

PRIVATE AUTOMATIC EXCHANGES

WITH P-A-B-X APPENDIX

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AUTOMATIC  ELECTRIC

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

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NOTE: Since this is an Educational Series Bulletin, the complete line of P-A-X's and P-A-B-X's is not described. However, representative switchboards of each general type are included.

PRIVATE AUTOMATIC EXCHANGES

1. INTRODUCTION

The Private Automatic Exchange, abbreviated P-A-X, is an automatic intercommunicating system which serves business houses, institutions, residences, and ships in the same manner that a Community Automatic Exchange serves a community. The P-A-X is composed of the regular Strowger equipment arranged and adapted to fit the requirements of intercommunicating systems and renders the same quality of service as that furnished by public automatic exchanges. These switchboards are made in a number of standard types and sizes. Size ranges from three telephones to any number desired. Switchboards once installed may be increased in capacity as the need arises. A 100-line capacity system may be thus increased to, say, a 1000-line system or one of intermediate size.

The P-A-X is an isolated telephone system serving a single building or group of associated structures, often though a P-A-X may be connected to other telephone systems. When a P-A-X is arranged to permit calls to be made to and from the public exchange, it is called a Private Automatic Branch Exchange (P-A-B-X). See Appendix for details.

The P-A-X as an isolated system has a number of advantages. It permits "double track" telephone service: An inquiry on the city exchange phone may be investigated and answered over the P-A-X while the city call is waiting. The private system also reduces the number of calls which must be handled by the manual switchboard attendant and gives general communications efficiency.

The subject of P-A-X's could be divided in several ways. Systems using Strowger switches could be discussed against rotor relay systems. In the latter, which are not to be considered in detail, 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. These switchboards are similar to their corresponding C-A-X counterparts.

The division of the Strowger systems adopted here is based on capacity rather than on the type of switch employed for any given function.

2. SMALL P-A-X'S

Most P-A-X's with capacities for 25 or fewer lines employ rotary linefinders and rotary connector switches. Section 5 describes a 10 line system; Section 6, a 20 line system.

3. MODERATE AND LARGE SIZE P-A-X'S

These are generally of the lineswitch type though linefinders are employed on some. Exchanges with an ultimate number of lines less than 100 have Strowger connectors while larger systems require selectors. In other words, a Private Automatic Branch Exchange of moderate to large size employs practically the same switch train as a city exchange of comparable capacity.

The switchboards are enclosed in attractive steel cabinets of sturdy design. In exceptionally large exchanges, however, the switches are rack mounted with individual dust covers. Either type of mounting may be expanded by adding additional cabinet sections to the former and more shelves or racks to the latter. The unit system of mounting the switches on the shelves makes the addition of equipment relatively simple.

4. SPECIAL SERVICES

P-A-X's may be equipped to render various services including Code Call, Watchman's Supervisory and Recording, Conference, Executive Right-of-Way, and Alarm. Other services as required in schools and special institutions are available. In addition, arrangements can be made to limit service on some telephones and to give special privileges to others.

4.01. Code Call

The code call service permits a code to be sounded by bells, buzzers, horns, whistles, or lights under the control of a number dialed on any of the regular P-A-X telephones, thus signaling someone that he is being searched for. The person whose code is being sounded answers the call by dialing a certain code-call-answering number on the nearest P-A-X telephone. This automatically stops the code call machine and places the calling and called

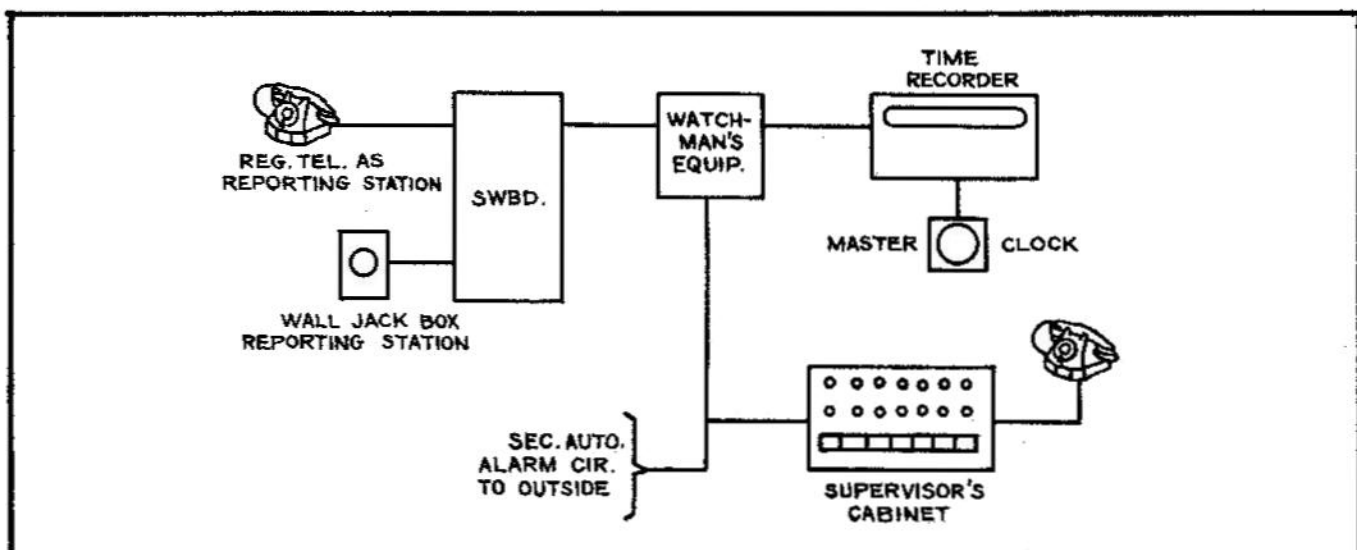


FIG. 1. A P-A-X FITTED WITH WATCHMAN'S SUPERVISORY AND RECORDING SERVICE

persons in telephonic communication. The calling person can stop the code-call machine at any time by replacing the handset on the cradle. P-A-X code call systems are discussed in Bulletin 670.

4.02 Watchman's

This service makes the P-A-X telephones available as watchman's stations for reporting from a patrol route. The watchman dials a certain number from each of the telephones designated as stations. This causes a lamp to glow on a panel in front of a supervisor, indicating the station from which the call is made. The call is also recorded on a paper strip attached to a special recording clock. The supervisor may give instructions over the telephone, if he so desires, when the watchman calls. The equipment is designed so as to give an alarm if each station is not reported within the predetermined intervals or if the stations are not reported in the correct order. See Fig. 1.

4.03 Conference

This feature enables any desired number of telephones within limits, to be connected to a common line over which all the conferring persons may speak or be heard. There are three types. "Meet Me" requires that the members to a conference dial the designated conference number at the appointed time. A second form provides for signaling simultaneously a maximum of 20 predetermined stations in a fixed group. A third permits the progressive addition of stations from a predetermined group. The person calling the conference dials an assigned conference number followed by the numbers of the desired telephones, as each answers, he is instructed to wait until all have answered. See Figs. 2 and 3.

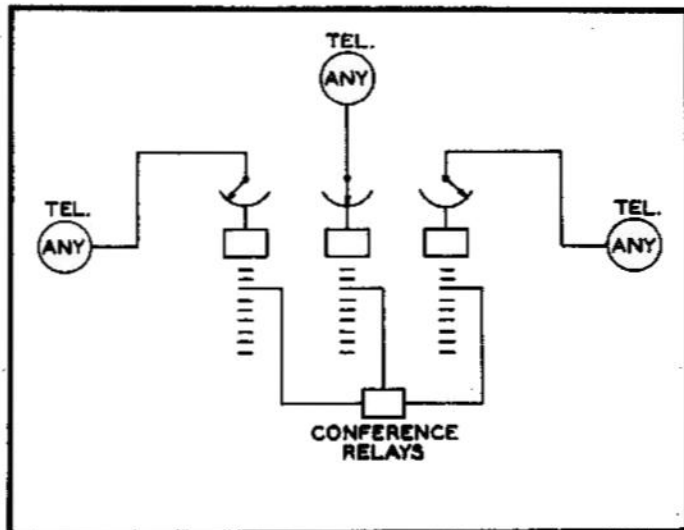


FIG. 2. CONFERENCE FEATURE PROVIDING "MEET ME" SERVICE

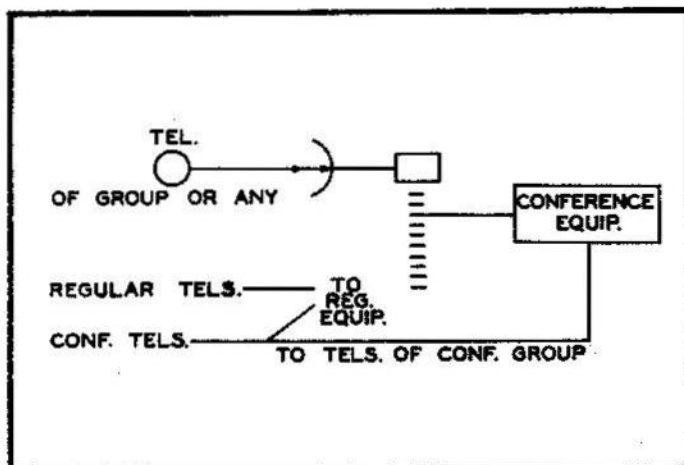


FIG. 3. CONFERENCE FEATURE CALLING A FIXED GROUP OF TELEPHONES

4.04 Executive Right-of-Way

Executive right-of-way is an arrangement by which a person using one of the executive telephones may reach any telephone whether that telephone is already in use or not.

4.05 Fire Alarm

The P-A-X telephones alone, may always be used for emergency alarms with the fire marshal's telephone equipped with a loud ringing bell. More elaborate fire alarm systems require special equipment. The equipment used, consists of a number of closed circuit alarm boxes placed at convenient points, a supervisory panel at the gate house or fire marshal's office, and a code sender. If upon the outbreak of a fire a pull-box is operated, the code sender automatically sends out the fire code for that box to all of the code call signal devices. As always, an alarm may be sent in by dialing the fire marshal's telephone. The fire marshal, after receiving the information over the telephone, may send out the code call of the nearest box to the fire by operating a key which starts the code sender. See Figs. 4 and 5.

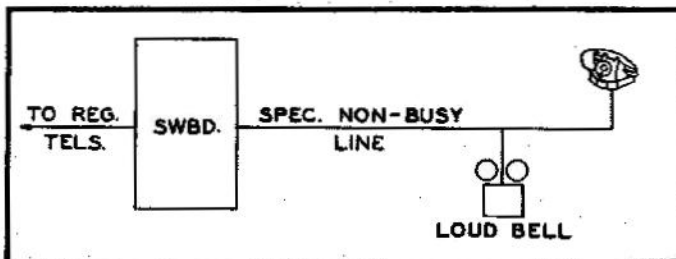


FIG. 4. FIRE MARSHALL'S TELEPHONE WITH A SPECIAL NON-BUSY LINE TO INSURE THAT ALL CALLS WILL REACH THE MARSHALL

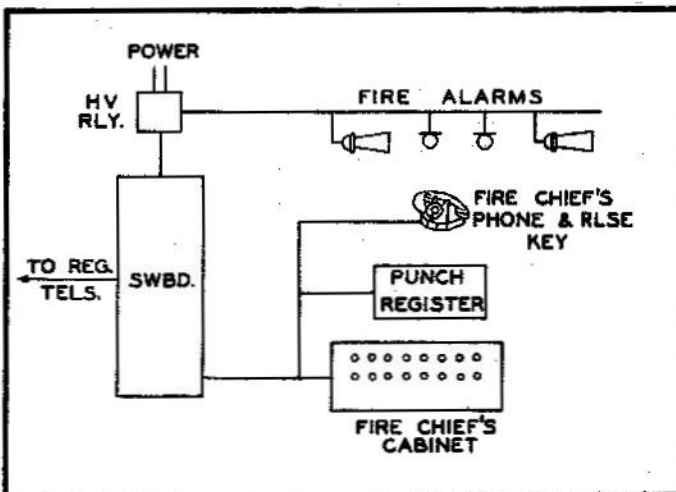


FIG. 5. A COMPLETE FIRE REPORTING SYSTEM WITH PROVISIONS FOR HOLDING CALLS TO FIRE MARSHALL AND FOR SUPERVISING ALARM SIGNALS

4.06 Key-Calling or Direct Line

The key-calling unit consists of a small cabinet with a row of keys. The executive making a call to any one of certain stations merely flips a key. The bell at the called station rings continuously indicating an executive call while a

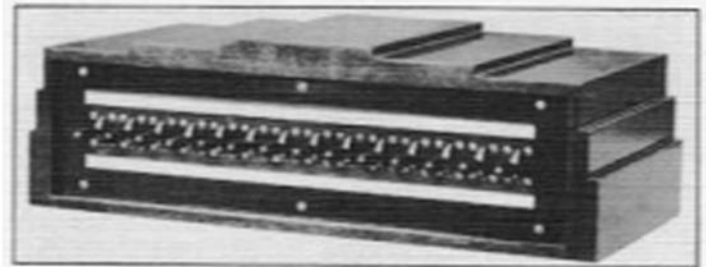


FIG. 6. KEY-CALLING CABINET

buzzer in the executive's cabinet sounds. When the buzzer stops, the executive lifts his P-A-X handset and begins conversation. A direct line connects the executive with each station on the service. See Fig. 6.

4.07 Two-Line Monophones

These provide the facilities for "double-track" service, executive-secretarial service, P-A-X-direct line, and similar switching services. A two-line Monophone consists of a regular Monophone combined with a sub-base which contains key equipment for switching from one line to another. See Fig. 7.

It provides facilities for making or answering calls on either of two lines with a single desk telephone and affords provisions for holding one connection while talking over the other line. The "holding" keys, when provided, are mechanically linked to the handset cradle switch and are restored when the handset is replaced. For this reason, a small push-button is provided in the top of the sub-base and is used instead of the cradle switch for releasing a connection in case it is desired to dial a second time on one line while holding a call on the other or for recalling the operator in a manual system.



FIG. 7. TWO-LINE MONOPHONE ARRANGED TO MAKE OR ANSWER CALLS OVER TWO LINES

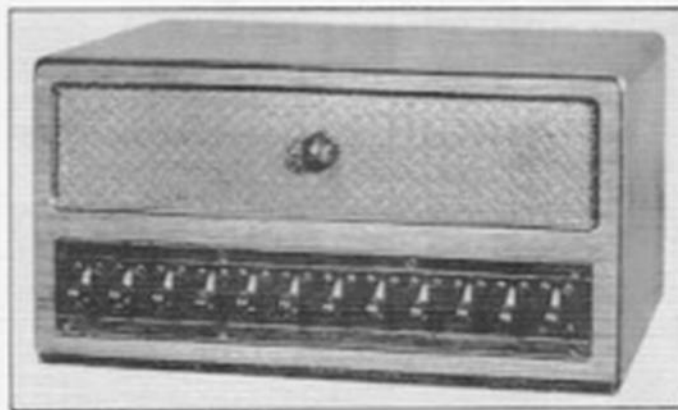


FIG. 8. EXECUTIVE LOUDSPEAKING TELEPHONE WITH DIRECT-LINE KEYS

4.08 Loudspeaking Direct-Line

This development combines facilities for key-calling, as described above, with two-way loudspeaking equipment so that it is not necessary for the executive to use his handset. A call is made by flipping a key. When the called party answers, his reply is heard through the loudspeaker, and the conversation is then carried on by speaking in an ordinary tone. For conversations not intended to be overheard, the regular P-A-X Monophone is instantly available. This system is covered in Bulletin 346. See Fig. 8.

4.09 "Pick-Up"

This service permits an individual or an assistant to answer calls on his telephone by dialing a special number from any other telephone on the system. Time can thus be saved by individuals such as supervisors who are away from their desks much of the time but still within hearing distance of their telephones.

4.10 Secretary Answering

A number of arrangements may be made whereby a secretary has facilities for answering and transferring calls to an executive. One of these enables a secretary to answer calls coming in to a number of P-A-X telephones but does not permit the secretary to enter upon connections once they are established. The latter method is detailed in Bulletin 332.

4.11 Autodial

With the Autodial, connections can be made to frequently called P-A-X stations without dialing. A pointer is set, a lever pressed and the autodial does the dialing.

4.12 Party Line

P-A-X's of certain types can be equipped for selective ringing on two party lines. The elaborate party line arrangements adopted on C-A-X's are not customarily employed.

4.13 Monitoring

This provides a means of listening in on calls when supervision is desirable as in schools and other institutions. Signal lamps associated with the talking paths are located at a central point and the proper lamp lights when a call is in progress. The lamps may correspond to (1) individual telephones or trunks; (2) particular selectors or connectors. The monitor may listen in without disturbing the conversation but may engage in it if desired. See Fig. 9.

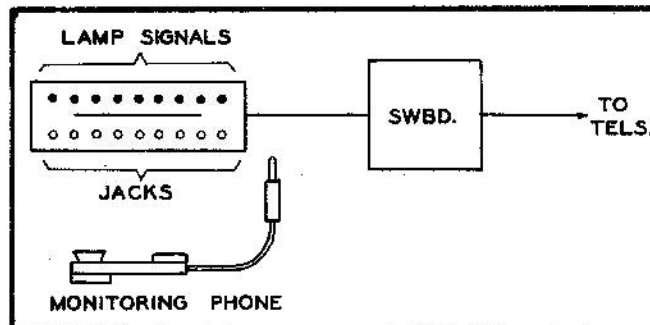


FIG. 9. ARRANGEMENT FOR MONITORING CALLS ON LINES ASSOCIATED WITH LAMP SIGNALS

5. THE 10 LINE P-A-X TYPE 32A1

This P-A-X is intended for the use of organizations requiring a complete private dial communication system of ten lines or less with switching equipment for two simultaneous connections. See Fig. 10.

5.1 Description of Equipment

The P-A-X consists of one shelf, mounting the local switching units, a ringing converter, a fuse block and a terminal block. A second shelf holds power equipment.

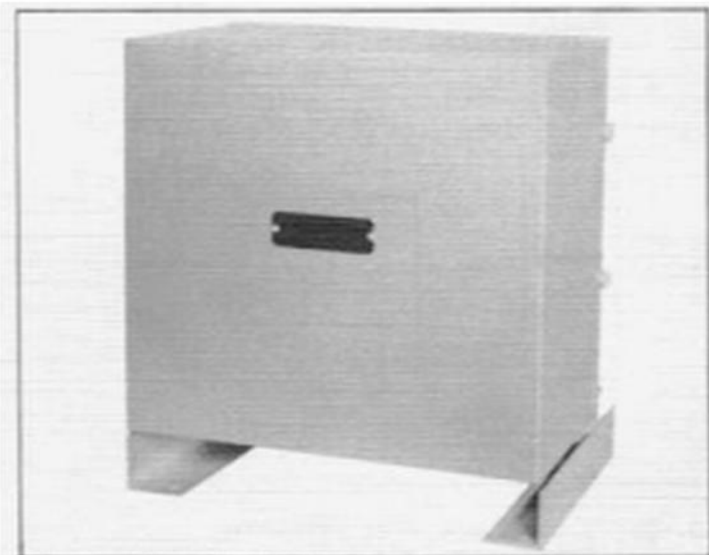


FIG. 10. CABINET CONTAINING TYPE 32A1 SWITCHING UNIT

The line equipment consists of one relay per line and a relay common to all lines. The switching equipment for completing local calls consists of four 11-point rotary switches and associated relays, providing facilities for two simultaneous local conversations. Each connection is established by means of two rotary switches acting as a unit, one switch as a line-finder and the other as a connector. These switching units are termed "finder-connectors."

5.2 Battery and Charging Equipment

The switchboard operates on 24 volts supplied by a storage battery floated, usually by a trickle charger (Section 8.21).

5.3 Numbering Scheme

When automatic ringing is employed, one digit establishes the connection, stations being numbered "1" to "0". With dial-controlled ringing, two-digit numbers are ordinarily used for the local lines. The first digit selects the line, and the second digit (usually "8") causes ringing current to be sent out to the telephones. Two telephones per line may be selected by long and short rings. Thus for a long ring the numbers would be, "18" - "28" - "38" etc; for a short ring, "12", - "22" etc.

5.4 Local Calls

Fig. 11 is a single-line diagram of the method in which a local connection is switched. When a person originating a call removes the handset from the cradle, one of the rotary switches operates as a line-finder, connecting dial tone to the calling line as soon as the line is found. The digit dialed causes a second rotary switch to operate as a connector to select the line. Automatic ringing now commences. If dial controlled ringing is employed, a second digit must be dialed to cause the bell to ring. The bell is rung only once unless the "ringing digit" is repeated, which may be done as often as it is necessary to signal the called station. The length of the ring is proportional to the digit dialed. If the called telephone is in use, "busy-tone" will be received. Both parties to a connection receive talking battery through the same relay coil, thus making it possible for either one to hold the connection.

6. THE 20 LINE P-A-X TYPE 32A21

A P-A-X similar to the previous provides a capacity of twenty lines and may also furnish additional services.

6.1 Equipment

The equipment is similar to that of the previous with the exception that 25-point switches are used instead of 11-point. The power equipment provides for 24 volt operation.

6.2 Number Scheme

The one line diagram as shown in Fig. 11 also applies to this type with minor exceptions. Three digit numbers are required since the rotary switch banks have 25 positions instead of eleven. Thus numbers "1" to "9", "01" to "09", and "001" to "004" inclusive are used for station numbers as they serve to drive the switch wipers over the contacts, a zero being equivalent to ten pulses. The number "004" is equivalent to 24 pulses.

6.3 Code Call Service

The code call service is provided in two forms. One form uses an automatic ringing machine having 100 codes available. The other form, known as dial ringing, is accomplished by dialing digits of various combinations, for example, digit "8" may be used to produce a long signal, and digit "2" a short signal.

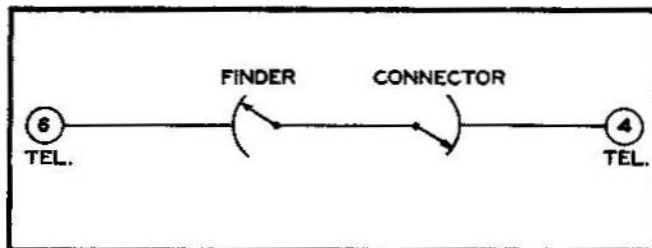


FIG. 11. DIAGRAM OF A ROTARY FINDER AND ROTARY CONNECTOR SYSTEM AS EMPLOYED IN TYPE 32A1 OR 32A21 P-A-X

7. COMMON TALKING SYSTEM P-A-X TYPE 32A38

This system was especially designed to meet the service requirements of schools, small factories, offices, etc., where a large number of telephones are not required and where the traffic is not heavy. It is referred to as the "Common Talking System" because all telephones are connected to a common pair of wires. The bell of each telephone is rung over an individual wire. Although all telephones are connected to the one common pair of line wires, it is customary to install the system with an individual pair of wires to each telephone, and connect them together in a junction box at the switchboard.

A maximum of 90 telephones instead of 100 may be connected to this system when code call service is provided although the usual limit based on traffic volume is between twenty and thirty telephones. Calls are made on a 2-digit basis. When a telephone is called, the bell is caused to ring only once. To signal again, the number is re-dialed without hanging up the receiver. Busy lamps are sometimes provided and located at points where they may be seen by the users so that a person can observe whether or not the system is in use, before attempting to make a call.

7.1 Switchboard

The switching equipment is mounted on five vertical-type relay mounting strips bolted to top and bottom cross angles. This assembly is enclosed in a sheet metal cabinet two feet high, fitted with front and rear doors. See Figs. 12 and 14.

The equipment proper consists of a Strowger two-motion switch and associated relays, ringing apparatus, and a telephone line terminal block. The Strowger switch and relays are mounted on strips 4 and 5, right to left when viewed facing relays. Ringing equipment is on strip 1. The terminal block (4 rows of 30 terminals each) is on the rear of strip 4. Strip 2 is reserved for direct line or master station service while strip 3 is for code call equipment. These strips are used only when the special services are provided.

7.2 Master-Station Service

In this particular type of P-A-X, master-station service may be employed if desired in place of full automatic operation. The master-station is the only one equipped with a dial. Calls from all other stations come to it automatically. They may then be transferred by the master station. Local stations can not, thus, call each other directly.

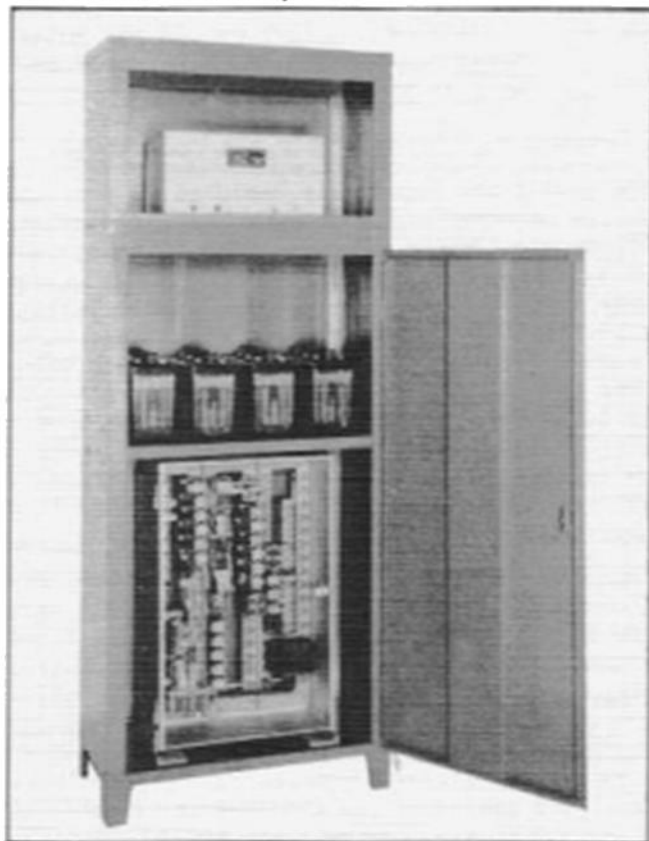


FIG. 12. THE 32A36 SWITCH CABINET MOUNTED WITH STORAGE BATTERIES AND CHARGING UNIT

Auxiliary master stations are equipped with dials for selectively signaling all stations. Two or more auxiliary master stations may be assigned to a secret service group. Any two of these may then carry on a conversation without being heard by the master station or any outlying local station. However, when more than two auxiliary master stations are assigned to the secret service group, secrecy is not provided between members of the group. Under certain conditions, two simultaneous conversations can be held, i.e., one in secret service group and one in the ordinary-service group. See Fig. 13.

7.3 Direct-Line Service

Two stations which have frequent occasion to call each other may be provided direct-line service. This removes the traffic from the switchboard and gives secret service. Under this condition, two calls may be in progress simultaneously, i.e., one in the switchboard, and one on the direct line.

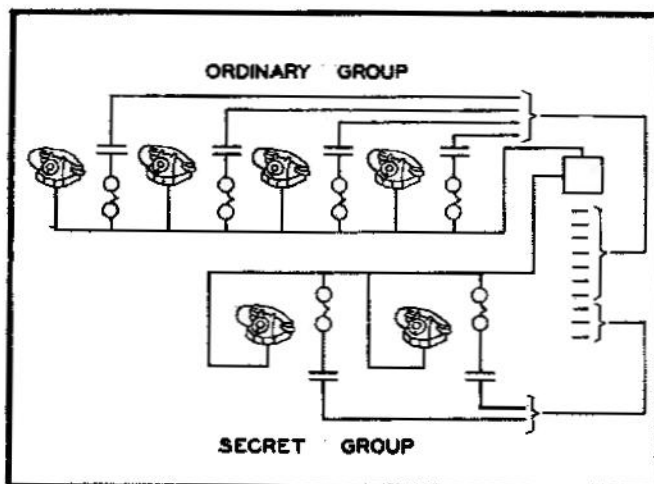


FIG. 13. DIAGRAM OF THE 32A36 COMMON TALKING P-A-X SYSTEM. SECRET GROUP MAY OR MAY NOT BE EMPLOYED.

7.4 Circuit Explanation

In Fig. 34, the circuit for a common talking P-A-X is shown. The telephones which are to have the ordinary service are all connected to the "ORD." service or master station line leads. These telephones are equipped with dials and can, therefore, dial a pre-determined two-digit number to cause the equipment to signal, by one long ring, the called party over an individual ringing lead. The equipment then releases. The called party's telephone is already connected to the same line as the calling party's so when the call is answered, transmission battery will be supplied to both telephones over the same line and through the same common battery feed relay.

The telephones which are to have secret service are all connected to the secret service line leads; however, the signaling between telephones is the same as on ordinary service. Secret service is given only on calls between telephones on the secret service lines. These telephones have the same service as the telephones connected to the "ordinary" line circuit, but a conversation between two parties on the secret service line cannot be heard by a party on the ordinary line.

The telephones which are not equipped with dials are connected to the "direct" or "manual line" circuit as desired. Removing the handset from the cradle of a manual station will cause this line circuit to signal the "master" station with one long ring. The master station completes the connection by dialing the desired party's number.

The "direct line" connections, "Y" wiring, provide means for establishing connections between two manual lines. Removing the receiver from a telephone connected to one line will cause this equipment to send out a "splash" ring of generator on the second line.

7.41 Seizure by Ordinary Service Call

The "ordinary" service and master stations are equipped with dials. When the calling party removes his handset, the loop circuit will be closed to A in series with 1G. A operates and closes B. B operates, closes M, and prepares the circuit to C and the vertical magnet. M operates, grounds the CHG ST lead to start the charger, grounds the OBL lead, closing the circuit to the busy lamps, and prepares its own holding circuit. G operates, locks through 2G, opens the circuit to prevent the operation of K, and short circuits its own number 1 winding to improve the impulsing circuit to A. E3 in Sub-Figure 3 operated when M did to prevent the master station from being signaled by a manual phone while a call is in progress on the common circuit.

7.411 Raising Wipers to Dialed Level

A follows the impulses received from the dial and when at normal closes 2C in multiple with the vertical magnet. C operates, prepares a holding circuit to 2C and the vertical magnet, and short circuits 1C to make C slow to release. The vertical magnet follows the impulses received from A and raises the shaft and wipers to the dialed level. The VON, vertical-off-normal, springs operate after the first step of the vertical magnet and close D. D operates, prepares the impulsing circuit to the ROT, rotary, magnet, and grounds the GEN ST, generator start, lead. After the last impulse of the series, C restores and transfers the impulsing circuit from 2C and the vertical magnet to 2E and the rotary magnet.

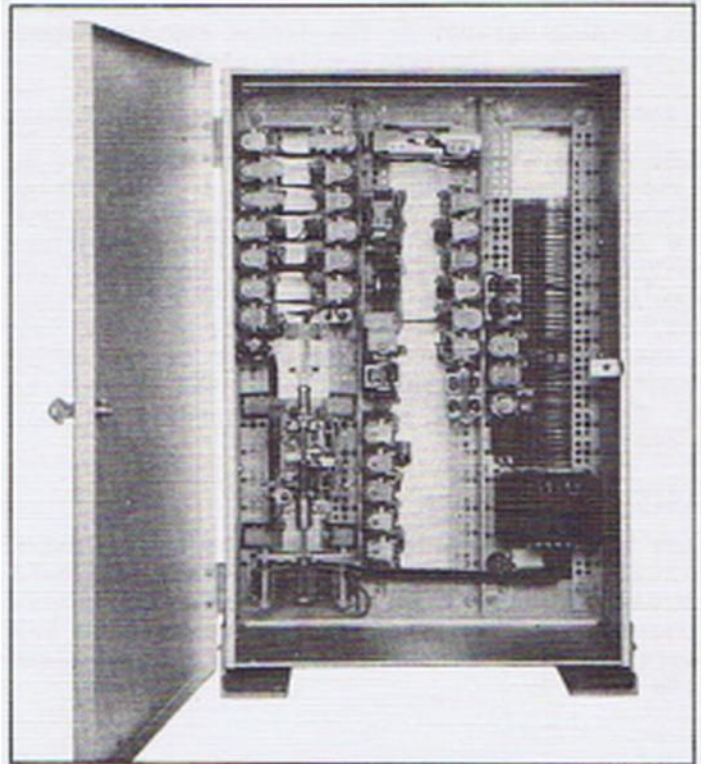


FIG. 14. INTERIOR OF A TYPE 32A36 SWITCH CABINET

7.412 Rotating the Wipers to the Ringing Lead

A follows the second series of impulses and when at normal, closes the circuit to 2E in multiple with the rotary magnet. E operates on the first impulse of the series, closes F, closes the holding circuit to 2E and the rotary magnet, and short circuits 1E to make E slow to release. F operates, closes its locking circuit, and opens one operating circuit to E and the rotary magnet. The rotary magnet, via the remaining operating circuit, follows the impulses received and rotates the shaft to the dialed telephone's ringing lead. After the last impulse of the series, E restores; opens the incomplete circuit to 2E and the rotary magnet to prevent the operation of that magnet should the circuit to A be again interrupted and closes N.

7.413 Signaling the Dialed Station

N operates, grounds the "+L" lead, through its weighted spring, closes an intermittent circuit to H, and connects the generator current over the DIR GEN lead to the RING wiper. The generator current sent out over the RING wiper completes a circuit over the RING lead through the ringer and condenser at the called station's telephone and back over the "+" lead to ground at the spring of P.

When N operated, it closed an intermittent circuit to H. H is slow to operate due to the short circuit across its first winding. When the weighted spring of N comes to rest, the

current will be closed to operate H. H opens the ringing circuit to the dialed station, opens B, and closes its own locking circuit.

7.414 Restoring the Shaft and Wipers to Normal

When H operated, the circuit was opened to B. B restores and closes the circuit to the release magnet. The release magnet operates and restores the shaft and wipers to normal. The VCN springs operate when the shaft restores to normal and open D. D opens the circuit to the release magnet, removes ground from the GEN ST lead, and opens the circuit to F and H. F on restoring opens N. H on restoring closes the circuit to B. B operates and closes the circuit to hold M operated.

7.415 Transmission

When the called party answers, the transmission circuit will be completed. Whether the call (ordinary service only) is from a telephone connected to the ordinary line leads or the secret service, transmission battery is supplied from relay A.

7.416 Releasing

When both parties have replaced their handsets, the circuit will be opened to A, which opens B. B opens M which opens the charge start circuit, the busy lamp circuit, and E3.

7.42 Secret Service Calls

On a call within the secret service group, certain differences in operation of the equipment occur in order to provide secrecy. The left normal post springs operate on calls to levels 1, 2 and 3. When a call is made from one telephone in the secret service group to another in that group, these springs serve to disconnect the secret service line from the regular line.

7.421 Seizure for Secret Service Calls

Relay A operates closing B; however, G does not operate this time and hence K may operate to give secrecy after the called party has been signaled.

7.422 Signaling the Dialed Station

Up to this point, all circuit operations are as previously described (Sub-Sections of 7.41). N will operate as previously. When its weighted spring comes to rest, H will operate which opens the ringing circuit, opens B, closes its locking circuit, closes K. K operates, closes its locking circuit, transfers the secret service line from the winding of A to J. J operates, closes a locking circuit to hold K, closes the circuit to the secret service busy lamps over the SBL lead, and prepares the circuit to 2L.

7.423 Restoration of Wipers and Transmission

The shaft and wipers return to normal as before. Relays J and K are the only relays operated. Transmission is from J.

7.424 Secret Service Busy

After a call has been established within the secret service group, the regular equipment is free for calls within the ordinary group. If a party in the ordinary service group attempts to make a call to the secret service group, he will receive busy tone. Operations will be as explained. The left normal post springs operate at the end of the first series of impulses and since K is operated, closes the circuit to L. L operates through 2L, opens the ringing circuit to prevent ringing the called station on the busy secret service line, and closes 1L. The two windings of L are in opposition so that L will operate as a buzzer and thus place a varying potential on condenser M.

7.43 Direct Line or Manual Telephone Relays

The relays in this group (Sub-Figure 3 of 34) consist of two line or battery feed relays and those necessary for starting the ringing equipment and for signaling the called direct line or the master station according to the service. When direct line service is specified, relays C3 and D3 perform the same function for line 2 as A3 and B3 do for line 1. The equipment is then wired by the "Y" wiring.

7.431 Signaling the Direct Line or Master Station

When the calling party removes his handset, the circuit will be closed to relay 1A3 irrespective as to whether the telephone is the direct line (1) or a manual phone. A3 operates, removes the short circuit from its number 2 winding to improve transmission, and closes B3. B3 operates, opens incomplete ringing circuit to the calling telephone, prepares the ringing circuit to the direct line (2) or master station according to which is connected, grounds the OBL lead, grounds the GEN. ST. lead, short circuits 2A to prevent A from operating on generator current when "X" wiring (Manual Service) is used, and closes an intermittent circuit to E2. The ringing equipment operates, and generator over the DIA. GEN. and RING lead will cause the bells to ring at the called station. When the weighted spring of F3 comes to rest, the circuit will be closed to E3. E3 operates, removes the short circuit from the number 2 winding of A to improve the operation of A should the master station extend the call, removes ground from GEN. ST. lead, and opens the ringing circuit to the called station.

8. THE PLUNGER LINESWITCH P-A-X, TYPES 25 AND 50

The P-A-X's generally employ power, supervisory, ringing, and special equipment which is somewhat

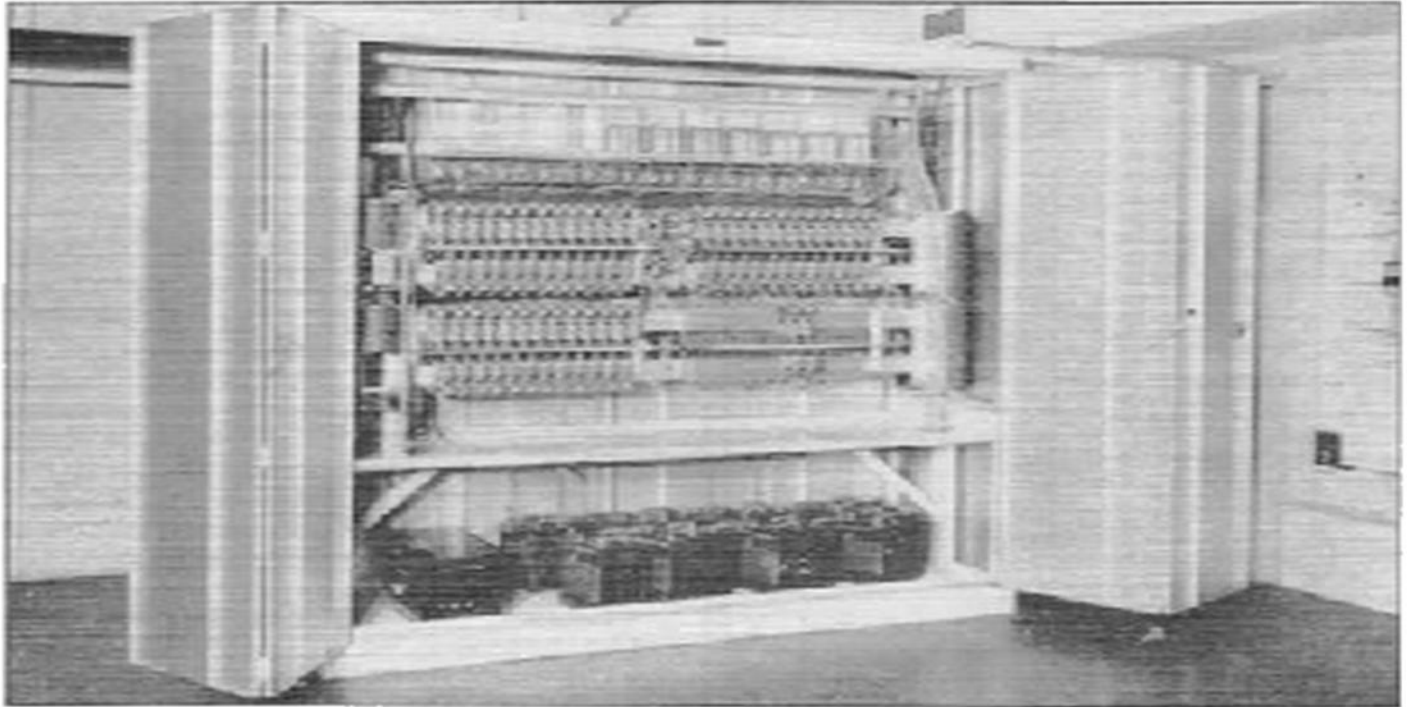


FIG. 15. TYPE 50 P-A-X SHOWING PLUNGER LINESWITCHES WITH BATTERIES AND CHARGER BELOW

different from that of a public exchange. Although this equipment also varies between P-A-X's according to size and type, the apparatus which is typical of many P-A-X's will be described here to introduce the equipment and circuits.

The system to be described is that of a plunger lineswitch P-A-X of one-hundred lines or more. An installation is shown in Figs. 15 and 16. The Type 50 is unlimited in capacity while the Type 25 is recommended for installations of 20 - 100 lines.



FIG. 16. TYPE 50 P-A-X WITH WATCHMAN'S RECORDING EQUIPMENT TO THE RIGHT

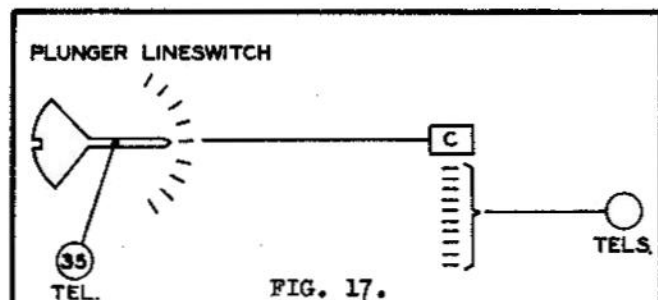


FIG. 17.

DIAGRAM OF A TYPE 25 OR 50 P-A-X
SHOWING PLUNGER LINESWITCH AND
STROWGER CONNECTOR

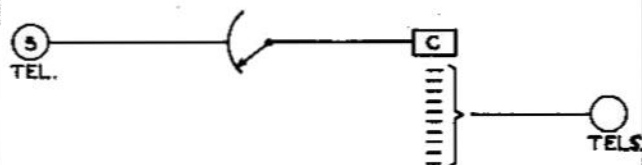


FIG. 18.

DIAGRAM OF A TYPE 32A31 P-A-X SHOWING
ROTARY LINEFINDER AND STROWGER CONNECTOR

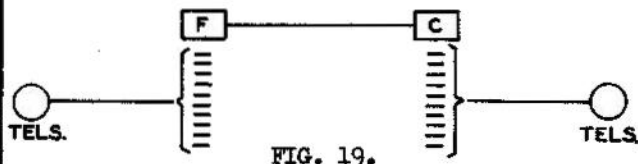


FIG. 19.

DIAGRAM SHOWING THE USE OF A STROW-
GER LINEFINDER AND CONNECTOR

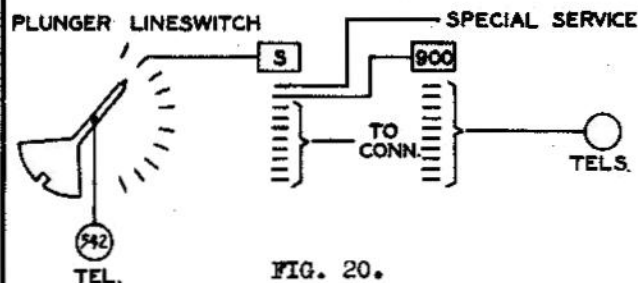


FIG. 20.

DIAGRAM OF A TYPE 50 P-A-X SHOWING
PLUNGER LINESWITCH, STROWGER SELEC-
TOR, AND CONNECTOR

8.1 The Switch Train

The lineswitches, selectors, and connectors are similar to those employed in a public exchange and hence do not require special description. Except in the large P-A-X's, the selectors and connectors are arranged to start the tone and ringing equipment when seized for a call. See Figs. 17 and 20.

8.2 Power Equipment

The power requirements of a P-A-X are considerably different from those of a large central office, but they do resemble the needs of an unattended C-A-X. First the power supply to the switchboard must be reliable. If the commercial supply is dependable, battery eliminators may be employed. Usually, however, storage batteries are deemed desirable to insure the constant supply of current free from interruptions or large voltage variations. Generally, automatically controlled charging is arranged to carry the actual exchange load permitting the battery to "float" in a fully charged condition. Secondly, the power equipment, including the storage batteries must require little or no regular attention. The following methods of charging have been developed with these points in view.

8.21 Trickle Charging

The charging rate of a rectifier can be adjusted to a value which in a 24 hour period will be just sufficient to replace the current used and to bring the battery up to normal. Hence during periods of heavy traffic, the battery must carry a considerable part of the load.

8.22 Constant Current Charging

With a charger of this type, current is of a high fixed value. Irrespective of battery voltage or the exchange load, this charger gives a continuous output of a predetermined number of amperes. When the busy period is over and the exchange load falls, the battery begins to receive the full charge. This will soon bring the battery up to its full capacity; at which time, it is necessary to disconnect the charger. Advantage is taken of the fact that the voltage of a storage battery rises during charging in proportion to the amount of charge in the battery and the rate of charge. This rise in voltage can be used as a measure of the charge within the battery. Thus the voltage of a cell under charge will rise from 2.10 at discharge towards 2.7 with maximum charging rate and the cell approaching the fully charged state. A voltage sensitive relay trips at the desired voltage (at 54 but not 52 volts) and cuts off the charger.

There are two methods of restarting the charger. (a) When the voltage of the cells falls from

2.05 (open circuit) towards 1.75, a voltage sensitive relay releases (at 47 volts but not 47.5) starting the charger, or (b) 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.

8.23 Constant Voltage (Full Float Method)

The circuit is arranged such that a constant voltage of approximately 2.15 volts is maintained across each cell. The charger normally supplies all of the D.C. required by the load at the same time furnishing the battery with a trickle charge to make up for internal losses. The battery "floats" in parallel with the charger. Should the battery become discharged during an emergency, the charger will bring it up to normal.

With no exchange load and a fully charged battery, there is no current flow from the charger and hence no danger of overcharging the battery.

8.24 High and Low Rate Operation

This method is similar to the above "full float" except that during no load periods the constant voltage charger is turned off. A low rate charger serves to replace internal battery losses.

8.25 Motor-Generators and Commercial D.C.

Sometimes motor generators are employed. The diverter pole type, a form of compound-wound generator, falls under the full float method, Section 8.23. If commercial direct current is available, it may also be used through resistances. The exchange voltage is 48 volts for the larger and 24 for some of the smaller.

8.26 Circuit Explanation

Fig. 21 illustrates a typical charging scheme. The control system is such that the charger is operated continuously until the battery voltage reaches the high limit, say 54 volts. If the charger is off, when a connector is seized or an abnormal condition arises in the switching equipment, it is started. Thus, the operation of any of the supervisory alarm relays A to D, Fig. 35, or of the motor start relay D-2, will result in the starting of the charging equipment as follows: The operation of any of the relays mentioned operates relay F-2 from ground on the charge start lead. Relay F-2 locks up to ground at a break contact of G-2, grounds the H.V.R. lead (high voltage relay), operating the "relay switch" shown in Fig. 21, and thus starts the charger. Relay F-2 also prepares a supervisory circuit and a high voltage control circuit (to relay G-2). The circuit to the supervisory charge lamp passes through a break contact of relay H-2. Relay H-2 is operated by a part of the charging current and is, therefore,

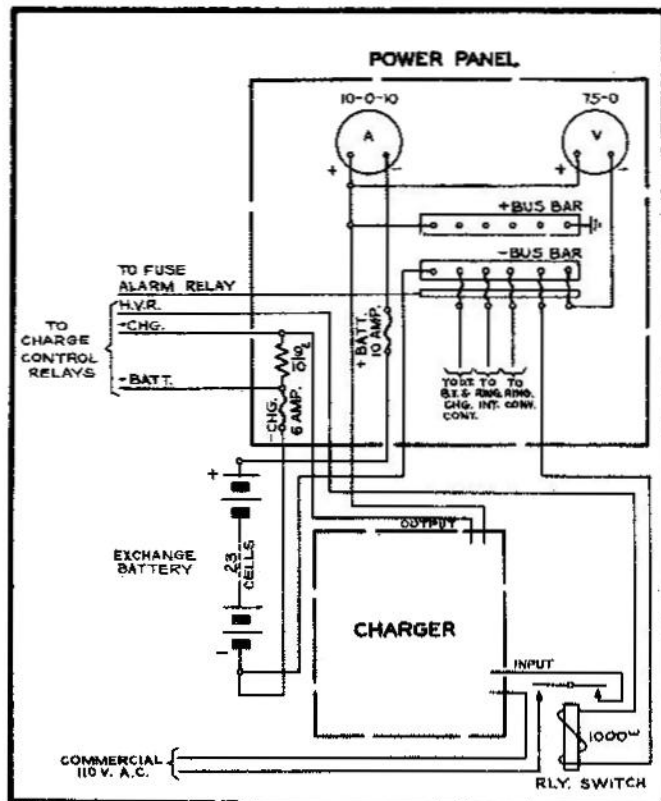


FIG. 21. A TYPICAL POWER PANEL

normally operated whenever relay F-2 is operated. If the charging start circuit is closed and the rectifier fails to charge the battery, H-2 releases and closes the circuit to a white lamp. If the condition exists for more than a brief interval, the lamp glows and the alarm buzzer sounds. The operation of the alarm circuit is explained under the heading "Supervisory Circuits."

As mentioned above, relay F-2 closes a circuit to G-2, a voltage sensitive relay. Relay G-2 is so margined that it will operate on 54 volts but not on 52.

When the voltage reaches the high limit, G-2 closes its "X" contact, operates fully, and breaks the locking circuit to relay F-2. Relay F-2 releases, opening the circuits to G-2 and the charging equipment relay switch which both release.

If the charge start lead should be grounded during a high-voltage period, relay G-2 is operated by an "X" contact of F-2 and prevents the closing of the locking circuit to F-2. Hence the charger is operated only for the length of time that the operating circuit to F-2 is closed.

8.27 Miscellaneous Circuit Explanations

8.271 Supervisory Circuits

The supervisory relays, Fig. 35, are shown for a lineswitch, selector, and connector system. For

a 100-line system, the selector supervisory relays E and F are omitted. The number of relays similar to G furnished depends on the percent trunking employed on the lineswitch board.

The operations involved in the fuse alarm circuit will be described as typical of the alarm circuits of this system. When a fuse blows, battery is conducted from a fuse-alarm bar to relay A. Relay A closes a circuit from (+) ground, "fuse lamp" lead, a red fuse-alarm lamp, through the 1000-ohm winding of delay relay A-1 to (-) battery. Due to the 1000-ohm resistance in the circuit the red lamp is not illuminated. Relay A-1, however, operates, but due to the action of its weighted contact there is a delay before the circuit is finally closed to relay B-1. This operation is explained in the next paragraph. B-1 operates, cuts the 6-3/10 ohm winding of A-1 in parallel with the operating winding, permitting the fuse-alarm lamp to glow, and closes a circuit to the alarm buzzer.

The delay in the operation of B-1 is brought about as follows: The operation of A-1 sets its weighted contact into vibration. On each oscillation, a circuit is momentarily closed to relay B-1, which is slow-to-operate. The pulses of current to B-1 are at first too short in duration to operate it. When the vibrating contact has almost come to a stop, the circuit to B-1 is maintained long enough to operate it. Thus a delay of several seconds is brought about between the operation of A-1 and B-1.

8.272 Dial Tone Generation

Dial tone is generated by means of a relay which is operated only when dial tone is required. In a selector system the dial tone is started as follows: Ground is connected to the line relay of the selectors through relay E. Hence, when a selector is seized, relay E operates, grounds the dial tone start lead and connects dial tone to the (+) lead to the line relay. In a connector system, the operation of a relay in the connector, when the connector is seized, grounds the dial tone start lead. The dial tone lead is connected directly to the connector jacks.

The dial tone is produced as follows: When the dial tone start lead is grounded, relay E-2 is operated by one winding. The operation of E-2 connects its second winding in parallel with the first winding and, due to the fact that the magnetic effects of the two windings oppose, relay E-2 immediately releases, only to be re-operated by the first winding. The relay is thus caused to "buzz" rapidly, as long as the dial tone start lead is grounded, thus rapidly charging and discharging a condenser, which results in the production of the dial tone current (A.C.).

8.273 Busy Tone Generation (Fig. 35)

Busy tone is started and generated similarly to dial tone with the exception that the tone is interrupted. Relays A-2, B-2, C-2 and, in certain cases, D-2 are involved. When the busy tone start lead is grounded by the action of a selector or connector, relay C-2 is operated. C-2 operates B-2, which in turn starts the busy tone relay A-2. Relay B-2 also short-circuits relay C-2, causing it to release after a slight delay. The release of C-2, opens the circuit to relay B-2. B-2 restores, stopping the busy tone and removing the shunt around B-2. B-2 operates again to commence a new cycle. The busy tone is thus continuously interrupted. The mechanical adjustments of relays A-2 and E-2 are such as to produce tones of slightly different pitch.

8.274 Motor Start Relay

Relay D-2 is operated as soon as a connector is stepped off normal, from ground at the off-normal springs, to start the charging equipment (if off), busy tone relays, ringing interrupter, and ringing converter.

8.275 Ringing Current

The ringing current is generated by a vibrator ringing converter and interrupted by either a rotary-cam-type or a relay-type interrupter. The operation of the ringing converter shown in Fig. 35 is as follows:

The operation of relay D-2, connects (+) ground, over the ringing converter start lead, through the windings of the converter's motor magnet to (-) battery. The armature is attracted to contact 2 and connects two other magnet windings in parallel with the operating windings. As the magnetic effects of the two sets of windings oppose, the armature is released, the tension of the reed momentarily carrying the armature against contact 1 on the back swing. The armature is again attracted and released and so on, thus being caused to vibrate at a steady rate in pendulum fashion.

When the armature is against the magnets, (+) ground is connected through contact 2, through a primary winding of the transformer and through the windings of the choke coil to (-) battery. When the armature is on its back swing, (+) ground is sent through contact 1 and through a primary winding of the transformer in the opposite direction to the original current pulse. An alternating current is induced in the secondary winding of the transformer and is used for ringing.

The "generator" current is superimposed on D.C. as customary. The choke coil, which is a repeating coil, and the condensers act as a filter to keep noises, caused by the converter action, out of the battery.

8.276 The Ringing Interrupter

A ringing interrupter is used here for two purposes: one, to furnish the ringing cycle of ringing and silent periods, and two, to connect the generator to only a portion of the load at a time, so as to require a smaller converter than would otherwise be needed. The ringing interrupter, shown in Fig. 35, consists of three slow-to-operate relays, three sets of springs, and a set of rotary cams driven by a motor magnet.

When the interrupter start lead is grounded, the motor magnet operates, and relay C-3 oper-

ates, energizing relay A-3, which operates relay B-3. Relay B-3 opens the circuit to the motor magnet, permitting it to restore and step the cams around to the next position. The operation of B-3 also short-circuits relay C-3, permitting it to restore. C-3 shorts A-3, which restores, shorting B-3. When B-3 restores, the motor magnet is again energized, and the cycle repeated as long as the interrupter start lead is grounded. The operation of the cams connect generator to each ringing group in turn for a part of the cycle and (-) battery for the remainder of the cycle.

P-A-B-X APPENDIX

9. INTRODUCTION

The private automatic branch exchange (P-A-B-X) is similar to a private automatic exchange (P-A-X) except that facilities are provided for making calls to and from the public exchange through the P-A-B-X.

Simplest arrangement is to list the P-A-B-X numbers in the telephone directory. The calling party then dials into the P-A-B-X. However incoming calls from the public exchange are usually completed by an attendant who knows the P-A-B-X number of the wanted party and who can render personal service to the calling party. The attendant may have one of two types of cabinets before her: (1) The familiar floor type with a complete manual multiple of all P-A-B-X telephones. Connections with incoming calls are set up manually using cord circuits. (2) Turret Type cabinets are placed on a desk or table. Connections are set up by dialing into the

P-A-B-X. Supervisory lamps and keys for answering and releasing the various trunks appear on its face.

Outgoing calls (P-A-B-X to public exchange) may be handled in any of several ways. One method requires the service of the attendant to extend the line to a public exchange trunk. The attendant may thus exercise discrimination in granting trunk service.

Another method of making outgoing calls permits the calling party to seize public exchange trunks directly by dialing the single digit assigned. The trunks are usually connected to the "9" or "0" level on the connectors (or selectors if present). The connectors when arranged for this service rotate automatically on the selected level to find a free trunk. Under restricted service, only certain telephones may obtain trunk service.

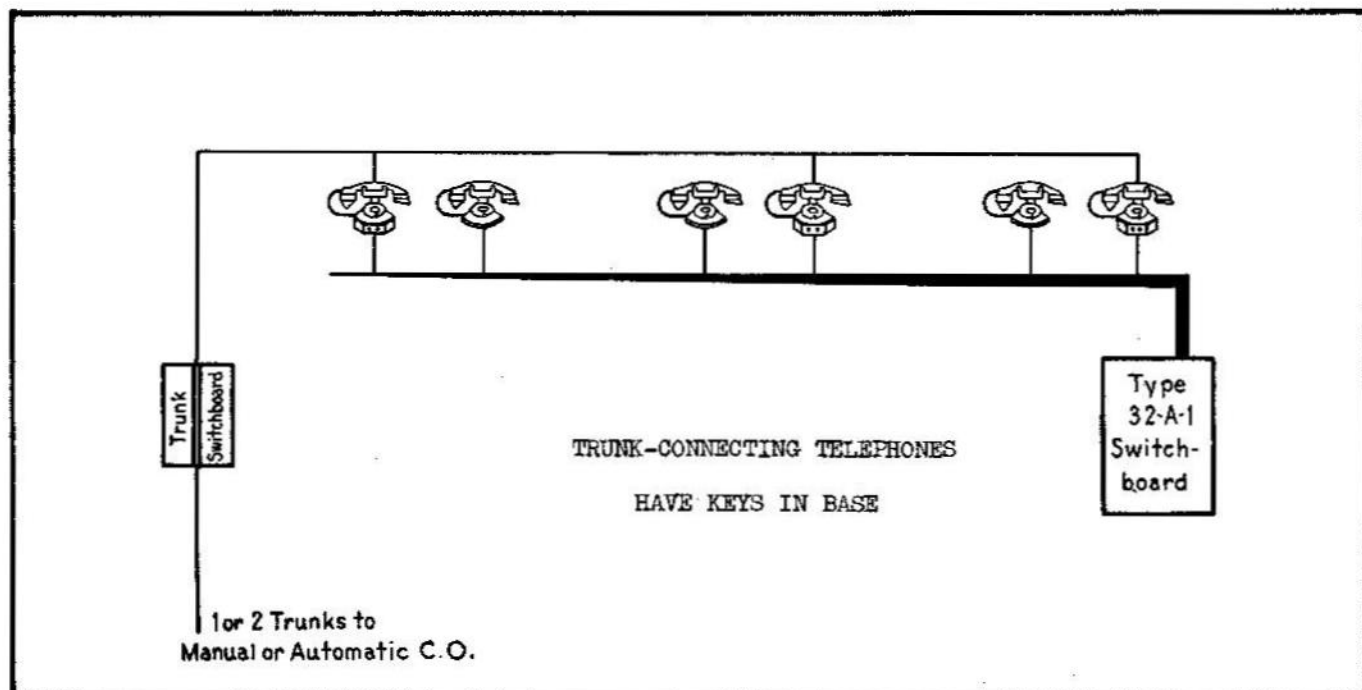


FIG. 22. SERVICE DIAGRAM OF A TYPE 32A1 P-A-X WITH CITY TRUNK CONNECTED UNIT

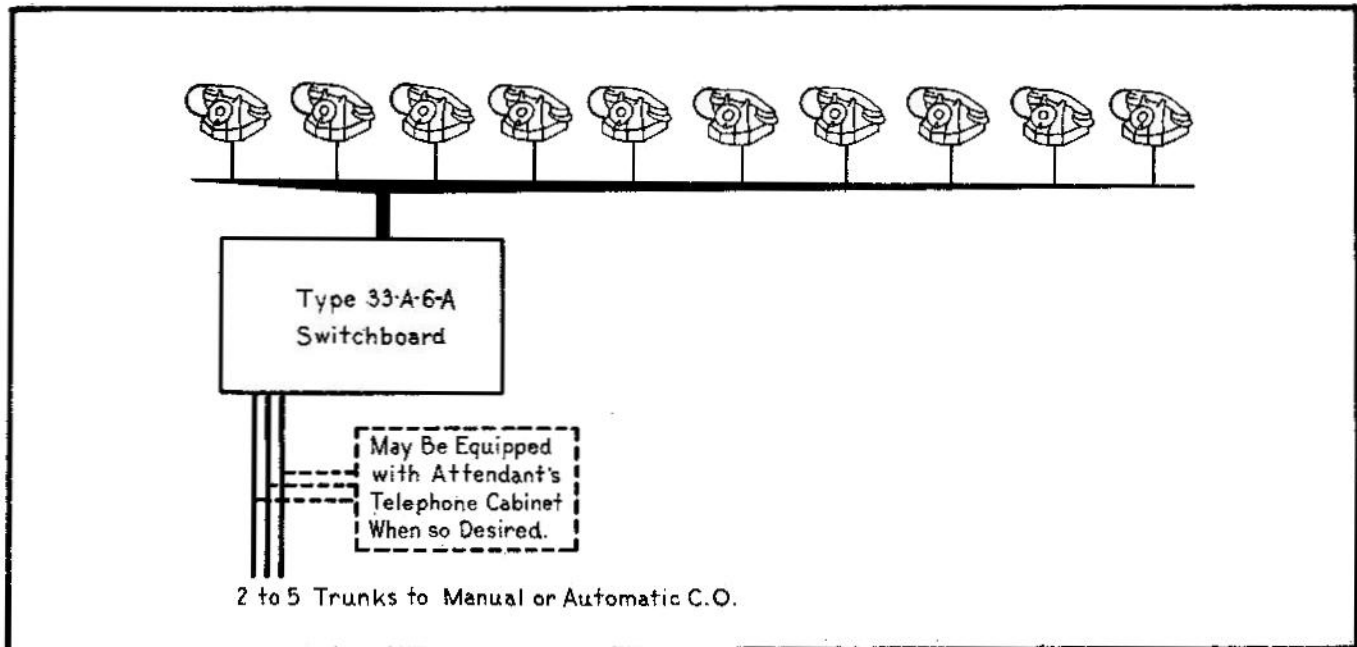


FIG. 23. SERVICE DIAGRAM OF TYPE 33A-6-A P-A-B-X

10. TYPE 32A1 P-A-X WITH TRUNK EQUIPMENT

The simplest arrangement for giving trunk service is shown in Fig. 22. The interior telephone system is essentially that of the P-A-X described in Section 5; however, one or two circuits parallel to the P-A-X lines offer trunk service to telephones of the two-key-in-base type. The keys permit switching the Monophone to one or the other of the two trunks from the P-A-X line.

If a party, while talking on an outside trunk, receives a local P-A-X call, his station bell will ring. He can release the trunk key (not replacing the handset, thereby holding the outside trunk) and answer the P-A-X call. Upon reoperating the trunk key, he will be returned to the outside call.

An incoming call may be answered at any 2-key Monophone and then transferred to any other 2-key Monophone. This is accomplished by merely restoring the trunk key without replacing the handset and dialing the desired P-A-X station. When the desired P-A-X station answers, he is requested to operate the proper trunk key to "pick up" the waiting central office call. Secret trunk service may be had on one Monophone if a third key is added. No attendant is needed for the above system.

11. TYPE 33A6-A P-A-B-X (20 Stations, 5 Trunks)

This is truly a P-A-B-X for connections are made to central office trunks at the automatic switchboard. Three classes of station may be had, all having full intercommunication. However, restricted stations cannot originate or receive

trunk calls. Semi-restricted stations may have trunk calls transferred to them but cannot directly answer or originate trunk calls. Non-restricted stations may originate, answer, or transfer trunk calls. In addition, the special P-A-X services are available to P-A-B-X's. See Fig. 23.

11.1 Unattended

If there is no regular attendant provided for answering incoming trunk calls, these are answered by any non-restricted station which may then transfer the call to any non- or semi-restricted telephone.

11.11 Answering

When the trunk signals sound, a party at a non-restricted station (1) removes his handset; (2) listens for dial tone; (3) dials "8"; (4) trunk signals cease; (5) answers call giving name of company.

11.12 Transferring

When the party at a non-restricted station finds out what person in the organization is wanted by the public exchange subscriber, he (1) pushes transfer button; (2) listens for dial tone; (3) dials number of wanted party; (4) ringing or busy tone is heard; (5) requests answering party to take call by pressing push button; (6) transfer tone is heard indicating that the trunk call has been transferred. Calls to the public exchange may be transferred in a similar manner. Successive transfers may be made from both non-restricted and semi-restricted stations as described above.

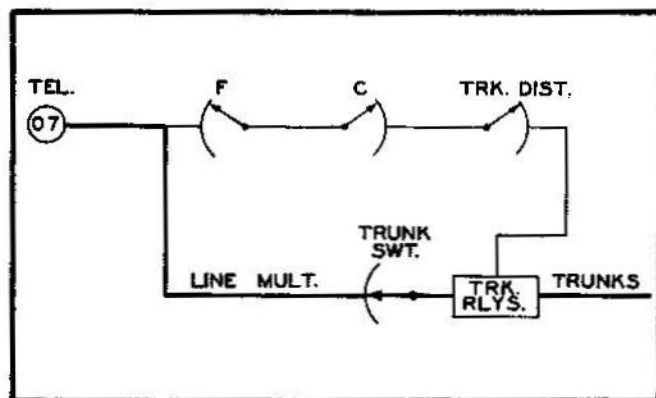


FIG. 24. PATH OF TRUNK CALL IN A 33Ab-A P-A-B-X

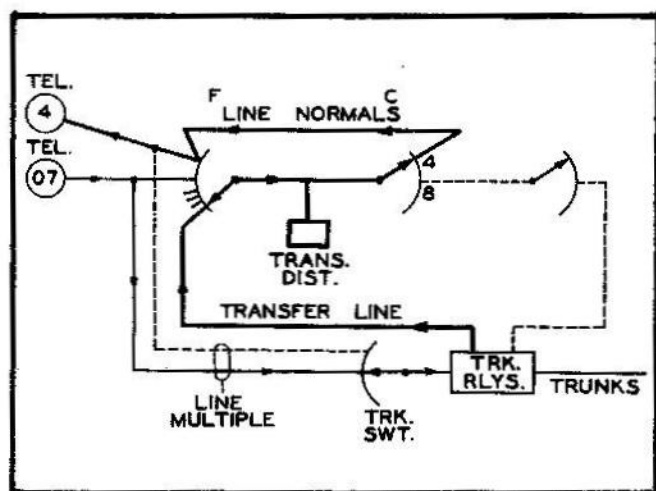


FIG. 25. SUBSCRIBER "07" TRANSFERS TRUNK CALL TO "4" BY CAUSING FINDER "F" TO SEIZE A TRANSFER LINE AND BY DIALING "4"

11.13 One Line Diagrams of a Transfer

To transfer call (Fig. 24), station 07 (Fig. 25) presses button on telephone and dials number desired. Pressing button places a holding bridge in trunk relay group across the public exchange trunk and marks this trunk in the finder switch banks, via the transfer line circuit. There is one transfer line circuit for each trunk. Each transfer line circuit is assigned one contact on the finder. The finder wiper now locates the transfer line associated with the trunk to be transferred. This stage of the operation is shown in Fig. 26.

The connector wiper stands at station which is to receive calls. Station 4 is rung.

For the person at station 4 to pick up the trunk call, he presses his transfer button. This causes the transfer distributor to mark the new local line 4 in the banks of the trunk switch via the connector and connector multiple. The trunk switch steps to the transfer line 4; the finder connector link releases, and the holding bridge (not shown) is removed. Fig. 27

shows this stage which is similar to Fig. 24. Additional transfers are made in a like manner.

11.2 Attended

If it is desired that an attendant answer incoming calls from the public exchange, an attendant's cabinet (turret type) is furnished. See Fig. 28. With the attendant's cabinet, it is possible for both restricted and semi-restricted stations to dial the attendant and request her to set up connections to the public exchange. These are known as delayed calls. Non-restricted and semi-restricted stations will receive a busy tone on answering a call which has been extended from a public exchange by the attendant who has withdrawn. By pressing the push button associated with each telephone, transfers will be completed.

If the attendant waits on a connection which she has extended, no busy tone will be heard, and the attendant instructs the answering party

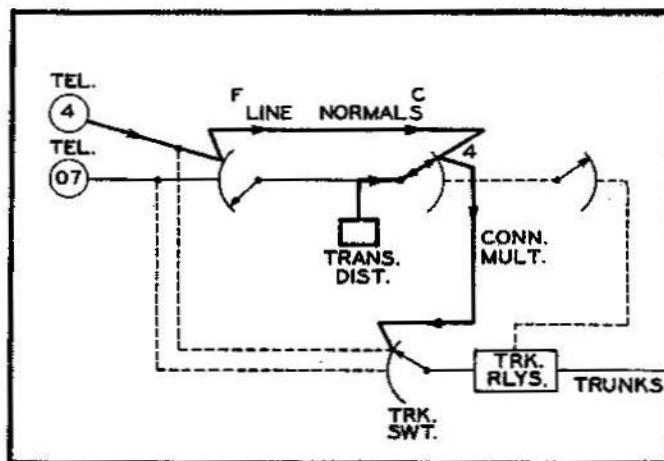


FIG. 26. SUBSCRIBER "4", REQUESTED TO TAKE CALL, CAUSES TRUNK SWITCH TO FIND HIS CONNECTOR MULTIPLE

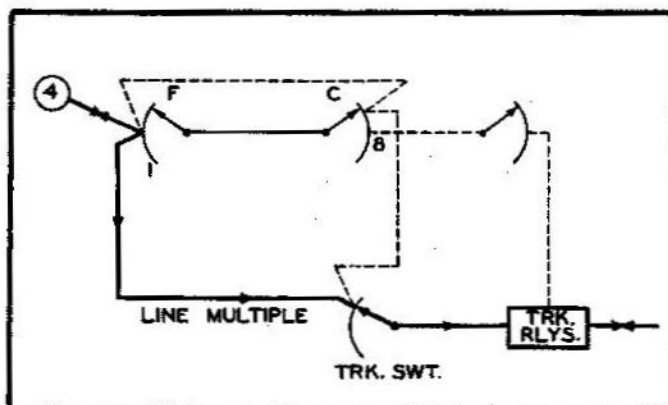


FIG. 27. SUBSCRIBER "4" NOW IS CONNECTED TO THE TRUNK VIA THE LINE MULTIPLE, FINDER-CONNECTION LINK HAS RELEASED

to take the call by pushing the button. The attendant's cabinet can be switched out of service by turning a key.

11.21 Attendant's Cabinet

The attendant's cabinet has two keys which are used for making and answering calls over the public exchange trunks. In addition to the normal position, the keys have an "ANS" and a "RLSE" position. When the buzzer signal sounds the attendant (1) removes handset from cradle; (2) operates either public exchange trunk key; (3) buzzer ceases, supervisory lamp glows;



FIG. 28. ATTENDANT'S CABINET FOR 33A6-A P-A-B-X

(4) gives name of company; (5) decides whether to release call by operating trunk key to "RLSE" position or to transfer call; (6) transfers call by operating transfer key for one second; (7) listens for dial tone; (8) dials number of desired station; (9) hears ringing (or busy tone); (10) requests answering party to press button; (11) supervisory lamp is extinguished when transfer is complete; (12) hears transfer tone, restores trunk key to normal, and handset to cradle.

If the transfer is not completed, the attendant may return to the connection by again operating trunk key to "ANS" position. If the person to whom the call has been transferred wishes to re-transfer that call, he may do so by pressing his push button and dialing the wanted station as described previously.

The attendant also has an "information" trunk at her disposal. This is essentially a non-restricted P-A-B-X line for receiving local calls. However, if both of the trunk keys are held by calls in progress, the information trunk may be used to make public exchange trunk calls as described for non-restricted local stations.

Calls made to the public exchange may be transferred in the same manner that any incoming call would be.

Fig. 29 shows a one line diagram of the complete circuit minus the attendant's cabinet.

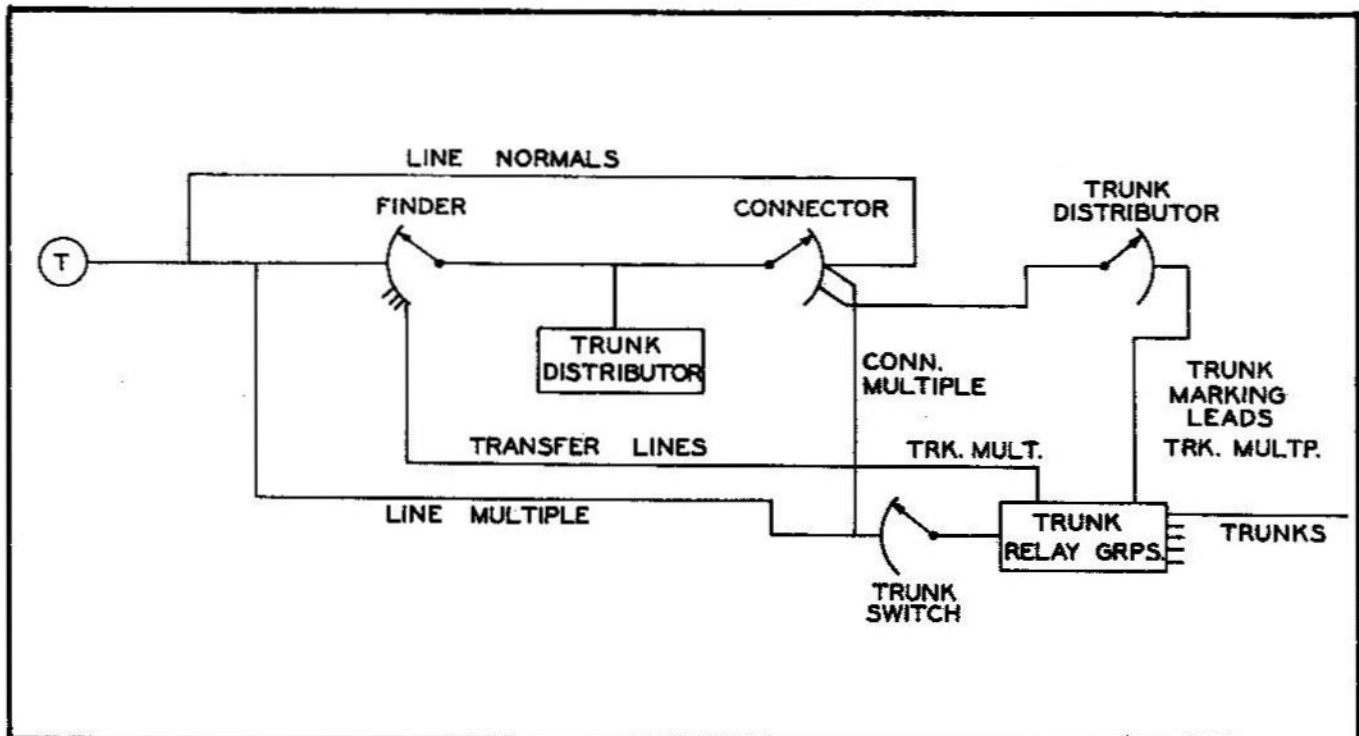


FIG. 29. COMPLETE DIAGRAM OF THE 33A6-A P-A-B-X

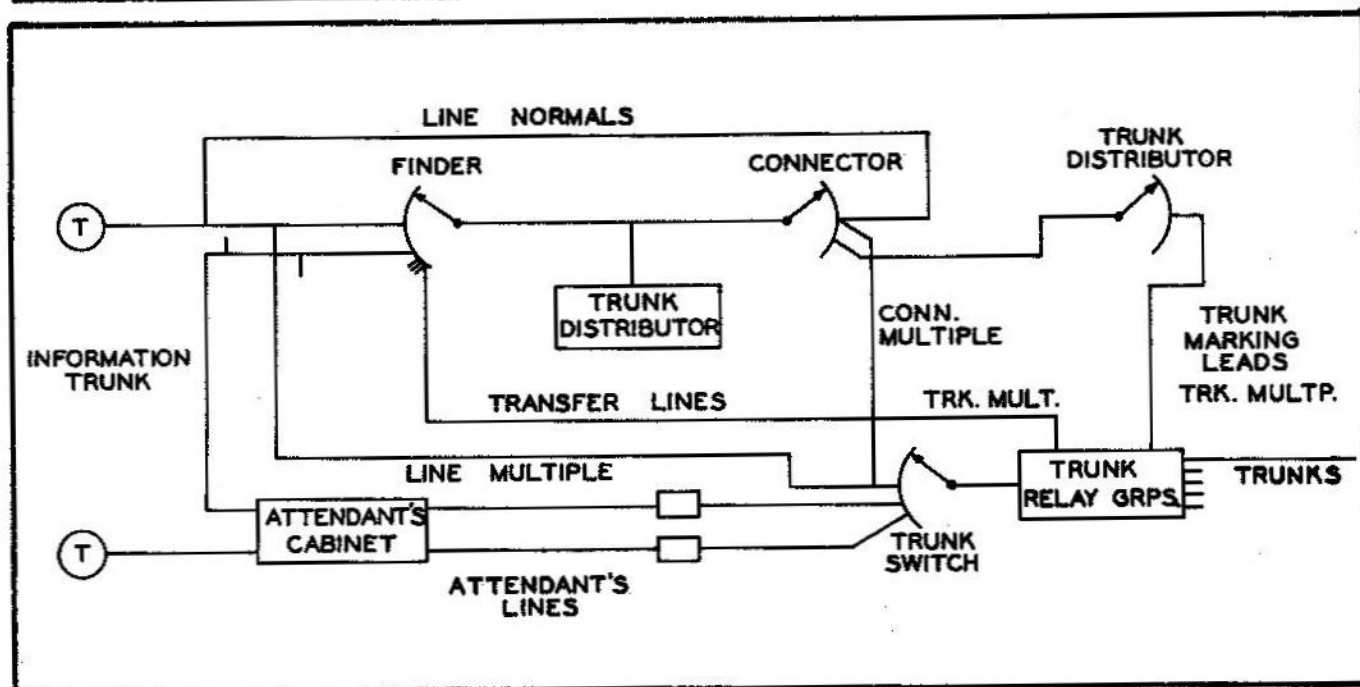


FIG. 30. COMPLETE DIAGRAM OF THE 33A6-A P-A-B-X WITH ATTENDANT'S CABINET. THE CABINET HAS DIRECT ACCESS TO TRUNK SWITCH AND TO ONE UNRESTRICTED LINE AS WELL. THUS, THE ATTENDANT MAY SEIZE A TRUNK BY OPERATING A TRUNK KEY.

Fig. 30 shows the attendant's cabinet added which is seen to consist of essentially one regular non-restricted telephone circuit and two circuits which have direct access to the trunk switch and thus may pick up trunks directly without the necessity of setting up a finder-connector link. Thus on simplest analysis, these two lines resemble a regular non-restricted circuit stripped of all connections -- finder, line normals, connector, connector multiple -- with only the line multiple remaining.

11.22 Trunk Seizure by Attendant

To seize a trunk for an outgoing call, the attendant need merely operate one of the keys associated with the two attendant's lines. The

trunk switch will find the line and connect a trunk to the public exchange. The supervisory lamp associated with the key operated will glow. When the call is completed, the key is moved momentarily to the release position. The lamp will be extinguished as soon as the public exchange releases the trunk. Incoming calls are handled in the same manner.

11.23 Transfer of a Trunk Call on Information Trunk

The transfer key on the attendant's cabinet corresponds to the transfer button provided at each P-A-B-X station. Transfers over the information trunk are exactly as described in Sections

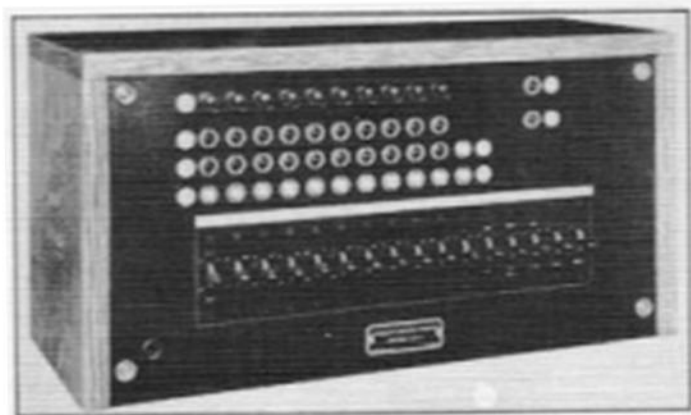


FIG. 31. TURRET TYPE (CORDLESS) ATTENDANT'S CABINET AS USED ON THE TYPE 25B OR 50B P-A-B-X

11.12 and 11.21 for non-restricted stations. The method of transfer over the two attendant's lines is described in Section 11.21 and resembles the steps shown in Figs. 25, 26, and 27.

12. TYPE 50B P-A-B-X (Unlimited Capacity)

The switchboard unit resembles the Type 50 P-A-X. However, it is possible to make calls into the public exchange by dialing "0." Calls from the public exchange are answered by an attendant who may complete or transfer calls by dialing into the P-A-B-X (turret type cabinet) or by plugging into a full multiple of local lines in a floor-type cabinet. Fig. 33 shows the service diagram while Fig. 17 illustrates a connection in a 90 line exchange (connectors only) and Fig. 20, a connection in an 900 capacity system (selectors and connectors).

A system such as the type 50B or the smaller type 25B is extremely flexible. Additions may be made readily to increase their capacities; also the special services outlined in the P-A-X, Section 4, may be fitted.

Discriminating service, limiting certain stations to intercommunicating service only, can be provided without special equipment merely by wiring for it.

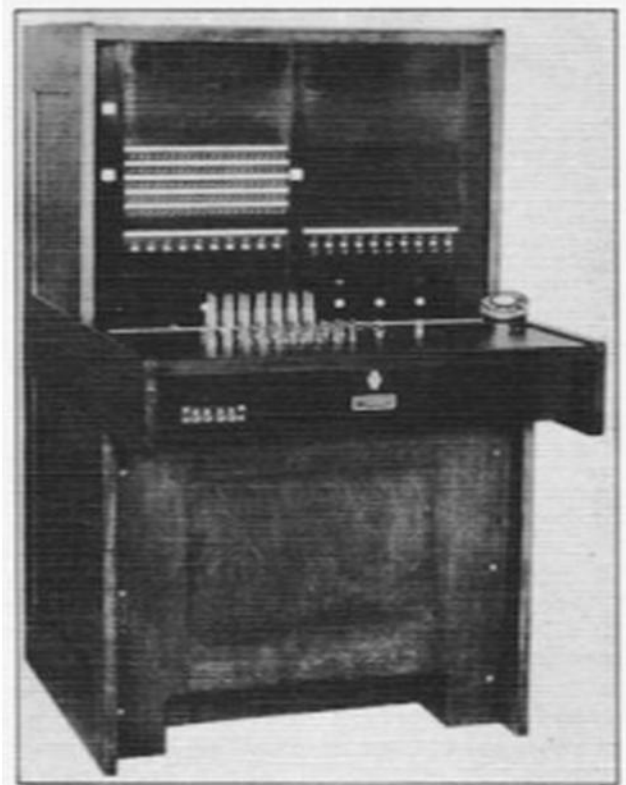


FIG. 32. CONVENTIONAL FLOOR TYPE ATTENDANT'S CABINET WITH CORDS FOR SETTING UP CONNECTIONS ON TYPE 25B OR 50B P-A-B-X

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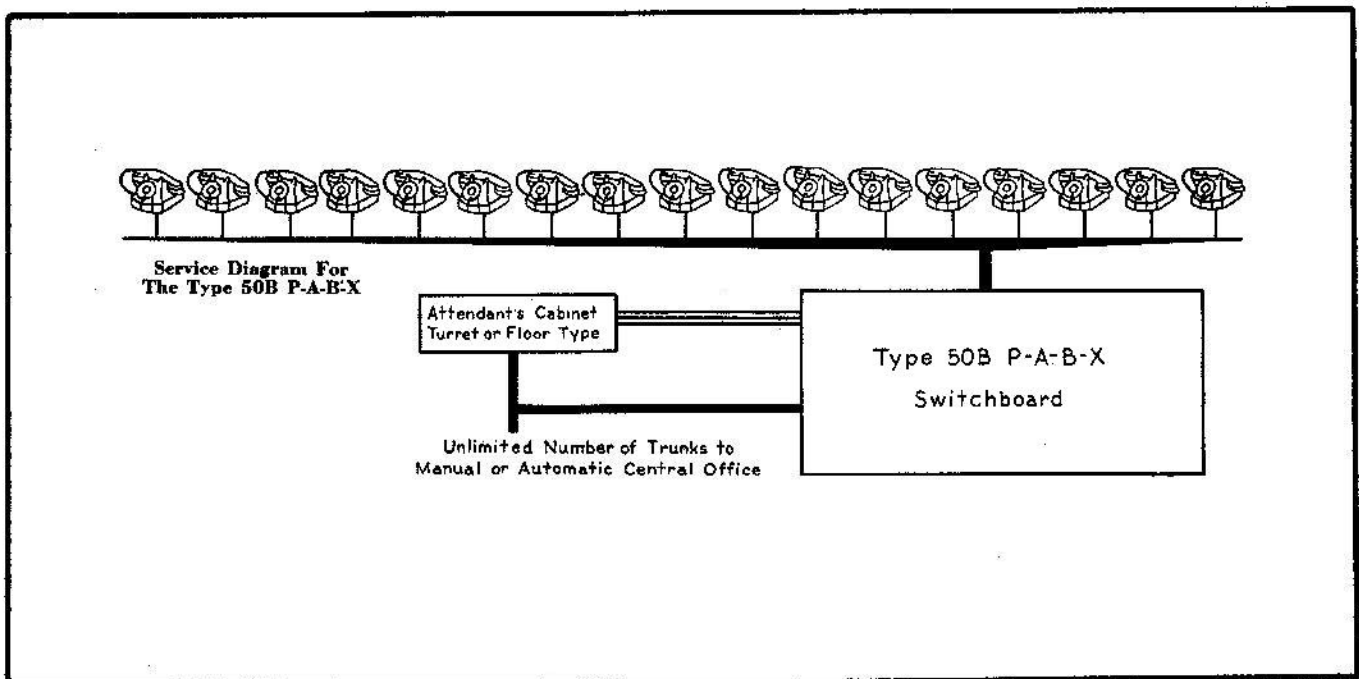


FIG. 33. SERVICE DIAGRAM OF THE TYPE 50B P-A-B-X

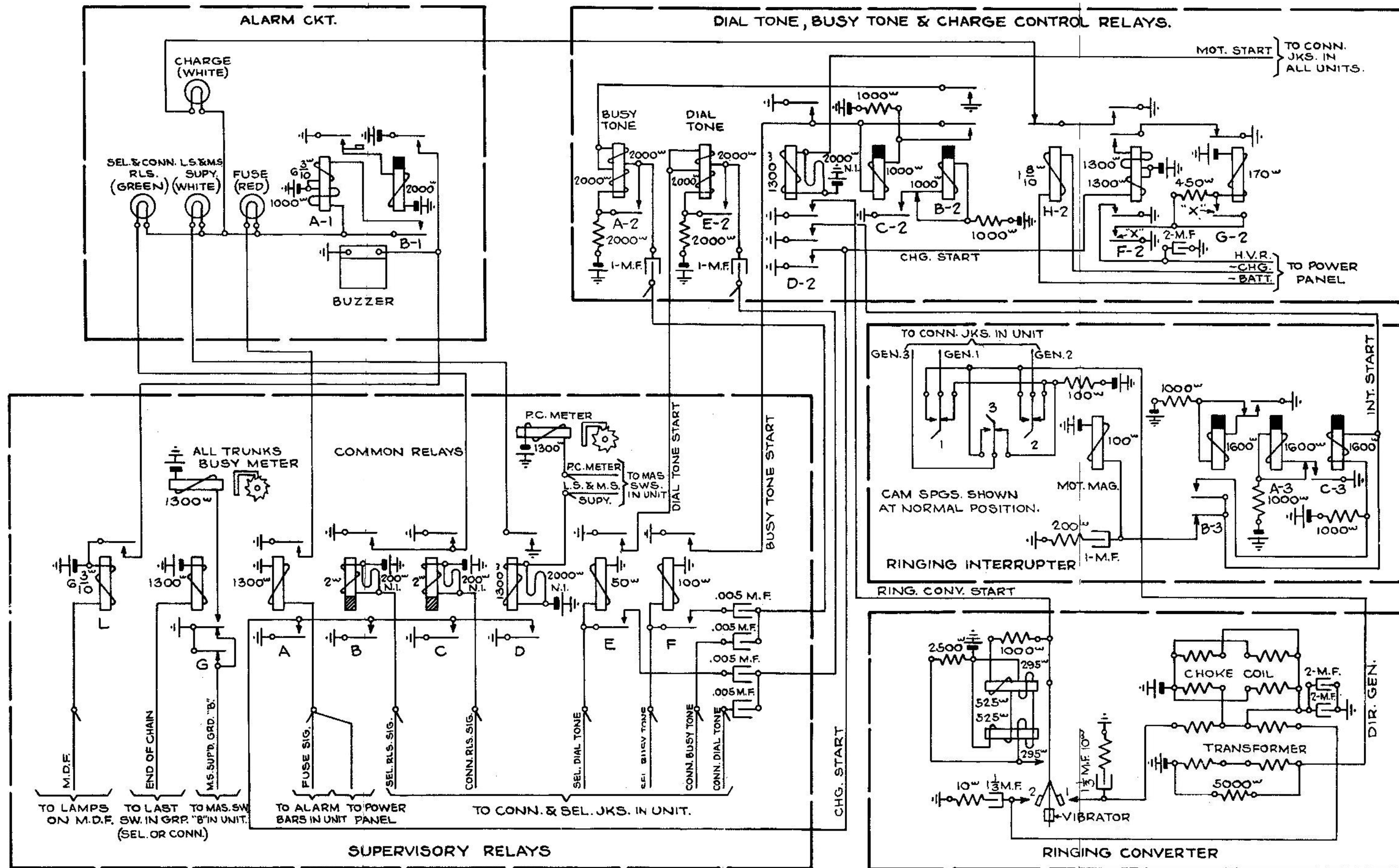


FIG. 35. PLUNGER LINESWITCH P-A-X SUPERVISORY AND OTHER CIRCUITS