

# PRIVATE BRANCH EXCHANGE SYSTEMS

*Telephone Systems Training*

**COURSE: CENTRAL OFFICE EQUIPMENT**

LESSON NO. 6



ISSUED BY

*Western Electric Company.*

INCORPORATED

HAWTHORNE WORKS

*Industrial Relations Branch*

*Training Department*

Western Electric Company Inc.  
Hawthorne Works  
Industrial Relations Branch  
Training Department

Telephone Systems Training  
Course: Central Office Equipment

Lesson No. 6

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This lesson is issued to describe the general features of Private Branch Exchange Systems. Information contained herein is to be used for training purposes only.

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## Section 1. History and Development

A Private Branch Exchange serves a group of stations within a single establishment in a manner closely parallel to the way in which a central office serves subscribers in a particular area. There are more than 130,000 Private Branch Exchanges in use in the Bell System at the present time. In some of the larger cities Private Branch Exchange attendants out-number central office operators.

As the telephone came into general use and greater numbers of employees in offices and factories found occasion to take advantage of its time-saving possibilities, a demand arose for more than one station in the larger establishments. There arose also a need for the telephone for intercommunication; a bookkeeper in the office found much time and energy could be saved if he could talk directly with a clerk in the shipping room. Out of these demands arose the Private Branch Exchange, or PBX as it is abbreviated, a private central office serving directly its own stations.

A PBX was not, of course, the only solution possible. There could have been the same multiplicity of stations within the establishment and the same possibility of intercommunication, had each station had its own line to the main central office and its own number. Any station could have called another by passing through the central office operator, and so far as the members of the organization were concerned there would have been little difference except that the station designation numbers might have been longer.

From the standpoint of someone calling in from the outside, however, there is a considerable difference. The outsider often does not know the name of the person he wants to talk to; he knows what he wants to find out or what knowledge he wants to impart but that is all. If for any establishment there were only a long list of names and numbers in the directory, he would be helpless. Obviously, the only satisfactory solution is to have but a single number for any one establishment and a single person--or, for the larger concerns, a single group of persons--to answer all incoming calls. This person, the PBX attendant, with intimate knowledge of the organization could connect the incoming call to the station that could most effectively deal with it. Thus the need for an attendant was paramount in calling the PBX into existence, and the attendant is still of primary importance to the modern PBX system.

If there are fifty telephone stations in the local establishment, they will never all want to talk with the outside simultaneously. At any one time some stations will not be in use at all and some may be talking to other local stations, leaving only a small remainder making demands for outside service. The number of central office trunks will never equal the number of station lines. The ratio of the number of trunks to lines will always be dependent on traffic conditions. If 5 subscribers out of every 100 wish to use the telephone at the same time, then 5 trunking paths must be available. Such an arrangement provides 5% trunking. This ratio varies over a considerable range depending on the type of business. The attendant and the PBX of course, always partially, and occasionally entirely offset the savings due to the reduction in number of trunks. The attendant, however, performs so many useful services that she is generally regarded as an asset rather than an expense.

Differences in types of business as well as differences in size naturally affect the PBX equipment furnished to the subscriber. In some organizations most of the calling is between members within the organization, whereas in others practically no local calls are made. In some places conditions favor dial service while in others the manual system offers certain advantages. Differences in the number of stations to be served necessarily make a difference in the type of PBX furnished. Thirty-five varieties of PBX have been made in the past and probably more will be built in the future as methods of doing business change and as telephone apparatus and equipment improve. There has never been this number in standard use, however, at any one time.

In the manual class the range of size varies from the small cabinet type, with a maximum of seven stations and three central office trunks, to the large switchboard type used by the Consolidated Gas Company of New York. The latter has 650 station lines, 221 trunks to central offices, and 175 tie-lines to other branch exchanges, and requires 42 attendants during the busy part of the day.

Intercommunicating sets, which do not require an attendant for local calls, are interesting because of their small size. Lines run from each station to every other, and each station is in reality its own PBX; a key is depressed corresponding to the line wanted and no other switching equipment is required. In addition to this very small unit, PBX's not requiring an attendant for local calls have also been designed for larger installations. The present standards may have any capacity up to one approaching that of a central office. An outside number may be dialed without the aid of an attendant.

There is a large and increasing demand for tie-line intercommunication between PBX's. Large organizations, such as public service companies, often have a number of private branch exchanges located at different points throughout the city, and even between cities. The tie-lines may be arranged for dial or manual service, depending upon the type of PBX and the requirements of the subscribers. When tie-lines are provided between dial PBX's the circuits can be arranged, if desired, so that a station in one PBX can dial any station in another.

It is interesting to note that in some central offices in New York City approximately seventy-five per cent of the total working lines terminate in private branch exchanges.

Recently the 700 type PBX has been installed in the Straus Building, Chicago, for the S. W. Straus Company; Long Island Railroad, Jamaica, Long Island; Illinois Bell Telephone Company, Official Switchboard, Chicago.

The 701 type PBX installations include the City Hall, Chicago; Pennsy Railroad Offices, 25 Broadway, New York City; Prudential Insurance Company, offices, Newark, New Jersey; American Insurance Company, offices, Newark, New Jersey; National Broadcasting Company, New York City.

The 702 type PBX includes installations in the Pennsylvania Railroad Station, New York City; Hawthorne Works, Western Electric Company, Inc.

## Section 2. General Description of Standard PBX Systems

### 1. 506 Type PBX Switchboard

This PBX (Fig. 1) is a single position turret of the cordless type, with all connections being made by the operation of keys, and the associated equipment located within the turret readily accessible by means of a removable cover. It is arranged for local manual service and for operating into either manual, panel dial or step-by-step dial central offices. Equipment is furnished in two capacities; one includes 7 station, 5 connecting, and 3 trunk circuits; the other, 12 station, 5 connecting, and 5 trunk circuits.

Miscellaneous equipment includes a desk stand for the use of the operator, and when required, a dial is furnished with the desk stand so that connections may be made to a dial central office. Through dialing to a central

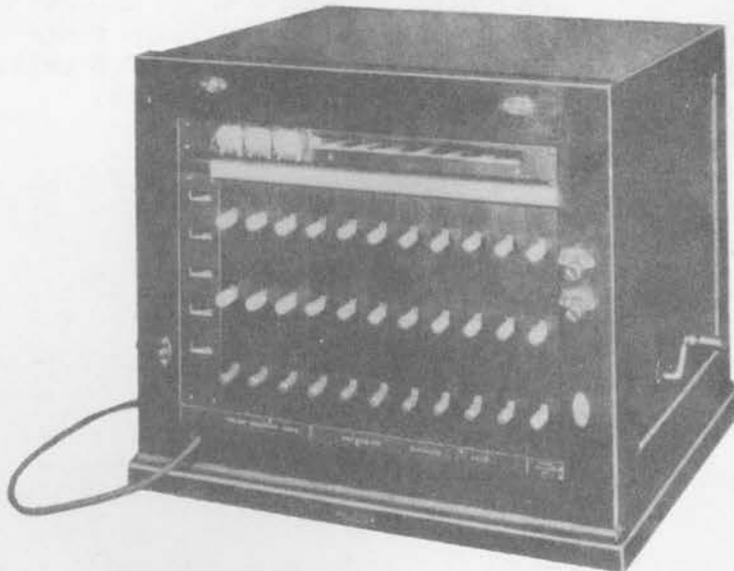


Fig. 1 506 PBX Switchboard

office from stations may be provided for by equipping the station telephone set with a dial. The through dial connection is established by operating an associated station key with a trunk key of the same designation. When the PBX is unattended, a through connection to the central office, either manual or dial, may be left set up for a certain station line.

Current supply for ringing is ordinarily obtained from the central office. If such is not the case, a hand generator is used for ringing the sta-

tions. This also serves as an emergency ringing supply in case of a central office ringing supply failure. Talking battery is obtained over a cable pair from the central office for local connections and over the trunk conductor on trunk connections.

### 2. 551 Type PBX Switchboard

This is a single position non-multiple type switchboard (Fig. 2), arranged for operation with either a manual or dial central office, and furnished in capacities of either, (a) 40 station lines, 10 trunk and 10 cord circuits, or (b) 80 or 320 station lines, 15 trunk and 15 cord circuits. The operating features are the same as for the 506 type PBX switchboard. The framework is designed with a compact hinged gate, opening from the rear, upon which the equipment for the position circuits is mounted.

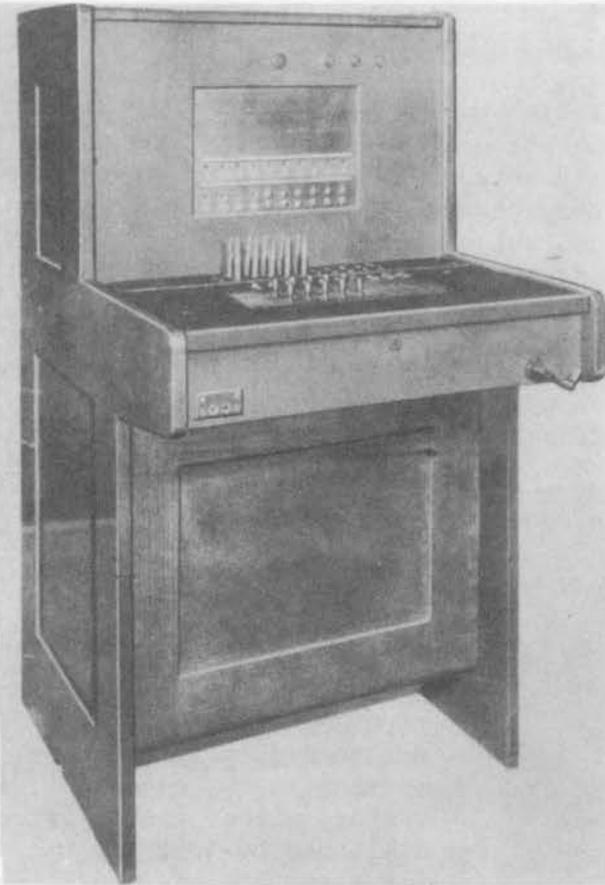


Fig. 2 551 PBX Switchboard

### 3. 552 Type PBX Switchboard

This PBX (Fig. 3) is a single position non-multiple type associated with the 701A non-multiple dial PBX, and is used to handle incoming calls.

It is arranged for local service and for calls to either a manual, step-by-step dial, or panel dial central office. It is furnished in a capacity for 300 dial station lines; 80 trunks, tie-lines or manual station lines; and 15 cord circuits.

Power for the ringing supply and talking battery ordinarily is supplied in the same way as for the 506 type PBX. In some cases a 101A power plant is furnished with the board and mounted adjacent to it. These power plants consist of small radio type batteries mounted in wooden cabinets and arranged for charging by means of cable pairs from the central offices. The number of cable pairs required for supplying power to the PBX is reduced to about 25% of that which would normally be required for a PBX without a local battery. This type power plant has an 8 to 18 ampere hour capacity with a voltage range of 15-20 volts, and consists of 8 cells of small radio type batteries.

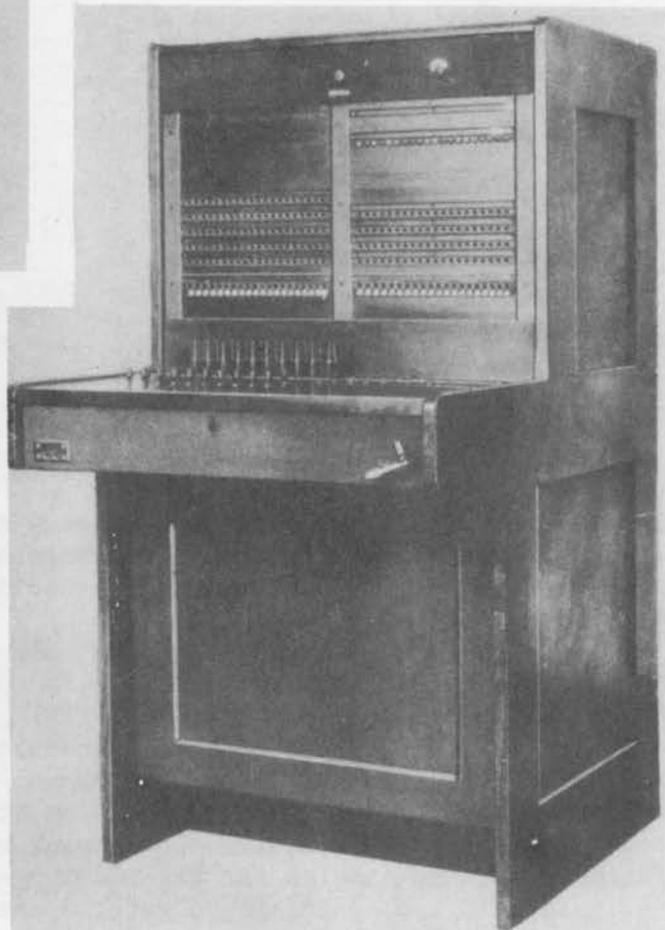


Fig. 3 552 PBX Switchboard

All incoming calls from central offices are answered by the attendant at the switchboard and the connections completed by her. All other connections are completed either manually or through the dial equipment.

The ringing current for the switchboard is supplied over cable pairs from the central office, while the battery supply is obtained from the power plant provided with the dial equipment. A hand generator is furnished to supply emergency ringing in case of central office ringing supply failure.

#### 4. 605A Type PBX Switchboard

This PBX switchboard (Fig. 4) is of the multiple type arranged for connection with either manual, step-by-step dial, or panel dial central offices. The standard capacity of the board is 3200 station lines and 480 trunk circuits, multiplied on a 4 panel basis. This capacity is variable in that trunk capacity may be decreased to increase the number of station lines or vice versa, depending upon operating conditions.

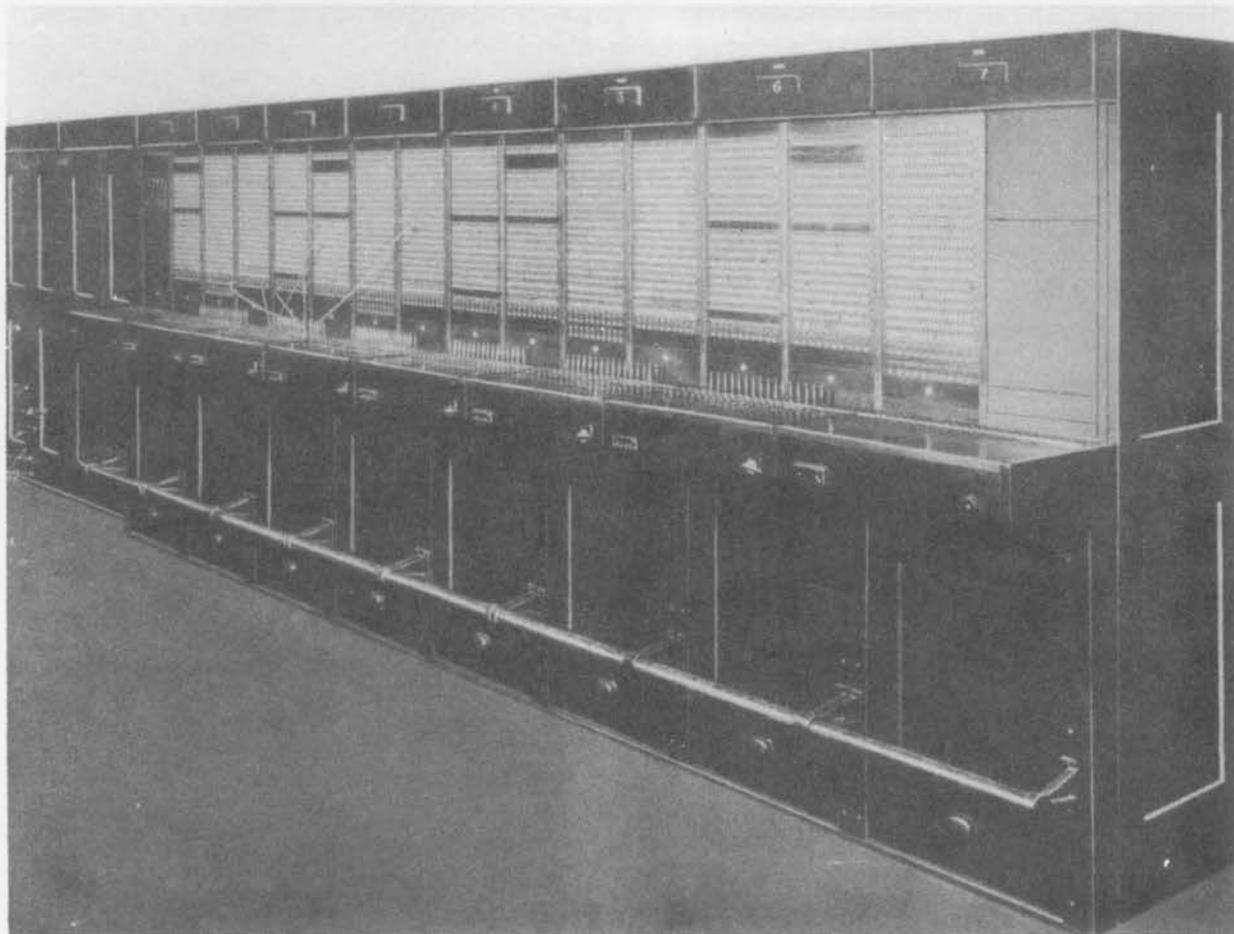


Fig. 4 605A PBX Switchboard

A dial is provided for the use of the attendant when connections are to be established to dial central offices. It can be cut in on any cord circuit in the position by operating the associated "Talk and Dial" key.

This switchboard is usually arranged with an enclosed distributing frame located at the head of the switchboard lineup. Next to the distributing frame is a section known as the Head Section and then follow the sections for the Regular Operating Positions. At the foot of the switchboard is a section known as the Foot Section. In both the head and the foot sections, in order to improve the operator's reach at each end of the switchboard, one jack panel is equipped with multiple equipment. These sections are arranged to mount the relay equipment for the trunk and tie-line circuits.

The regular section is a single position section of two 12" jack panels. The frame is of steel construction employing separate upper and lower units. This permits a lineup of several sections to be brought thru the average size office door or window. The section is arranged with a removable front panel and a rear door so as to provide access to the cords, cabling and equipment. It has been arranged to use mounting plates for mounting the relay equipment. These plates are mounted across drilled mounting irons, so arranged that they may be readily removed from the section. This permits the equipment to be mounted and the local cable soldered to it before being placed in the section.

The head section employs the same framework as that used for the regular section, providing space for the relay equipment for trunk circuit units and the relays and audible alarms for the alarm circuits. One panel is located in the face of the section for completing the multiple at that end of the switchboard. In the other panel are located the battery cut-off, night alarm, fuse alarm and power alarm switches and the lamps required for the different alarms.

The foot section employs the same framework as the regular and head sections, and provides additional space for trunk and tie-line units. Where more trunk units are required than can be mounted in the head and foot sections, it will be necessary to mount the additional equipment outside of the switchboard sections. Trunk and tie-line equipment are furnished on a unit basis, a terminal strip being provided with each unit.

The distributing frames (Figs. 5 & 6) used at the head of the switchboard lineup are enclosed in casings which line up with the switchboard. One style frame consists of 5 verticals arranged for 9 vertically mounted and 8 horizontally mounted 100 type terminal strips on each vertical. This type of single frame has a capacity of 1080 pairs of wires on the vertical side and 960 pairs on the horizontal side. It will take care of 760 station lines and 120 trunks and two frames will take care of the full capacity of the switchboard, 1520 station lines and 240 trunks. Another type frame consists of 8 verticals arranged for 10 vertically mounted and 9 horizontally mounted 100 type terminal strips per vertical. The terminal strips on the left vertical are omitted when the growth is right to left in order to provide space for the cables to the switchboard multiple equipment. This frame has a capacity for terminating 2800 pairs of wires on the vertical side and 2520 pairs on the horizontal side. In the top part of these distributing frames is a

compartment for splicing cables. This permits bringing the paper insulated lead covered cables from the central office and various house boxes into the distributing frame, splicing a handmade cable to them, and then running them to the terminal strips on the vertical side of the frame.

A floor type self-supporting distributing frame having a fixed height of 7' is provided where it is desirable to employ an external distributing frame not in the lineup with the switchboard section. This frame is of the unit type, two units being available, one of 5 verticals and another consisting of a single vertical. The 5 vertical unit is ordinarily used as the

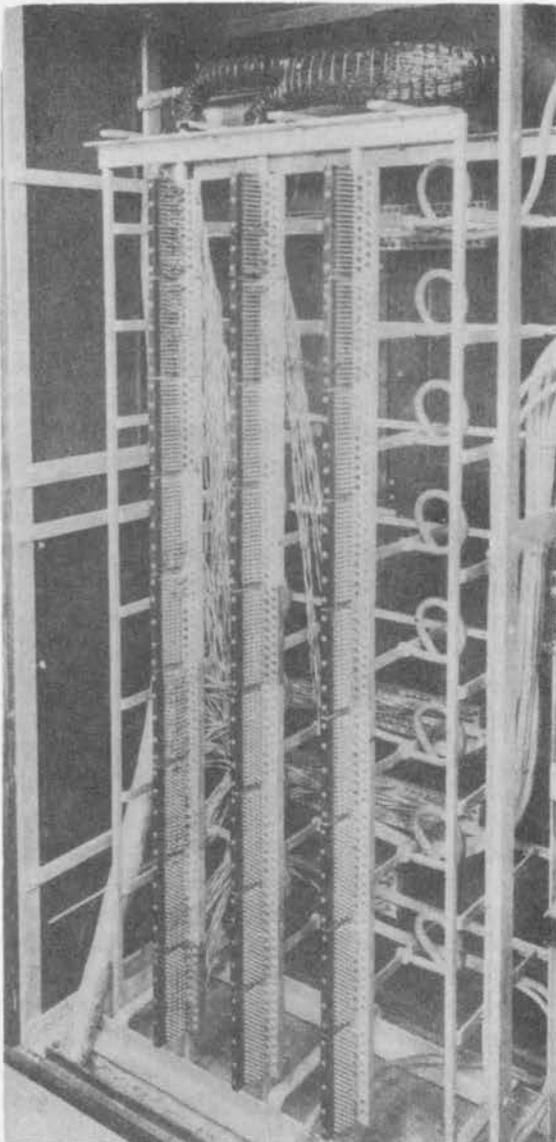


Fig. 5 605A PBX Switchboard  
Distributing frame at head  
of switchboard

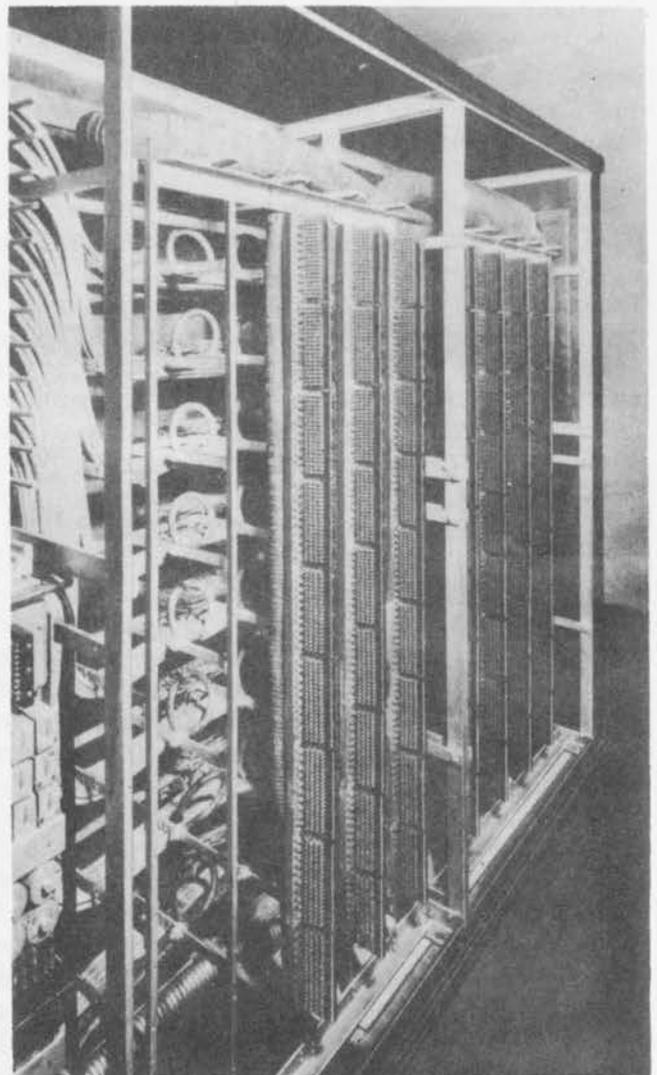


Fig. 6 605A PBX Switchboard  
Two distributing frames  
at head of switchboard

originating unit. Each vertical is arranged for 8 vertically and 8 horizontally mounted terminal strips. Normally, the frame is equipped with terminal strips on both the vertical and horizontal sides. However, where protectors are required, an arrangement is provided so that protectors may be mounted in place of terminal strips on the vertical side.

A cable turning section is provided where the floor type distributing frame is used. There is one available for each capacity and they are only of sufficient length for turning the cables entering the switchboard. The necessary lifting space required for maintenance purposes is obtained in the head section since the first panel in this section does not contain multiple jack and lamp equipment.

A 30° angle section for each size of switchboard is provided for use where it is necessary to change the direction of the switchboard line-up. This section has been designed without iron framework, and is supported by being fastened to the adjacent sections.

A telautograph section for each size of switchboard is available for use where it is desired to locate telautograph equipment in the section line-up. This section has been designed without iron work, being supported by fastening it to the adjacent sections. It is 12" wide and is arranged for one panel of multiple jack equipment. The keyshelf is designed to accommodate the telautograph sending equipment, while the receiving equipment is hung from the roof over the crown moulding. The space within the section is reserved for the fuses, terminal strips and relays required in connection with the operation of the telautograph equipment.

The relay rack for use with this switchboard, when an external relay rack is desired, is self-supporting, 7' high and has a capacity of 39 23" x 1 3/4" mounting plates. This relay rack is required only when it is necessary to mount equipment outside of the switchboard lineup. Where a relay rack is required, arranged to line up with the switchboard, one designed to mount in the same casing used for the distributing frame is available. It may be lined up with either the cable turning section or distributing frame, and as in the case of the switchboard and external relay rack it is arranged for 23" mounting plates.

The outside cables both for the enclosed type and the floor type distributing frames, are brought to the terminal strips on the vertical side. The station line jacks are connected to terminal strips on the horizontal side of the distributing frame and cross-connected to the terminal strips on the vertical side. The trunk and tie line jacks are cabled to the relay equipment (located in the head and foot sections or on a relay rack), then cabled to the horizontal side of the distributing frame, and then they are cross-connected to the vertical side. The short multiple cables in the switchboard are usually run on pins. Provision has been made, however, so that a multiple shelf can be used if jacks only are provided in the station line multiple.

The DC power for the operation of this switchboard is supplied from a storage battery located at the PBX. Three types of power plants are available for charging the battery as follows:

- (a) The 101C Plant for charging over cable pairs from the central office.
- (b) The 102 B. Plant for continuous operation of charging equipment located at the PBX.
- (c) The 204 A Plant for automatic operation of charging equipment located at the PBX.

These power plants are for use only where the switchboard is used as a manual PBX. When used as the manual part of a dial PBX, the power for the switchboard is obtained from the power plant provided with the dial switching equipment.

The ringing current for the switchboard is supplied from the central office over cable pairs.

The 101C power plant (Fig. 7) of 100 ampere-hour capacity with a 32-46 voltage range, consists of a battery cabinet having an upper and lower compartment. The lower compartment is arranged for mounting six 3-cell radio type batteries, one of these 3-cell units having 2 active and one dummy cell. The upper compartment is arranged for mounting the control equipment; fuses for terminating the cable pair charging leads, charge and discharge fuses, and resistances for the fuse alarm circuit. These cells are arranged to be charged over cable pairs from the central office.

The 102B power plant (Fig. 8), of 2.5 ampere-hour capacity with a 32-46 voltage range, employs continuous operation of the charging equipment and is used where close voltage range regulation is desired. It is used with 110 V 60 cycle A.C. or 115 V D.C. power service. This power plant is used in cases where the busy hour load is beyond the capacity of the cable pair charging power plants, but is not large enough to employ an automatic power plant. Tungar rectifiers or motor-generator sets are operated continuously and their output so adjusted that the daily load of the board is replaced plus sufficient capacity to keep the storage battery in good condition. The equipment consists essentially of two cabinets, an upper and lower unit. The lower cabinet mounts the battery equipment consisting of 18 cells of radio batteries, while the upper cabinet mounts the control equipment such as fuses, meters, switches, relays, etc. The charging machines are mounted on top of the upper unit.

Where 110 Volt, 60 cycle A.C. power service is available, the 3 ampere tungar rectifier has been standardized and one or two rectifiers are furnished depending on the initial and ultimate requirements. This allows a flexible arrangement for the A.C. charging equipment to meet the various load conditions from the initial to the ultimate stage of plant growth.

Where only 115 Volt D.C. power service is available, a motor generator set is furnished of a proper size depending upon the load requirements.

It is not economical or very practical to operate small motor generator sets in parallel as outlined above for the tungar rectifier; the motor genera-

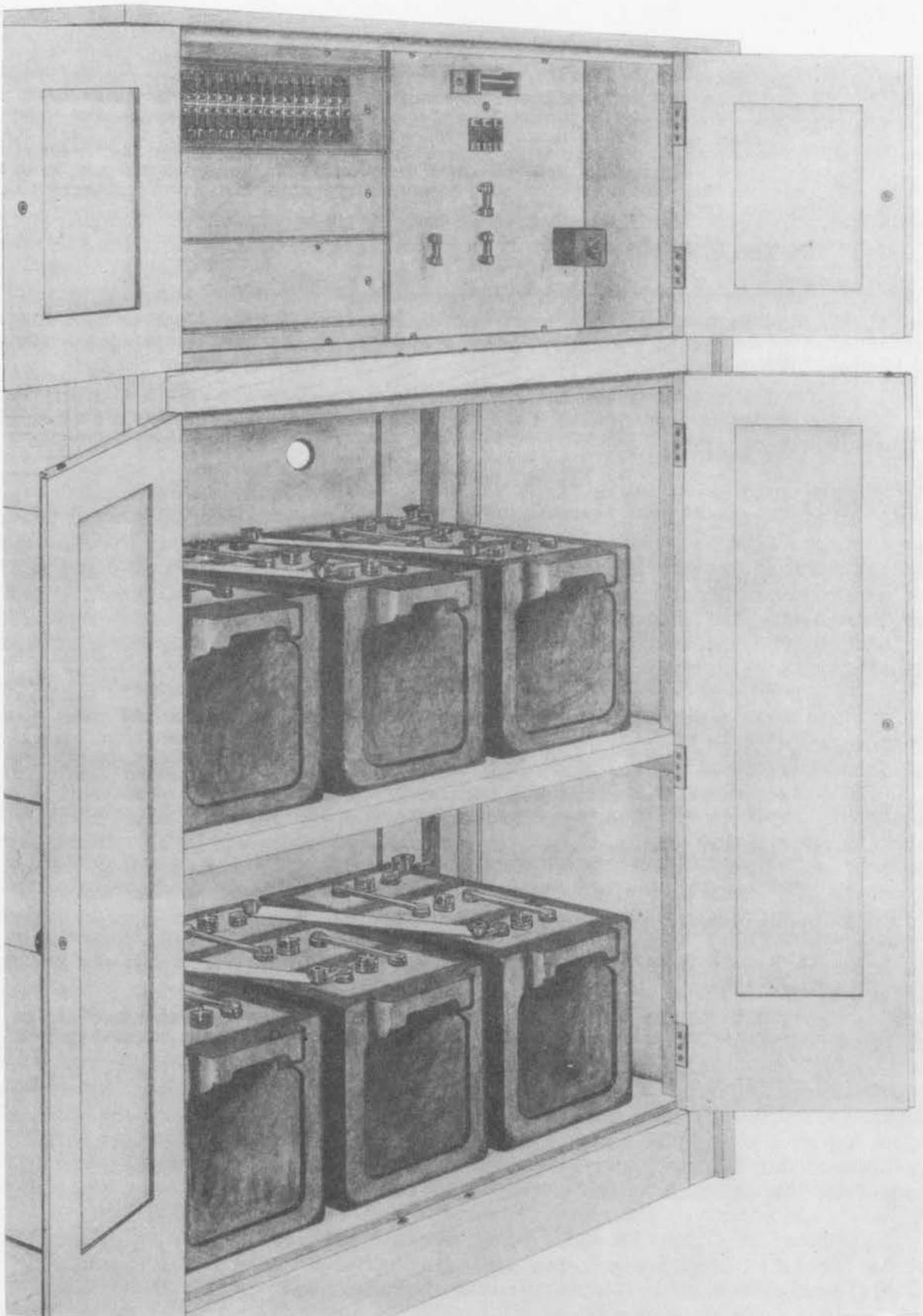


Fig. 7 101C Power Plant

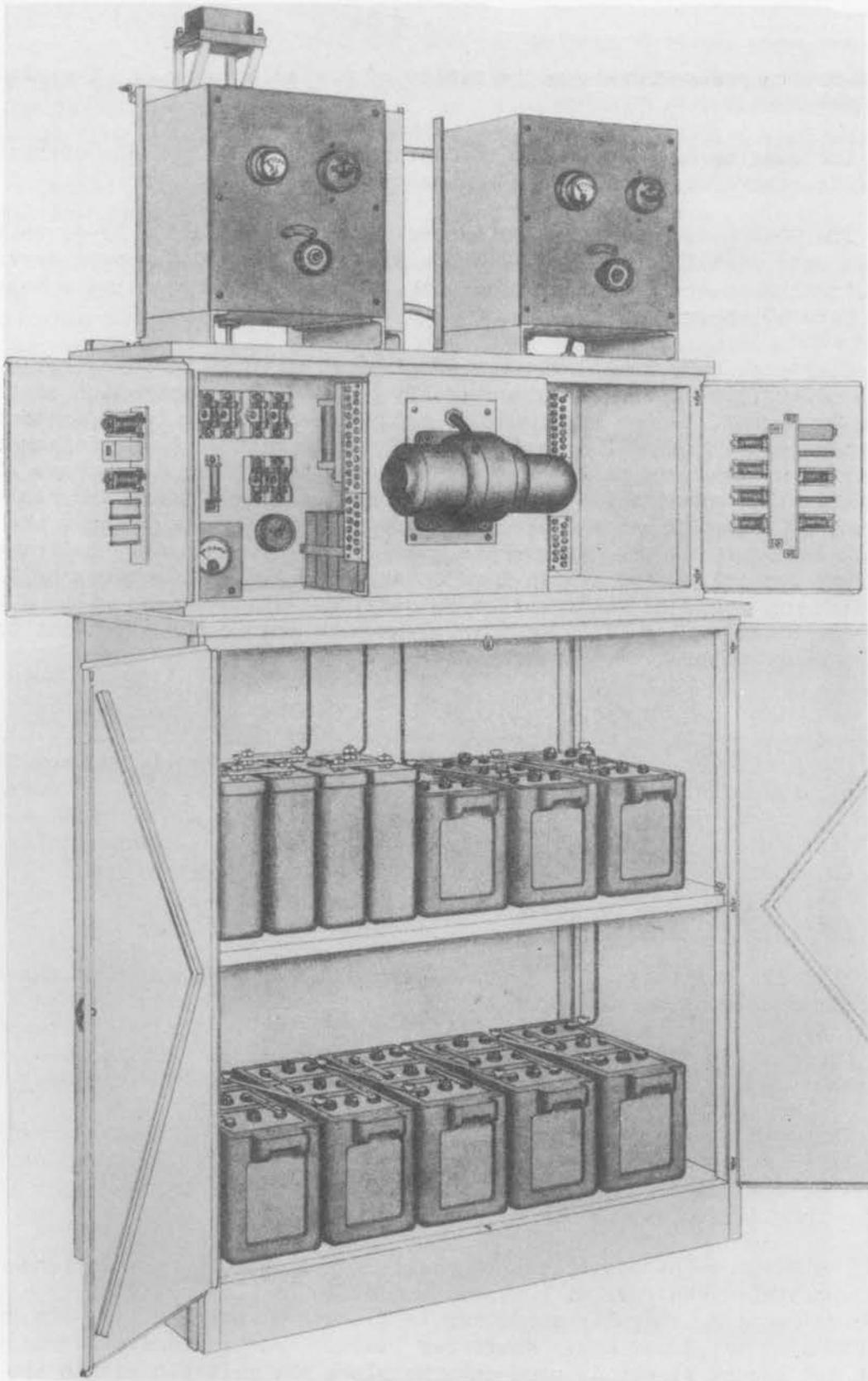


Fig. 8 102B Power Plant

tor sets are therefore furnished initially of a size to care for the ultimate load requirements.

The ringing current is obtained over cable pairs from the nearest central office, therefore, no ringing equipment is required.

The 204A power plant, of 30 ampere-hour capacity and a 32-46 voltage range, is used with 110 or 220 V 60 cycle A.C., or 230 V D.C. power service. It is automatic in operation and used with PBX equipment requiring a busy hour load of 5 to 50 amperes.

Where the busy hour drain exceeds 5 amperes it is very desirable to employ a power plant which is automatically operated, the operation of the charging equipment, tungar rectifier or motor generator set being controlled by an ampere hour meter. The power maintenance is reduced to a minimum since the ampere hour meter is so set that as soon as the battery discharges 10% it automatically connects the charging equipment to the battery and replaces the amount of charge taken therefrom plus sufficient capacity to put the battery back into good shape. Alarms are provided to automatically indicate to the nearest central office the failure of any of the vital features of the plant which may cause an interruption to service. These alarms will usually indicate such failures sufficiently in advance to enable the attendant to repair the damage without any service interruption.

Either of two types of batteries, pasted plate radio or enclosed glass jar (chloride accumulator cell), may be used. The radio type is used for the smaller plants because of its economy. The charging equipment required for this type power plant consists of tungar rectifiers for use with AC service and small motor generator sets for use with DC service. Ringing current is ordinarily obtained from the central office over cable pairs, but where this is not satisfactory, ringing interrupter equipment is furnished.

#### 5. 606A PBX Switchboard

This PBX switchboard (Fig. 9) is a multiple type board that can be used as a strictly manual board or as the manual part of a dial PBX in either a manual, panel dial, or step-by-step dial central office area. The capacity of this board varies with the installation; station lines 3520 to 9600, outgoing trunks 240 to 480, and incoming trunks or tie-lines 360 to 480.

The switchboard framework used is that of the No. 11 board arranged for single position lower units and 9-8 $\frac{1}{2}$ " panel three position upper units. All jacks in the board are of the 92 type. The steel framework of the lower unit is arranged to mount 23" mounting plates.

The first three positions, composed of a trouble and miscellaneous position partially equipped with multiple and two regular positions, is known as the head section. Regular operating sections are next in line with the foot section at the lower end. Where two lineups are provided, the first position of the second lineup is used only to place the multiple within the reach of the operator in the second position.

The trunks and tie-lines may be either on an "answer in the multiple" basis, with jacks thru-out the board, or on an answering jack basis with a maximum of four answering jacks per line.

Outgoing trunks are multiplied throughout the board and practically all of the circuits may be arranged with idle indicating lamps.

The maximum capacities in the strictly manual board are obtained by the use of the "inverted multiple" arrangement, that is, the switchboard is divided into two parts. In the first part of the board half of the station lines are equipped with line lamps while the other half appear directly above with jacks only. This order is reversed in the second part of the board.

If inverted multiple is used in a large installation, two separate lineups may be used, or an intermediate cable turning section may be inserted in the same lineup.

In the rear of the sections will be mounted supervisors equipment, position grouping circuits, and flashing recall circuits. The cord circuit and trunk and tie-line relay equipment is mounted on relay rack units.



Fig. 9 606A PBX Switchboard

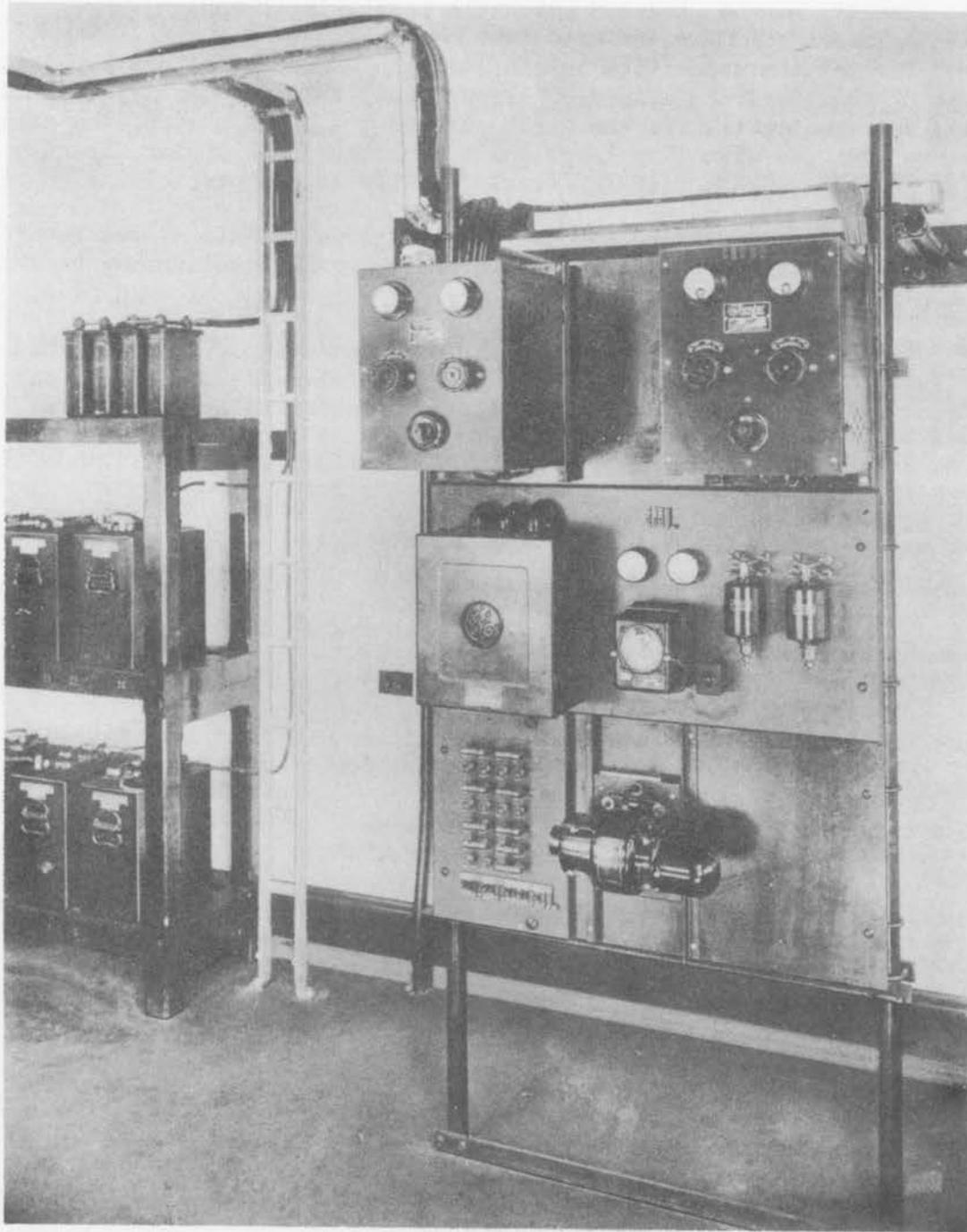


Fig. 10 205B Automatic Power Plant

The switchboard is arranged with a separate distributing frame in a terminal room. The main and intermediate frames may be used, or a combination frame. The most satisfactory arrangement is to locate the distributing frame or frames and the relay rack and power equipment directly below the operating room; however, the job conditions will often require location of terminal equipment elsewhere.

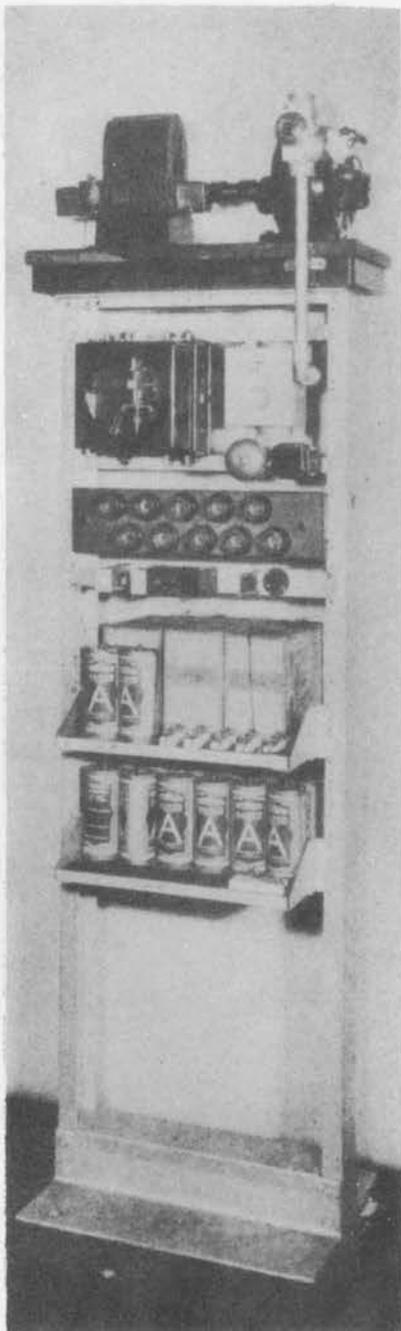


Fig. 11 The 805A  
20 Cycle Ringing  
Power Plant

The trunk, tie-lines and miscellaneous circuits for use with the 606A PBX are set up on a completely wired, self contained unit basis. These units employ 23" mounting plates. All leads from the apparatus on the unit are terminated on terminal strips.

The power supply required for the operation of this PBX is obtained from a No. 205B power plant with the ringing supply being furnished by a No. 805A power plant.

The 205B power plant (Fig. 10), of 30 or 50 ampere-hour capacity and a 45-50 voltage range, is in other respects like the 204A power plant explained previously. A number of counter EMF cells together with a voltmeter relay and control equipment are added features to maintain the voltage within a particular range.

The 805A 20 cycle ringing power plant (Fig. 11) is arranged in a self-contained unit, consisting of a line motor driven magneto, 84-H interrupter, necessary battery equipment, ringing transfer equipment for transfer from the regular source of power to the interrupter equipment in case the former fails, and alarm equipment, all of which is mounted on a floor supported relay rack framework. This plant requires 110 V 60 cycle AC for its operation

#### 6. 701A and 711A PBX

The 701A PBX (Fig. 12) is a combined manual and dial PBX, while the 711A PBX (Fig. 13) is a dial PBX without any associated manual equipment. Both are arranged to give 2, 3, 4 and combined 3 and 4 digit service. The capacity of the 701A PBX allows for 90 lines (2 digit service), 900 lines (3 digit service), 3200 lines (4 digit or combined 3 and 4 digit

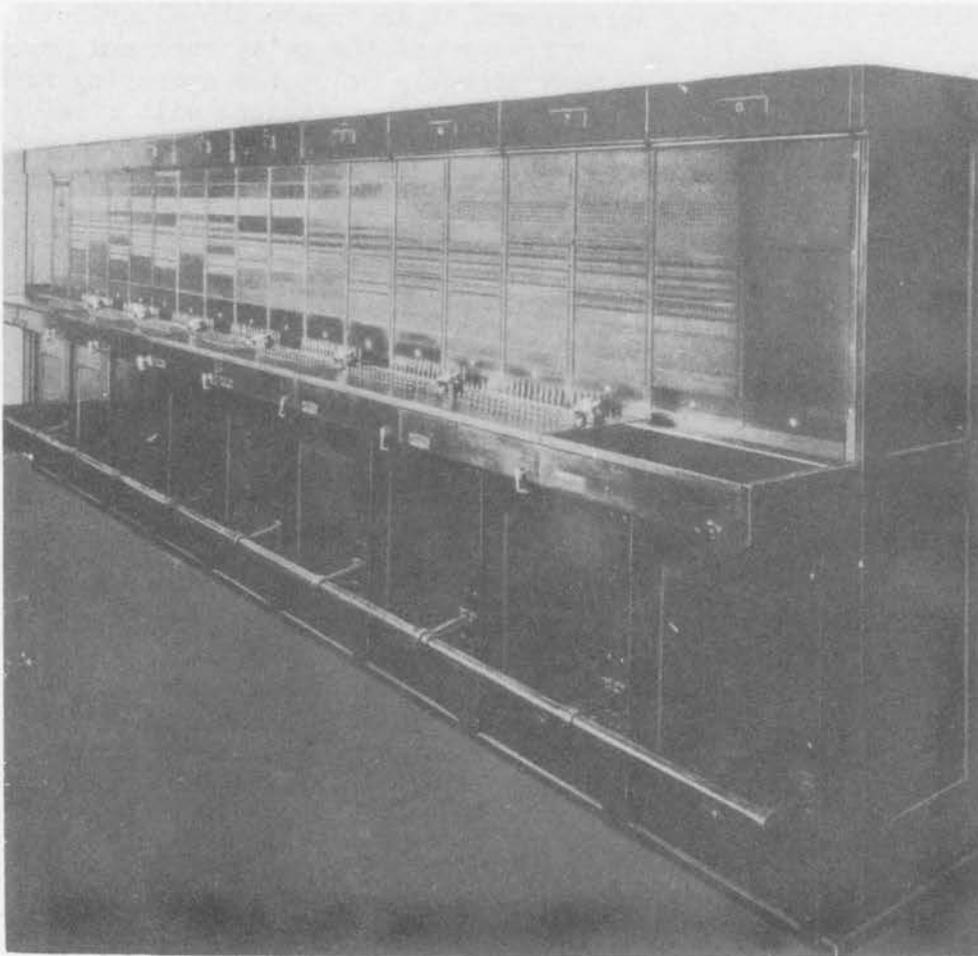


Fig. 12 701A PBX Switchboard

service), and trunks and tie-lines 80 to 480. The capacity of the 711A PBX allows for 100 lines (2 digit service), 1000 lines (3 digit service) and over 1000 lines (4 or combined 3 and 4 digit service).

The equipment of the 701A PBX consists of a manual switchboard, step-by-step dialing equipment and associated relay racks, distributing frame and a power plant. The manual switchboard is used for completing manually all incoming calls and certain outgoing miscellaneous calls. The step-by-step equipment provides means for connecting station lines mechanically to other station lines, to central office trunks, to operators and intercepting trunks and to tie-lines. Line finders are used to connect the calling station lines to idle selectors.

The manual switchboard equipment for a multiple 701A PBX consists of 605A PBX manual sections with the same cord circuits, telephone and dial circuit, and miscellaneous circuits, as used in the 605A manual PBX. In addition to the above, there are a number of other circuits, such as certain types of central office trunks, tie-lines and station lines which are common to the 701A and 605A PBXs.

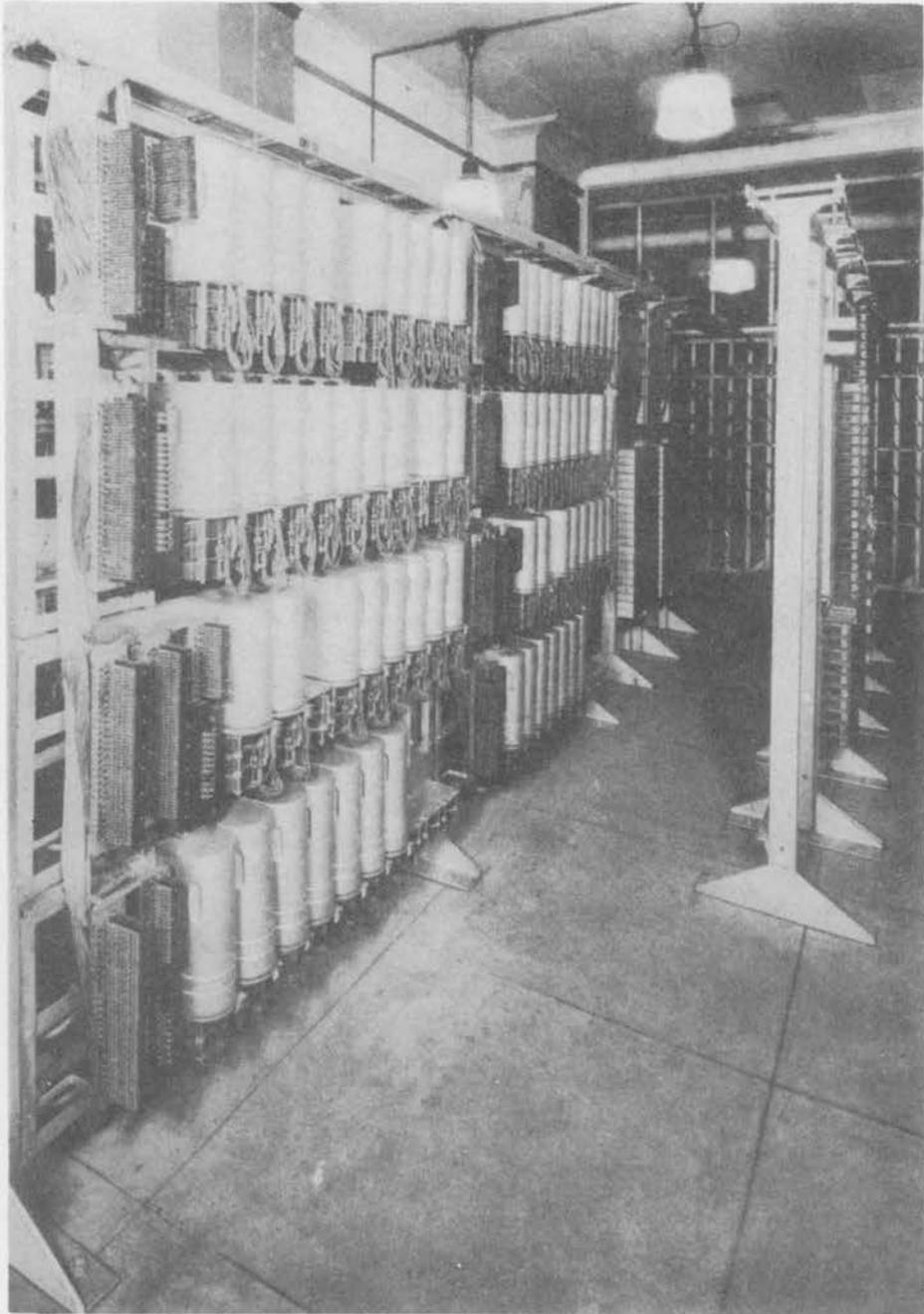


Fig. 13 711A PBX Switch Frames  
Line Finder and Connector Units

The manual switchboard equipment for non-multiple 701A PBX consists of a 552A switchboard. The same cord circuits and telephone and dial circuit as used in the multiple 701A PBX are used in the non-multiple PBX.

#### Equipment Arrangement

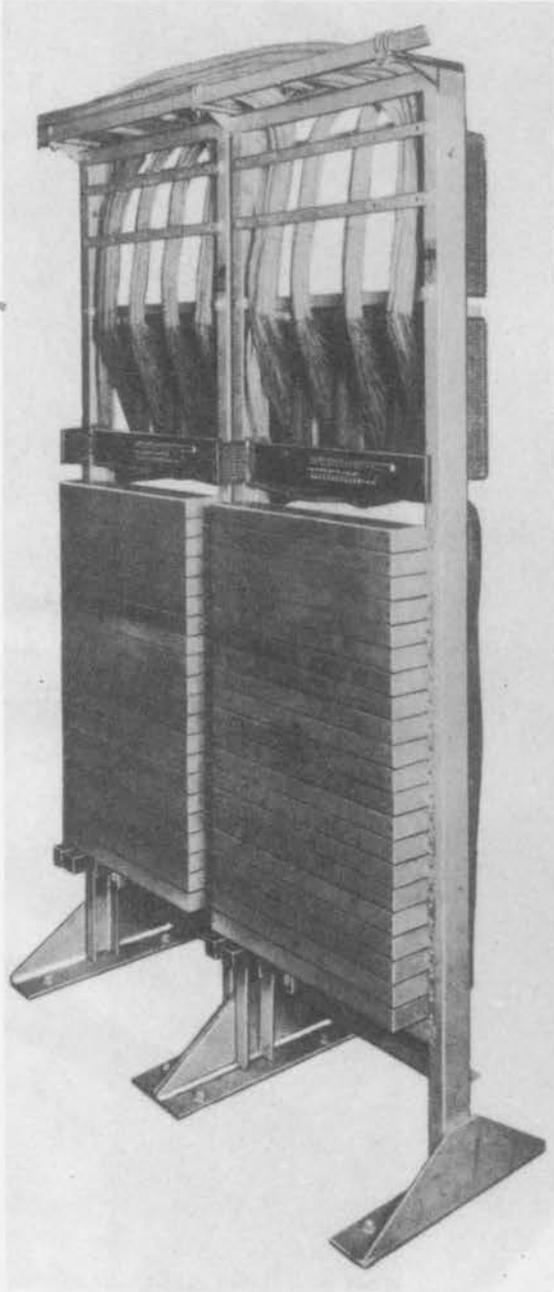


Fig. 14 701A PBX Line Relay Rack

Self contained units are provided for the mounting of line finders, selectors and connectors respectively, and for their associated banks. In addition, these units carry the necessary terminal strips for the termination of the bank multiple cables, the shelf cable, and fuse panel. In the case of line finder units a jack panel is also mounted on the unit. All units are of the same length, but the line finder and connector units are available in either single or double shelf types. The capacities of the line finder units are 9 and 20 line finders for single and double shelf units respectively, while the capacities of the connector units are 10 and 20 respectively. The selector units are of the single shelf type only with a capacity of ten selectors per unit. The units are arranged to mount on a switch frame.

The switch frame is double sided, 7 feet high and is arranged to mount units of the single or double shelf type on the front and rear. Line finder, selector or connector units can be mounted interchangeably. The capacity of the frame is 80 switches, 40 on the front and 40 on the rear. The frame is self-supporting although the floor angles are drilled so that the frame can be fastened to the floor if desirable.

The line and cut-off relays together with the group relays of the line finder circuit, are mounted on a line relay rack (Fig. 14). This is a shop wired rack with a capacity for 200 lines. In addition to the relay

equipment, the rack is equipped with terminal strips for the termination of switchboard cable from the distributing frame, line finder units, connector units and the switchboard.

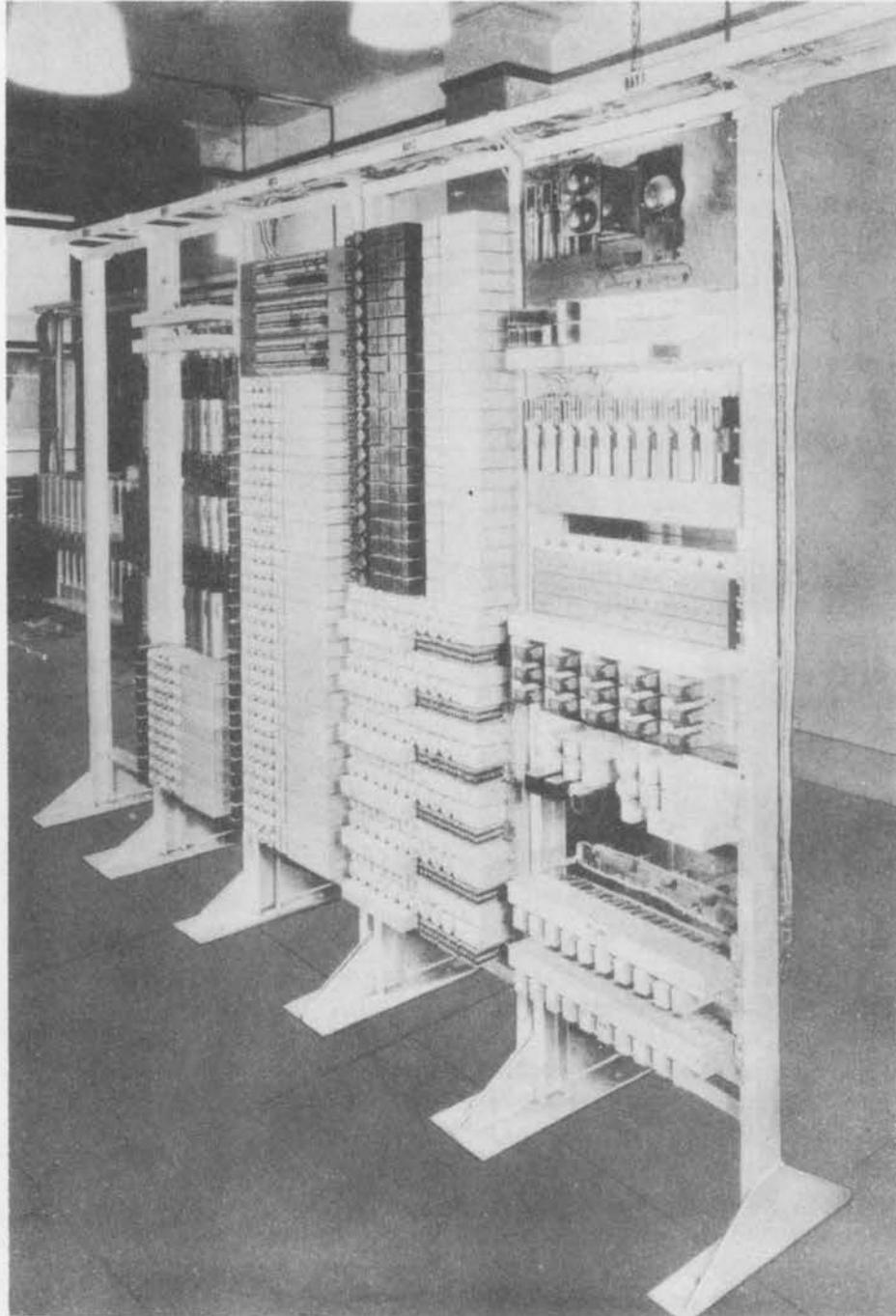


Fig. 15 701A PBX Miscellaneous Relay Rack

The rack is arranged so that it can be used as a distributing frame for the station circuits on smaller installations. For this purpose space is provided at the top of the frame for terminal strips for the termination of a maximum of 600 pairs of house cable. Jumper rings are provided on the frame to carry jumpers from these terminal strips to the terminal strip on which the local cable terminates. Rings are also provided on the end of the frame to carry jumpers to an adjoining frame. The use of the relay rack as a distributing frame is economical on installations up to at least 400 lines, where protection is not required on the station line circuits.

Miscellaneous relay racks (Fig. 15) are provided for the mounting of the apparatus for the trunk, tie-line and miscellaneous circuits. This apparatus is mounted on shop wired units consisting of single and 10 circuit relay rack units, each provided with a terminal strip for terminating the switchboard cable.

The lamps of the miscellaneous alarm circuits for the switch frames and units are located on the miscellaneous relay rack on which is also mounted a shop wired unit carrying the common equipment of the miscellaneous alarm, test line, ringing and voltage regulating circuits.

The supervisory lamps of the miscellaneous alarm circuit are located in the manual switchboard for the 701 PBX and the relay rack for the 711 PBX.

The battery and ringing supply for the 701A and 711A PBXs is obtained from a 205 type power plant at the PBX, which has been previously described.

#### 7. The 702A PBX

The 702A PBX is a combined manual and dial PBX. It has associated with it the 606A PBX which is used as the manual portion. The dial portion of the PBX employs, in general, the same equipment as in a step-by-step central office. It differs, however, in that different line finder and first selector switches are used where restricted service is required. The manual board makes use of separate upper and lower unit frameworks.

The capacity of the 702A PBX is sufficiently large to permit its use in the largest mercantile establishments and hotels. It may also be used for an official PBX in large central office areas. The manual board has an 8 panel station line multiple and a 6 panel trunk multiple. Arrangements are made for a station line capacity of 9600, 240 to 480 outgoing trunks, and a maximum of 480 incoming trunks or tie-lines.

The manual switchboard uses the separate upper and lower unit frameworks. The upper unit is a three position unit while the lower is a single position unit. Standard cable turning sections, angle sections and end panels are also used.

Standard step-by-step central office dial equipment is used for the dial board, wherever possible. Either 9'-0" or 11'-6" switch frames may be used, depending on ceiling heights.

The line finder units are built in three capacities to mount a maximum of 16, 20 or 30 line finder switches together with their associated banks, station line equipment, testing equipment, alarm equipment and fuse panel to serve 200 station lines (Fig. 16).

The 9' framework mounts 2 line finder units, and the 11' 6" frame provides space for 3 units.

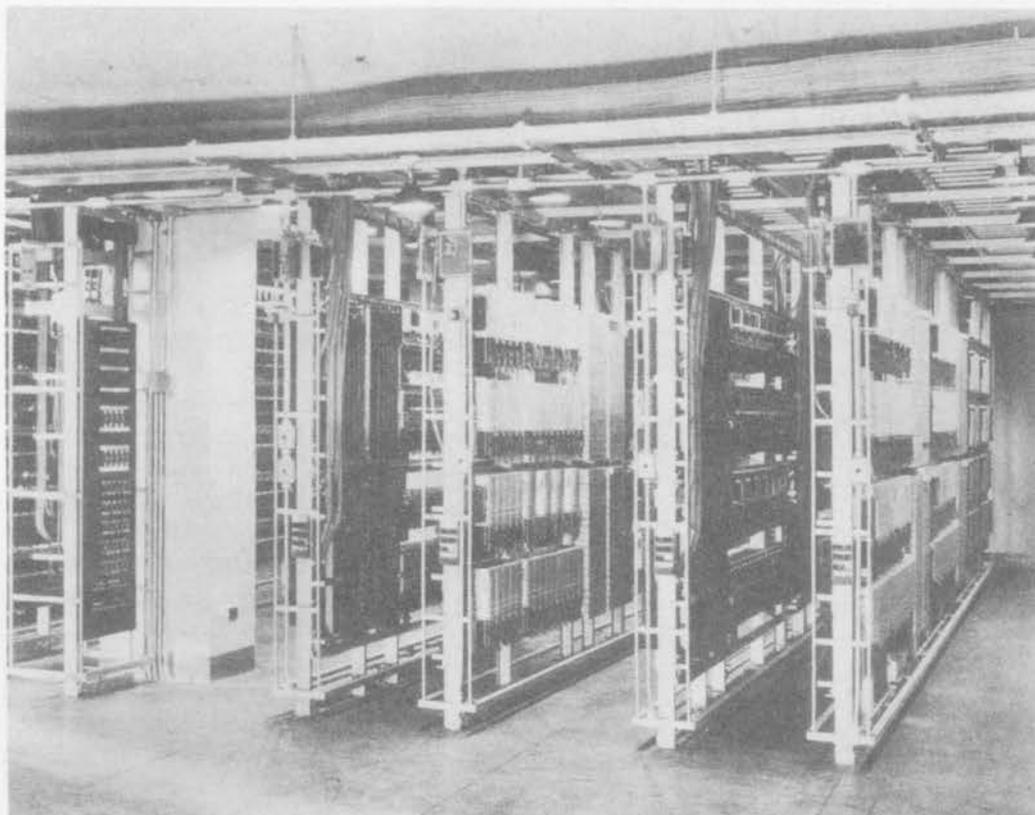


Fig. 16 702A PBX Terminal Room  
Showing Line Finder Frames

The selector switches (Fig. 17) are mounted on shelves having a capacity of 20 selectors per shelf. The 9' selector frame is arranged to mount 6 selector shelves, while the 11' 6" frame will care for 8 shelves. The connector switches may be mounted on frames of two different widths, a regular bay which will mount shelves of 10 connectors and a supplementary bay which will mount shelves of 5 connectors. The shelf framework that mounts 10 connectors is exactly the same as that used on central office step-by-step equipment, the eleventh connector position, however, not being wired or equipped. The 9' connector frame mounts 5 shelves, while the 11' 6" frame provides space for 7 shelves.

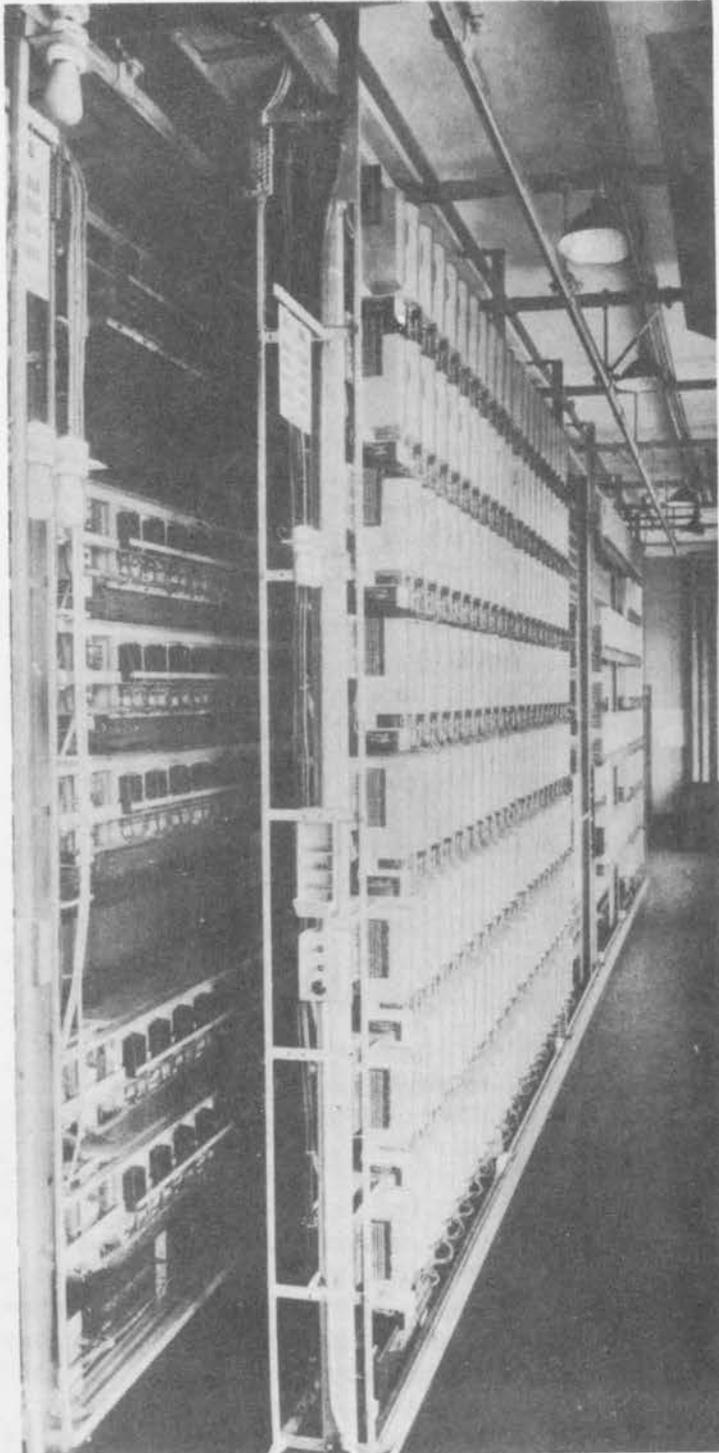


Fig. 17 Selector Frames

Standard central office distributing frames are used. Both separate main and intermediate frames and a combination type distributing frame in 9'-0" or 11'-6" heights are available.

The trunk, tie-line and miscellaneous circuits for use with the 702A PBX are set up on a completely wired, self contained unit basis. These units employ 23" mounting plates with all leads from the apparatus on the unit terminating on terminal strips.

The power supply required for the operation of this PBX is obtained from a 205B power plant, and the ringing supply is furnished by a 805A power plant. These power plants have been discussed previously. The 702A PBX is installed at the Hawthorne Works of the Western Electric Company. It gives 4-digit dial service to all local stations within the works, and to Clearing plant; direct two-way trunk service to Lawndale central office in Chicago, and Cicero central office in Cicero, Ill.; private wire service to A. T. & T. Co., 195 Broadway, New York City, and to W. E. Co. at Kearny, N. J. thru the PBX at 195 Broadway; tie-line connections with the official PBX of the Ill. Bell Tel. Co., Automatic Electric Co., Manufacturers Junction Railroad Co., Graybar Electric Co., and the Joint Ill. Bell and W. E. Co. warehouse at 23rd and Rockwell Streets. A manual 606A PBX switchboard handles all incoming calls,



and all outgoing calls for which a charge is made. Dialing the digit "9" will connect the station line to the Lawndale "A" operator; while dialing the digit 8 will connect the station line to the Cicero "A" operator. This "outside service" is available only to authorized station lines. Direct 2-digit dial service is given to the joint warehouse (dial 74), Graybar Electric Co. (dial 75), Mfg. Jct. R. R. (dial 76), Automatic Electric Company (dial 77), and Ill. Bell Tel. Co. (dial 79). These calls terminate at positions on a manual PBX, where the operator will complete the call manually. Fig. 17A gives a complete layout of the traffic handled, and the types of equipment required to serve the station lines in the Hawthorne Works.

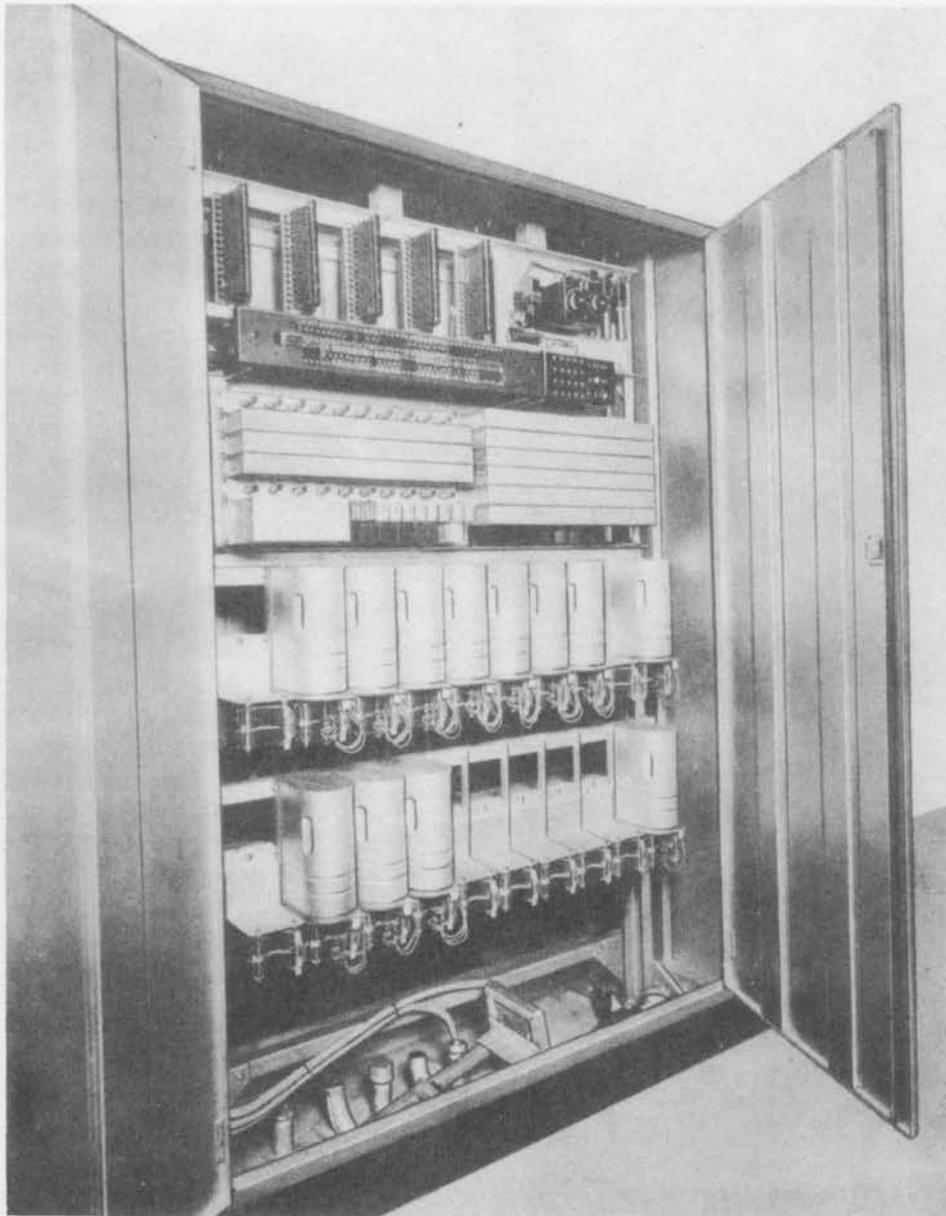


Fig. 18 740A PBX

## 8. 740 Type PBX

The 740A PBX (Fig. 18) is a small two-digit dial unit, comprising frame equipment, an attendant's cabinet (Fig. 19), and the necessary power equipment to serve a maximum of 88 lines. The unit is arranged for a capacity of 88 station lines (some of which may be converted for use with trunk or tie-lines), 10 line circuits for trunks or tie-lines, 1 line circuit for the attendant's telephone and 1 test line circuit.



Fig. 19 740A PBX Cabinet

Each station line may, by dialing, connect with any other station line, with a central office trunk (unless the station line is restricted) or with a tie-line to an associated distant PBX. Provision is made for tie-lines to as many as three distant PBXs. All incoming calls over trunks from the central office or over tie-lines from distant PBXs, signal the attendant who must complete the call by dialing the desired station line. The attendant may originate or complete calls to a central office or to a distant PBX. The PBX is arranged for operation with trunks to either a manual or a dial central office and with tie-lines to any type of manual or dial PBX. A line finder switch is used to connect an idle selector-connector switch to a calling

station line, a calling trunk or tie-line, or a calling attendant's telephone circuit.

The selector-connector switch is used to connect the calling party to the desired station line or attendant's telephone circuit or to select a trunk or tie-line on a level arranged for hunting.

A trunk circuit is used to connect incoming and outgoing calls to a central office, and a tie-line circuit is used to connect calls between various PBXs without a connection thru a central office.

The frame (Fig. 18) consists of a double sided framework arranged to mount on one side 99 line circuits, 20 100-point line finders, fuse, alarm, test and terminal strip equipment and on the other side, 20 selector-connectors, 19 trunk or tie line circuits and 1 attendant's telephone circuit unit.

A sheet metal casing is furnished when it is desirable to enclose the frame.

The attendant's cabinet (Fig. 19), consists of a desk turret arranged to mount key, lamp and terminal strip equipment for one attendant's telephone circuit and 10 trunk or tie-line circuits and auxiliary alarm equipment. Where more than 10 trunk or tie-line circuits are required, two of these desk turrets are used.

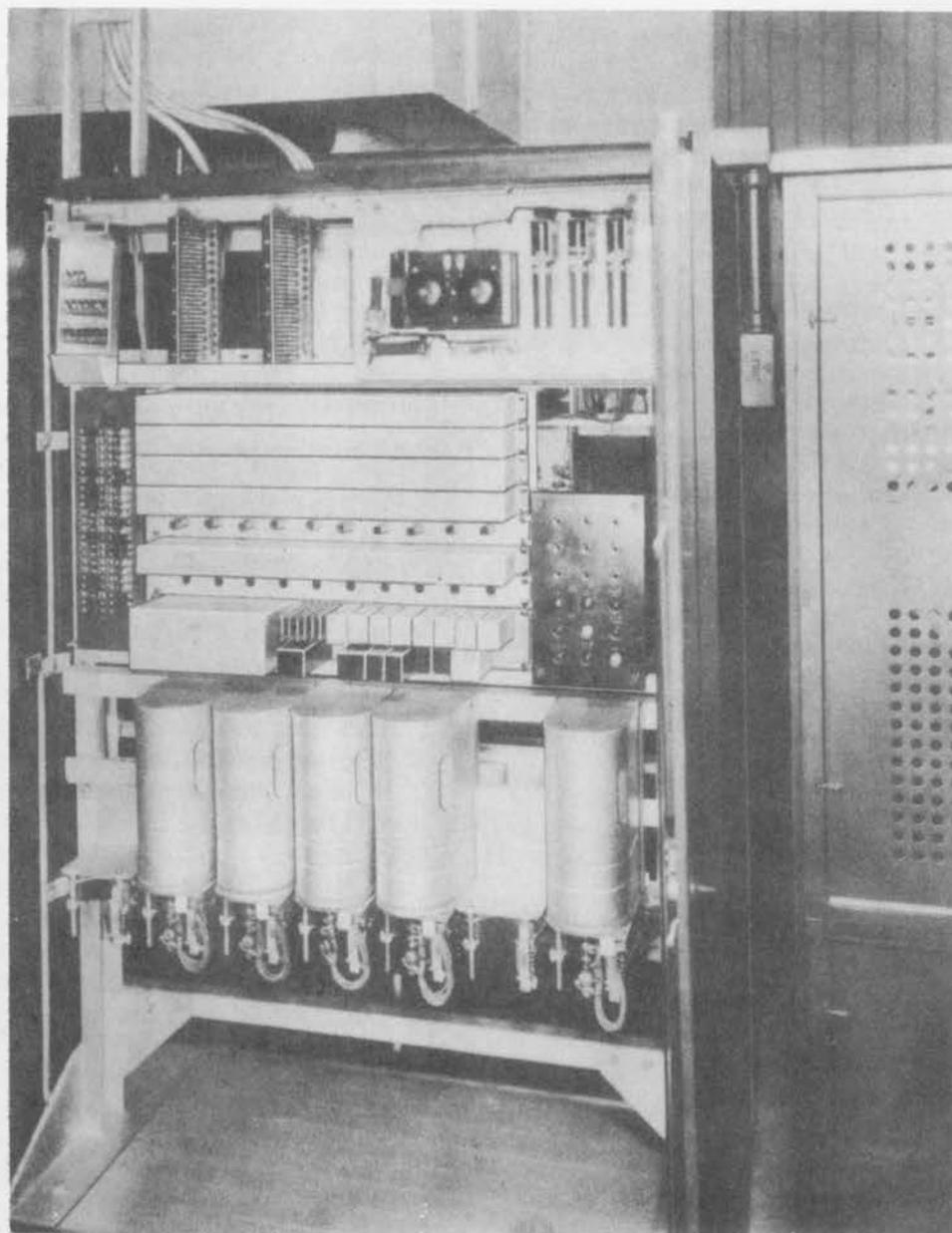


Fig. 20 740C PBX

The battery current for this PBX is supplied by a 102B power plant the details of which have been covered previously. The ringing current may be obtained over cable pairs from a central office or from a small ringing machine located at the PBX.

The 740B PBX is similar to the 740A PBX in type of equipment used, circuit arrangements, type of service handled, but is smaller, serving a maximum of 38 lines.

#### The 740C PBX.

The 740C PBX is a dial private branch exchange designed primarily, for use in a large residence or private estate, where particular attention must be given to the appearance of the equipment. It comprises a frame equipment (Fig. 20), one or two attendant's cabinets and power equipment to serve a capacity of 38 station lines. Provision is made for two attendant's cabinets (Fig. 21) so that incoming calls may be completed from either one or two locations. Incoming calls are all handled at the first cabinet unless its "switchboard service"

key is operated to transfer the control to the second cabinet.



Fig. 21 740C PBX Cabinet

Each station line may connect by dial with any other station line or with a central office trunk (unless the station line is restricted). All incoming calls over trunks from either a manual or a dial central office signal an attendant who must complete the call by dialing the desired station line. The attendant may also complete calls to the central office and originate either local or central office calls.

The line finder switch is used to connect an idle selector-connector switch to a calling station line, a calling trunk or a calling attendant's telephone circuit.

The selector-connector switch is used to connect the calling party to the desired station line, or attendant's telephone circuit or to select a trunk on

the fifth level. Trunk circuits are provided for connection to the central office.

The frame equipment consists of a double-sided frame arranged to mount on one side 43 line circuits, 7 50-point line finder switches, fuse, alarm, test and terminal strip equipment and on the other side, 7 selector-connector switches, 4 trunk circuit units and 1 attendant's telephone circuit unit. A sheet metal casing is furnished when it is desirable to enclose the frame.

The attendant's cabinet consists of highly finished walnut or mahogany shell enclosing a tray which mounts the key, lamp and terminal strip equipment for 1 attendant's telephone circuit, 4 trunk circuits and auxiliary alarm equipment.

The power equipment for the 740C PBX is the same type as used for the 740A and 740B PBXs, previously described.

### 9. The 750A PBX

The 750A PBX is a small dial private branch exchange designed primarily to provide intercommunicating and central office service for residences or smaller businesses requiring 15 station lines or less. Switching is done by means of relays under control of 206 type selectors. Two capacity arrangements are available; one furnishes equipment for 8 lines, 2 link circuits and 2 trunk circuits, which will allow 2 local and 2 central office connections to be established at the same time; the other furnishes equipment for 15 lines, 3 link circuits, and 3 trunk circuits, which will allow 3 local and 3 central office connections to be established at one time. This PBX is arranged to provide intercommunicating service between all stations and central office service to all or only part of the stations. Keys mounted either integral with the handset, or in a separate unit when the station is equipped with a wall or a desk set, (Figs. 22 and 23) are used for making central office connections for those lines that ordinarily require no central office service. Keyless stations are provided from which only local calls can be made. Incoming calls may be answered at any station arranged for central office service.



Fig. 22 750A PBX  
Hand Telephone Set

On incoming calls from the central office a bell rings with a distinctive tone, which is individual to the trunk, or a common bell is provided for all three trunks. In the latter case a trunk indicator is furnished in which lamps are provided to designate the trunk calling. The call is answered by pressing a hold key and dialing the desired party.

On a local call, line relays associated with the calling line connect to one of three link circuits, if one is idle, and a 206 type selector in the link follows the dial pulses of the called number (either one or two digits)

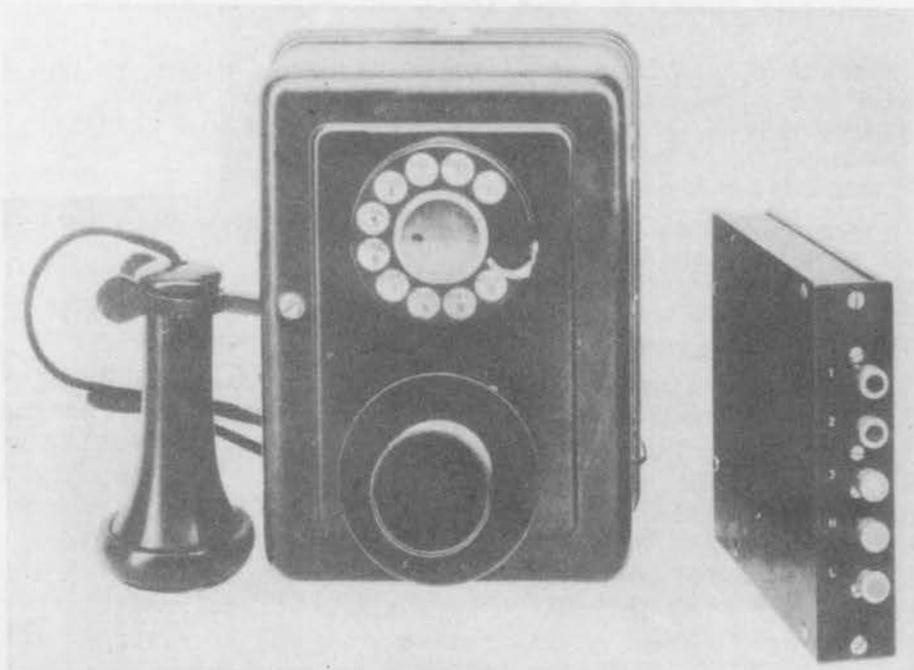


Fig. 23 750A PBX  
Wall Set with Key Box

and operates a connector relay associated with the called line to establish the connection. The station lines numbered 2 to 9 and 02 to 08 inclusive appear on bank terminals 2 to 9 and 12 to 18 respectively.

Stations to be given local service only will be equipped with standard dial telephones. For stations located at some distance from the PBX, two wire circuits will often be preferable and so that all keyless stations need not be cut off from the central office, a control cabinet has been provided to be located at a key station, and incoming or outgoing central office service can be given to any one of 3 keyless stations at one time, by the operation of keys at the control station.

The switching equipment consists of relays and 206 type selectors and these together with the power plant are housed in a metal casing finished in olive green color (Fig. 24). This casing is 5'-0" high, 2'-7" wide and 1'-10" deep. The relay equipment is mounted on a gate so that the PBX can be located against the wall of an apartment closet or similar confined space. All apparatus is readily accessible through a single door on the front of the casing.

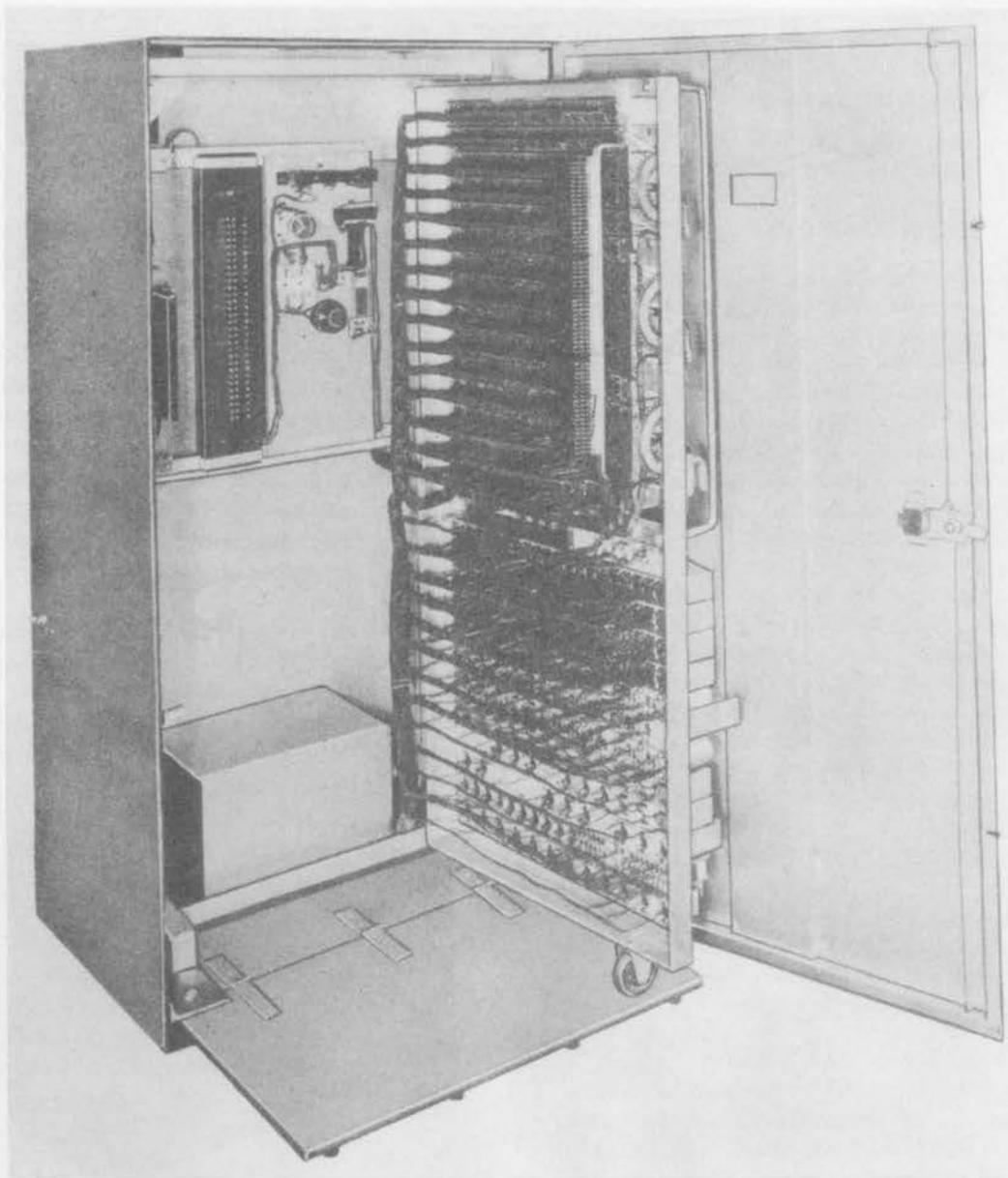
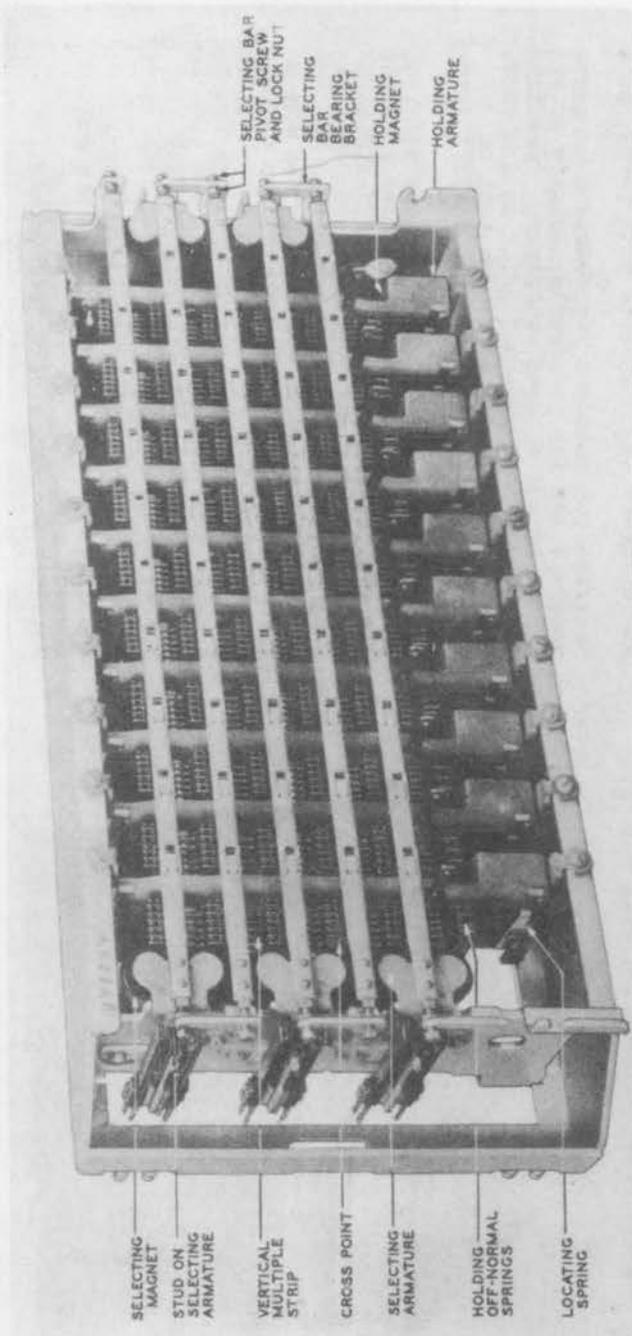


Fig. 24 750A PBX

The equipment is designed for 15 to 21 volt operation so that power can be obtained from a small local battery charged from a central office over cable pairs. The batteries may be charged by a local Rectox charger where conditions make it advisable.

10. The 755A PBX

This PBX, designed to replace the 750A PBX, has a capacity of 20 station lines, 4 central office trunks and 3 link circuits.



front and rear to afford access to apparatus and wiring. The associated power equipment, including the storage batteries, is housed in a separate compartment in the base of the rack. Arrangements are also made so that cross connections between the station lines and the relay equipment

It is a small dial equipment developed to provide secret inter-communication service and outside trunk service without an attendant. Local calls are dialed and central office connections are made by operating keys at the stations. The PBX has a capacity of 20 lines and 4 trunks and has been designed for both residential and business service. Three local intercommunicating paths are provided in addition to the 4 trunk paths so that, in all, seven talking connections may be set up simultaneously.

Fig. 25 Crossbar switch

The crossbar switch (Fig. 25) is used as the switching device which eliminates all rotary moving parts. The associated relays are practically all of the new "U" type (Fig. 26) which employ parallel spring contacts, as does the crossbar switch.

The equipment is arranged on a low floor supported relay rack (Fig. 27) which is enclosed and provided with removable casings

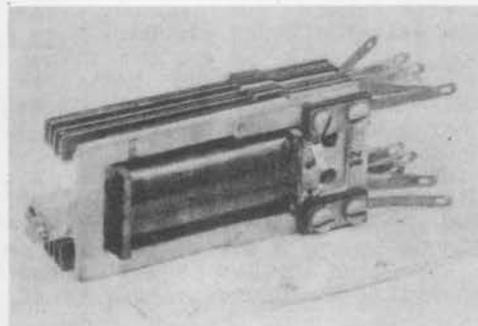


Fig. 26 "U" Type Relay

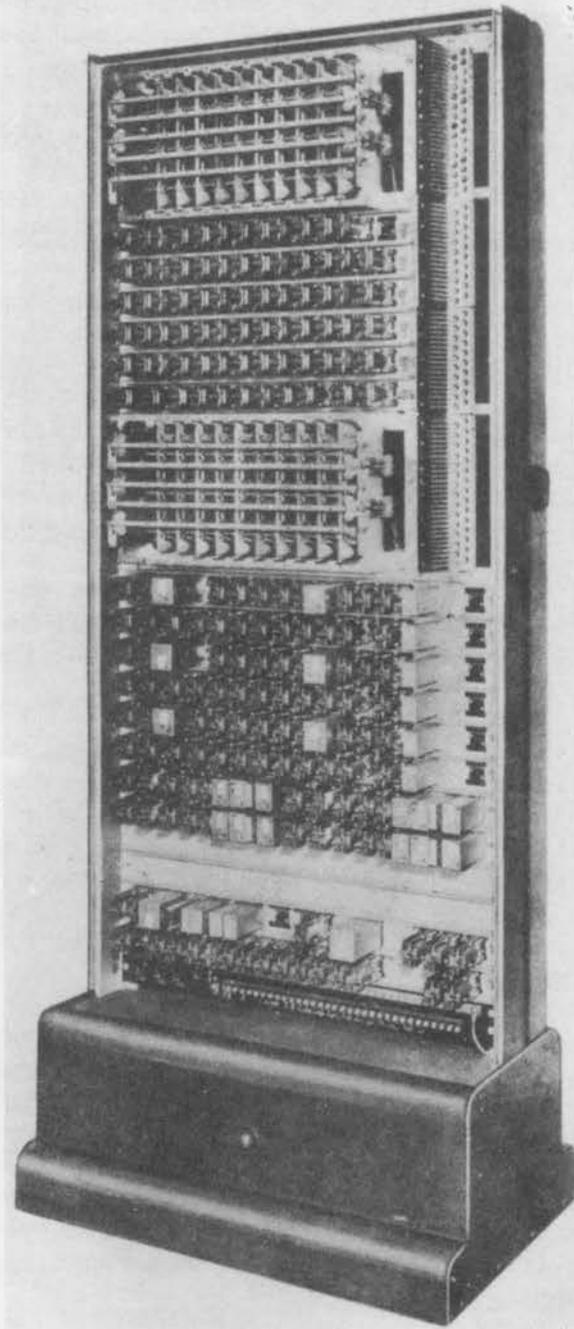


Fig. 27 755A PBX

associated with the line may be made within the PBX. The frame is basically a single sided relay rack arranged to mount 26" mounting plates. In size it is approximately 1' 6" x 2' 4" x 6' 0" high and is provided with a wooden base to afford a means of insulating it from the floor. The lower part of the frame is arranged to house the power plant including the storage batteries and associated charge and discharge apparatus. The fuse panel is located just above the battery compartment. Above this are mounted the relay units associated with the common tone, ringing, alarm and link allotter circuits as well as the trunk and link units. Above this are mounted the two crossbar switches with the line relay units and the associated common control and cut-off unit between them.

On local calls the operation of the dial causes the crossbar switch to connect the calling to the called line through one of the three link circuits. On outgoing central office calls the operation of a trunk key at the station causes the switch to connect the calling line direct to the selected trunk circuit on an incoming trunk call, an audible signal (and a visual signal if desired) indicate which trunk is in use. The call is picked up at any key station by the operation of the corresponding trunk key at that station. If the incoming call is for a person at another station, the trunk may be held while the wanted person is dialed. After answering, the second party is advised as to which trunk the call is on so that he may connect to it by operating the corresponding trunk key at his station.

Stations may or may not be afforded central office service. Those requiring central office service are referred to as key stations and are equipped with 6 keys, either as a part of the station set or in a separate key unit adjacent to it. Four of the keys are associated with the trunks, one is for

holding and the last for local connections. Nine wires are required to connect the key station to the switching equipment.

Stations to be afforded only local service are referred to as keyless stations and are equipped with standard 2-wire dial telephones. For stations located some distance from the switching equipment, the two wire circuits will often be preferable.

Three types of central office service for key stations are available: lock-out, to prevent the station from being connected to a busy trunk; non-lock-out, to afford the station access to the central office trunk even though it may be busy; and restricted, to afford no outgoing trunk service but to permit answering incoming calls and picking up transferred calls.

Conference service is provided so that any three key or keyless stations may be interconnected for conference purposes. This service is also possible on a trunk connection for key stations which are arranged for non-lock-out service.

Key stations may be arranged to pick up local calls directed to another station by means of a key. Line lamps are provided on an optional basis. The line lamp feature combined with the line pick-up feature facilitates the use of the PBX for secretarial service.

Other optional service features include: two line hunting groups, two lines each; trunk lamps; common ringers for trunks, three different group combinations; extension key stations; provision to pick up central office trunks for stations not otherwise associated with the PBX (for example, wiring plan stations); emergency service to central office, and local trouble alarm.

The PBX operates over a voltage range of 18 to 25 volts provided by a small local battery or a building battery.

The local battery consists of 5 small two cell storage units with associated charge and discharge equipment. The batteries, including their rubber trays, are set on a sliding shelf in the separate battery compartment in the base of the frame. The individual local battery may be charged either over cable pairs from the central office or by means of a local Rectox charger. Continuous ringing supply is usually obtained from the central office. Where not available, a local ringing machine may be provided. The dial and busy tones as well as interrupted ringing are furnished by means of interrupting relays in the common timing, tone and ringing circuit.

Generally, no extra apparatus to prevent radio interference is required, but spare mounting plate space has been located between the trunk units and the common tone and ringing units with the idea in mind that in those cases where such apparatus is required in conjunction with these circuits, it may be located in this spare space so that the associated wiring will be short. If radio interference filters should be required on the individual station line pairs, space for this equipment will be provided outside the PBX.

The 755A PBX, by means of the crossbar switch, the associated relays

and the dials and keys at the stations, permits the connection of any station to any other station over one of 3 links and to any one of 4 central office trunks. Each line occupies one vertical unit of a crossbar switch where it is afforded access to all the links and trunks which occupy the horizontals. On each vertical there are 10 sets of relay-like springs with the stationary contacts multiplied vertically and connected to the T, R, etc. of a particular line. Each set of moving contacts is multiplied horizontally through both switches and connects to the T, R, etc. of the trunks and links. In this way any line may be connected to any horizontal by the closure of a particular set of contacts which is called a crosspoint.

A local call is carried on through a double ended link, one end associated with the calling station and the other with the called station so that each link occupies two horizontal levels. Each trunk requires only one level for connecting to any line whether calling or called.

To connect a line to a particular link or trunk all sets of springs on the associated horizontal are momentarily marked by the operation of a selecting magnet. This inserts a finger between the armature and each set of springs on that level. The holding magnet associated with the line vertical is then operated to close that particular line through to the marked link or trunk and the selecting magnet releases. All of the selecting fingers excepting the one associated with the chosen line return to normal with the release of the selecting magnet. This one finger is trapped upon the operation of the holding magnet and is the means of closing the contact springs at the selected crosspoint.

Each key station is provided with 6 keys (Fig. 28): a line key (L), four trunk keys (1), (2), (3), and (4) and a hold key (H) so arranged that the operation of any key furnishes a ground to actuate a particular relay in the switching equipment and thus prepare the circuits for the desired function. The completion of typical calls is illustrated by Figs. 29 and 30.



Fig. 28 Hand Telephone Set with Keys

The progress of a local station to station call is illustrated in Fig. 29, line 36 calling line 32. Calling line depresses (L) key, lifts receiver and, through call allotter chain, in its turn seizes the common control which, through the link allotter, chooses the first idle link (assume link 1). Control causes link to operate the selecting magnets associated with its originating end (level 5) and prepares for any line to be connected to this level. Control causes holding magnet associated with the calling line to operate and connect line 36 to level 5 at crosspoint. Control releases selecting magnets and returns to normal await-

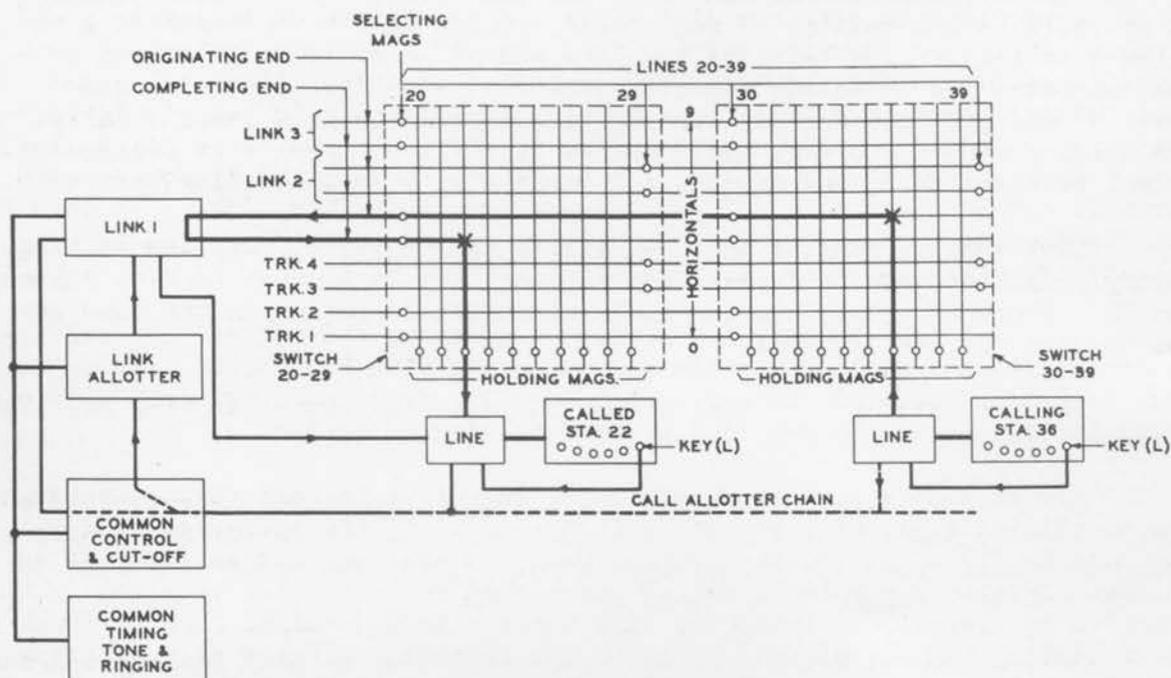


Fig. 29 Block diagram of a Local Call

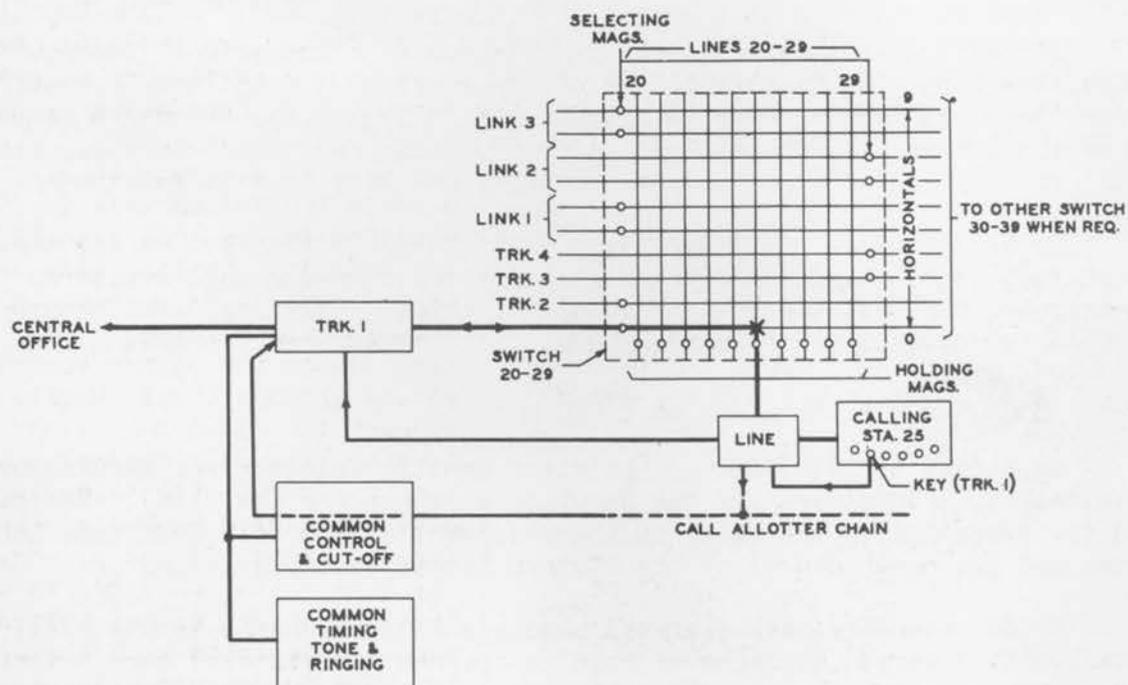


Fig. 30 Block Diagram of Central Office Call

ing next call. Link returns dial tone and dial pulses from calling station set up certain combinations of registering relays in link corresponding to called line (22). Link tests called line and if idle, (through common control) operates the selecting magnets associated with its completing end (level 4) and prepares for any line to be connected to this level. Called line holding magnet operates and connects line 22 to level 4 at crosspoint. Control releases selecting magnets and returns to normal awaiting next call.

Link applies ringing and when called line answers, supplies talking battery. Talking path is direct from calling line 36 through link to called line 22. Where a keyless station is involved the operation is the same except that no (L) key is used.

The progress of a central office call is illustrated in Fig. 30, line 25 connecting to trunk #1.

On an outward call the person at the calling station depresses idle trunk key (assume key 1) and line circuit through call allotter chain causes trunk to operate associated selecting magnets, and prepares for any line to be connected to level 0 (trunk 1) of switch.

Control causes holding magnet associated with calling link to operate and connect line 25 to level 0 at crosspoint. Station is thus connected through crossbar switch and trunk to central office.

Control releases selecting magnets and returns to normal awaiting next call.

If the trunk is busy and calling station is arranged for "lock-out" service, the person at the station receives busy tone. With "non-lock-out" service, he would be connected to a trunk even though busy, and might request that original user disconnect from the trunk. With restricted service, the calling station is denied access to the trunk and busy tone is returned.

On an inward call the operation is identical with above except that a trunk lamp or bell indicates on which trunk the incoming call awaits so that corresponding key may be depressed at station. Stations, even though restricted on outward trunk service, can still answer inward calls.

#### 11. A New Switchboard for the Blind

On August 9, 1935, one of the first Braille switchboards manufactured was installed in Baltimore for the Maryland Workshop for the Blind. The switchboard for operation by the blind is a development of the Bell Telephone Laboratories and was manufactured by the Western Electric Company, Inc.

Blind operators have operated cordless monitor boards in the past, but a totally blind person could never hope to operate the standard cord board. The Braille switchboard proper resembles from outward appearances a standard cord board except for a signal cabinet about 14 inches square and five inches deep, extending out to the left of the regular key shelf. This cabinet is faced with rows of plungers, each the size of a small pencil. The plungers



Fig. 31 A blind PBX operator? Yes; operates the switchboard at the Maryland Workshop for the Blind at Baltimore

project upwards slightly when a call is received or originated and there is one for each line, trunk and cord signal. There is also a different buzzer for each type of signal. With a quick move of her hand over the face plate of the signal cabinet the operator determines on which trunk a call is coming in or which station is originating a call.

You ask how she identifies trunks and stations from the plungers? The engineers have worked it out quite simply. Associated with each plunger and directly above is a Braille character telling her exactly which station or trunk is being used. Similarly, above each switchboard jack is a Braille character embossed in celluloid jack strips and matching the characters designating the plungers.

Miss Lena Necesson, operator at the institution, makes it appear very easy to handle the calls. A buzzer goes off, her left hand moves over the signal cabinet, and at almost the same instant her right hand inserts a plug in a trunk jack and she answers: "Maryland Workshop for the Blind."

John L. Beck, Superintendent of the Workshop, seems well pleased with the installation, although he accepted the equipment solely on factual data presented by the company's representatives. The telephone industry has had little or no experience with the boards in practical operation and therefore, the Company was not in a position to make a recommendation as to performance. It is realized that a blind operator can rarely achieve the speed and accuracy that an operator with sight can accomplish with a cord board.

The marketing of this equipment is another example of the Bell System's interest in the humanitarian uses of the by-products springing from developmental work in the communications field.