Figure 31. Two offices, A and B, each have local selectors, local connectors, and incoming connectors.

The local 1st selectors may connect with trunks to the incoming connectors at the distant office or connect with the local connectors at the local office. Thus the group selection is carried out at the originating office. This requires more trunk groups to the associated office and limits the capacity of the first switch to about one-half its levels for local service where both exchanges are equally large and loaded near capacity. However, one advantage of the plan is that no digits are wasted.

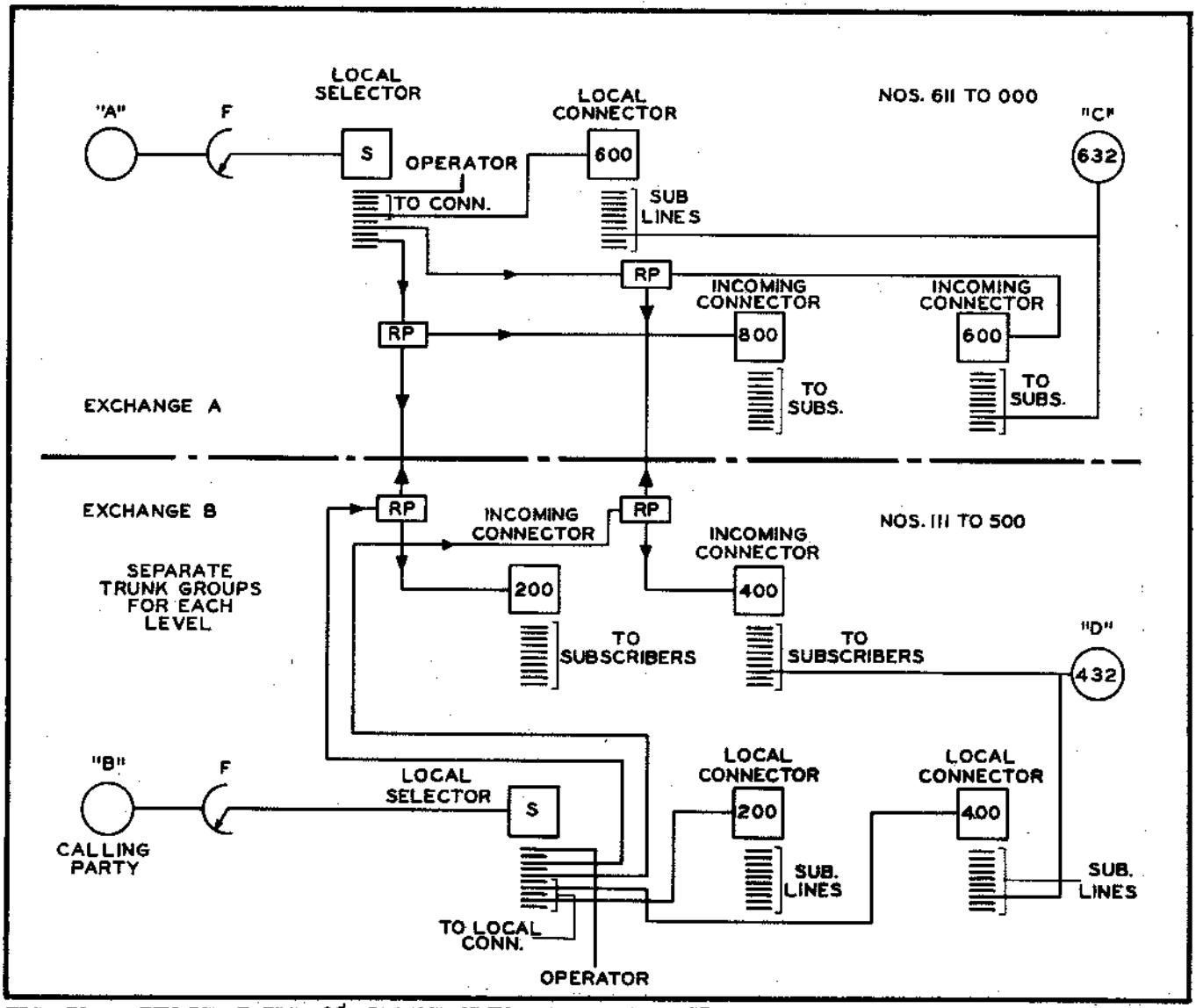


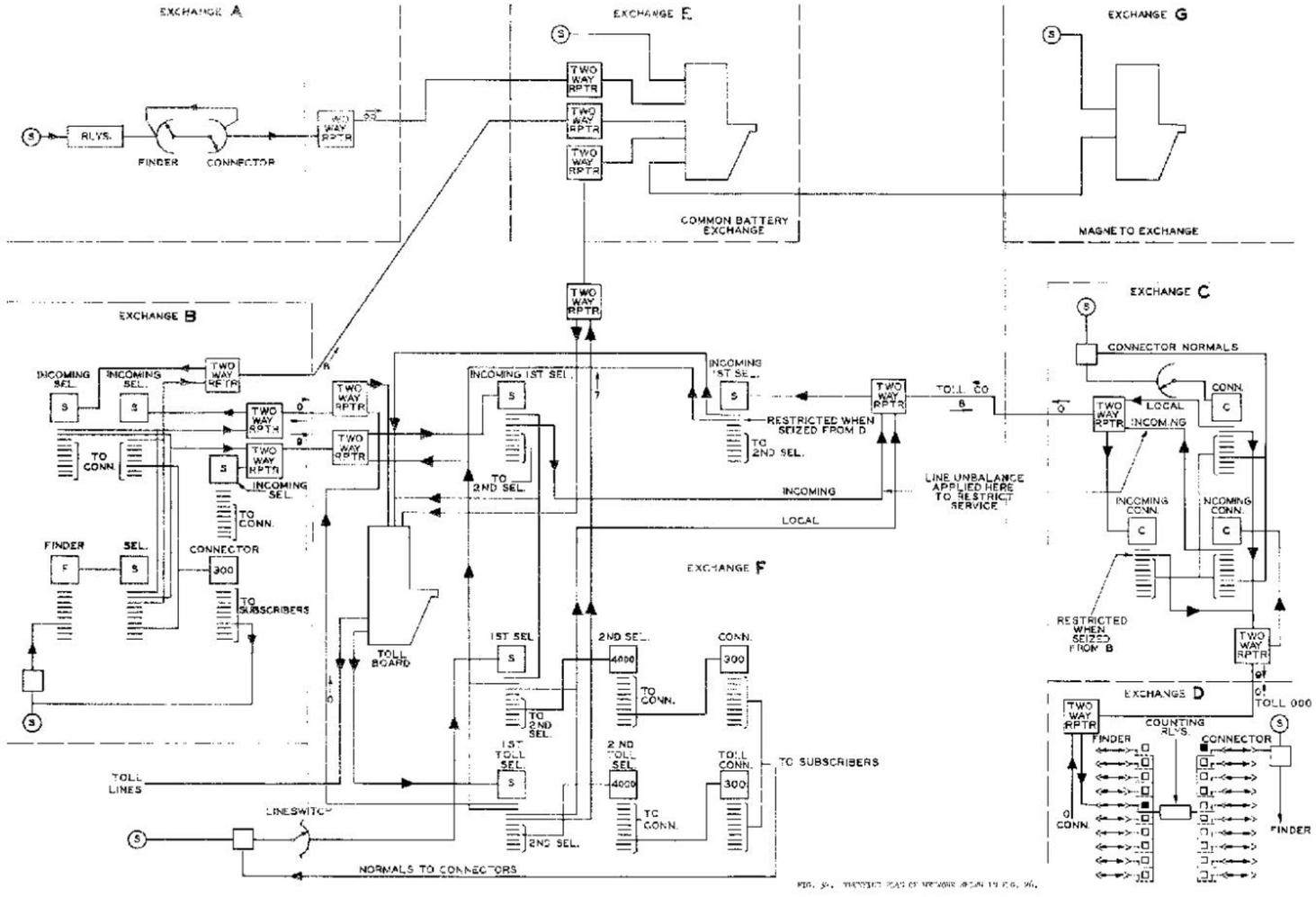
FIG. 31. NETWORK OF FIG. 28 ARRANGED WITH INCOMING CONNECTORS SUCH THAT THE CALLING PARTY'S LOCAL SELECTOR SEIZES THE DESIRED CONNECTOR IN EITHER EXCHANGE. A TRUNK GROUP FOR EACH CONNECTOR BANK IS REQUIRED.

NETWORK TABLE

SERVICE	EXCHANGE	NO. DIALED	CONNECTION COMPLETED
Free	A to E	A dials 00	Operator completes connections
Free	A to G	A dials 00	Operator at E connects to G
Toll	A to B	A dials 00	Operator at E dials into B
Toll	A to F	A dials 00	Operator at E to operator at F who dials into F
Toll	A to C or D	A dials 00	Operator at E to operator at F who dials into C or thru C to D
Toll	B to E, A, G	B dials 8	Operator at E completes connection to subs. at E, dials into A or connects to oper. at G
Free	B to F	B dials 0	Toll operator
		B dials 9	For free automatic service into F
Free	B to C	B dials 98	For free automatic service into C
Toll	B to D	B dials 0 B is blocked from dialing into D	Operator at F dials 89 for automatic service into D
Toll	C to E, A, G	C dials 00	Toll operator at F dials 7 for oper. at E who completes connection
Free	C to F	C dials 0	For free automatic service to F
		C dials 00	Toll operator
Free	C to D	C dials 9	For free automatic service to D
Free	C to B	C dials 09	For free automatic service to B
Free	D to C	D dials 0	For free automatic service to C
		D Dials 00	For free automatic service to F
Free	D to F	D dials 000	For operator at F
Toll	D to B	D dials 000 D is blocked from 009 into B	For operator at F who dials 0 for automatic service into B
Toll	D to E, A, G	D dials 000	For operator at F. Oper. at F completes call as F to E, A, G
Toll	E to A, G		Operator at E completes call locally or passes to operator at G
Toll	E to F		Operator at E has trunk to operator at F. Can Dial 00 in emergency.
Toll	F to E, A, G	Opr. at F Dials 7	Operator at F dials 7 for operator at E. Operator at E completes calls locally, dials into A, or passes calls to operator at G
Free	F to B	F dials 9 F operator dials 0	For free automatic service into B To complete toll calls into B
Toll		F operator dials 78	For Emergency Use to B
Free	F to C	F dials 8	For free automatic service into C
Free	F to D	F dials 89	For free automatic service into D
Free	G to E		Operator at G has trunk to operator at E

VARIATION: A could be provided through trunks A to B via "E" for automatic operation into B.

A second trunk from D could be carried through C so that D dialed only 00 for F operator.



In Figure 31, A dials 432 to reach D. The "4" steps the local selector at B to its fourth level. The selector then seizes an idle local connector in the 400 group. Digits 3-2 step the connector wiper to the called line. Had subscriber A at Exchange A dialed 432, he would have stepped the wipers of his local selector to the fourth level. The selector in A would have then seized a free trunk to a 400 incoming connector at B. The incoming connector would have connected with D when 3-2 was dialed by A.

If subscriber B in Exchange B wants to call C in Exchange A, he dials the directory listed number, 632. Dialing of the 6 steps the local selector at B to the sixth level. The selector cuts in on a free trunk to a 600 incoming connector at A. Dialing the digits 32 completes the connection to C, 632.

Thus selector levels 1, 2, 3, 4, and 5 are associated with connector groups in B. Selector levels 6, 7, 8, 9 and 0 are associated with connector groups in A. A may borrow unused levels from B, and "0" may be used for service to the toll operator.

ETM:RJ

14. AUTOMATIC TOLL TICKETING

In an automatic multi-exchange area in which a toll charge is made for inter-office calls, Strowger Automatic Toll Ticketing (SATT) apparatus may be employed to automatically issue toll tickets. This eliminates mixed manual-automatic operation, except for the long distant toll calls.

The SATT system consists of the following components: (1) a repeater for storing the terminal number of the calling party, the exchange code, terminal of the called party, and rate applicable to the call; (2) a converter to determine the class of rate, the route to the called exchange, and whether the calling party has a right to toll service; (3) a detector to determine the calling line; (4) a printroller which collects all the information including the time of day and passes this to the printer; (5) the printer unit issues a ticket with the calling party's number, the called party's, the date, the time, rate code, conversation time, and computed cost of the call; (6) the time and date unit.

Printed in U.S.A. by C.P.C. 1M-8-41