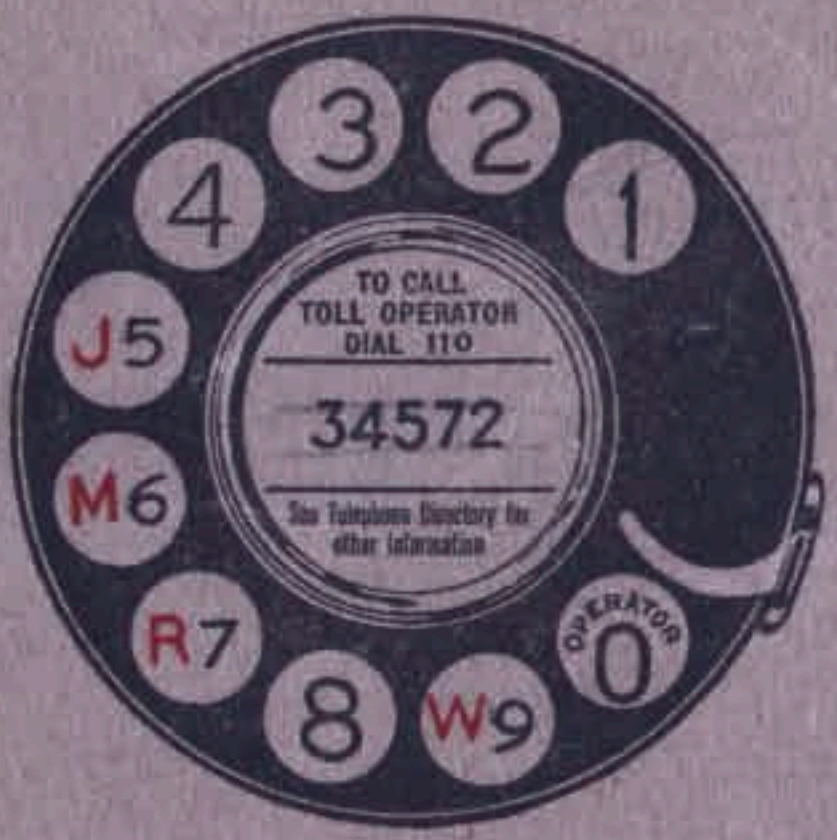
STEP-BY-STEP

Machine Switching Information for Employees



NEW ENGLAND TELEPHONE
AND TELEGRAPH COMPANY

Boston, Mass.
May, 1924

STEP-BY-STEP

Machine Switching Information for Employees

NEW ENGLAND TELEPHONE
AND TELEGRAPH COMPANY

Boston, Mass.

TO ALL EMPLOYEES

Realizing that a large number of employees are taking a lively interest in the Machine Switching Systems which are being installed in our Company's territory, a somewhat detailed description of the Step-by-Step type of equipment has been prepared which is contained in this booklet.

While it was the intent to avoid as far as practical the use of technical terms and descriptions, it was found necessary in a few instances to employ such terms in describing some details. However, it must be considered that there are many employees in the various departments who will be particularly interested in these details. The attention of employees who in their present line of duties come in contact with subscribers' lines, trunk lines, etc., is particularly called to a list of cautions given, clearly indicating the procedure to be followed when working on wires associated with machine switching offices.

The machine switching central office equipment, and associated call indicator equipment used in manual offices, is described in sufficient detail, so that after a careful reading you should be able to discuss intelligently the system in general, as well as answer a majority of the questions which may be asked you by your particular friends or the general public. Questions which you are unable to answer should be referred to your immediate superior, who will provide you with the desired information.

G. H. DRESSER,
General Manager,
New England Telephone and Telegraph Company.

May, 1924.

STEP-BY-STEP

Machine Switching Information for Employees

In order to care for the constant growth in telephone service, it is continually necessary to add to the telephone plant. Additions are made to existing exchanges until their ultimate capacity is reached. Then, new offices, commonly referred to as relieving units, are installed to absorb the growth in the particular area affected. Estimates of anticipated telephone growth for all areas are prepared and plans based on these estimates are laid for new buildings, new switchboards, and extensions to cable and wire plant.

These additions would not ordinarily call for particular attention were it not for the fact that the type of equipment being installed is new and is the result of important advances in the art, which have been made after a long period of study and experimentation.

The new equipment consists of an improved switchboard system whereby the subscribers are able to complete certain classes of calls without the aid of an operator.

As it is not possible to complete mechanically certain classes of calls, such as toll, information, and special district service calls, there will always be required large numbers of toll operators, information operators, and special operators to handle the constantly increasing business, even when machine switching is generally installed.

The term "Machine Switching"

The term "Machine Switching" is applied to telephone systems that utilize mechanical devices to establish telephone connections. That is, functions performed by operators in a manual office are accomplished by electrically controlled mechanical switches in a machine switching office.

Outstanding Machine Switching Systems

The outstanding machine switching systems in use at the present time, which have been installed by the Bell System, are known as the 500 point panel type and the 100 point step-by-step type.

Mechanical Devices Introduced In Manual Systems

The development of mechanical devices in telephone systems has advanced rapidly, and within the last few years machine switching telephone systems have reached a practical and economical stage. During the period of development, several mechanical devices have been introduced into the manual systems, which tended toward the elimination of manual movements in telephone operating, such as, automatic switchhook signalling, audible ringing signal, audible busy signal, machine ringing, etc.

Panel Type System

The panel type system derives its name from the arrangement of the switching equipment which consists in part of banks or "panels" of terminals mounted on frames and exposed to selector brushes which are driven up and down before the banks by power driven friction rolls.

The equipment and operation of this system was outlined in a pamphlet issued in July of 1922, and it may be very briefly described as a remote control power driven system. The desired number is dialed by the subscriber into a unit known as the sender, which in turn controls the selection of the called number throughout the entire system.

Where Used

This type of system will be used in large areas where several offices are necessary to meet the requirements for telephone service.

Step-by-Step Type

The "step-by-step" type system derives its name from the manner in which the switches are moved step-by-step by operating magnets in order to complete a connection.

The selection of the called number has a direct relation to the number of pulses dialed for each digit of a number. That is, for the digit 1, one pulse is transmitted; for the digit 2, two pulses are transmitted etc. The selectors in the office are controlled by these pulses and advance one position for each pulse dialed.

Small electro-magnets known as stepping magnets are used to move the switches in their vertical and rotary steps. This type of system will be employed in single office districts or small multi-office areas.

The description and illustrations given in the following pages relate to the step-by-step type only.

At present it is not practicable to complete certain classes of calls mechanically, for example, toll calls, information calls, intercepted service calls, etc., these classes being handled manually. An adequate amount of manual equipment must therefore be provided in all machine switching offices for toll operators, information operators, special service operators, etc., to care for this service.

How the Machine Switching System Operates

A call from one station to a station in the same or another machine switching office, in the same area, is completed mechanically without aid of an operator. The ringing of the called station is automatic and continues until the called party answers or the calling party hangs up.

Dial Tone

A humming sound known as the dial tone is heard by the calling subscriber when the receiver is removed preparatory to dialing. This tone serves as an indication that the mechanical switches are ready to receive the dial pulses.

Audible Ringing Signal

During the period of ringing the called party, an audible ringing signal which is an intermittent burr, burr sound is given the calling party.

Busy Signal

In case the called line is busy, or all trunks between the different units of apparatus are busy, a busy signal consisting of a rapid buzz, buzz, buzz sound is given until the calling party hangs up.

Called Line Out of Order Disconnected, etc.

If the subscriber dials a vacant number, changed or disconnected number, or if the called line is out of order, he will be connected to an operator who will report the status of the line called.

Reason for Extensive Number Changes

In step-by-step systems designed for an exchange of more than 1000 subscribers, it is necessary to assign four or five digit numbers to all subscribers' stations. This requires extensive number changes in order that all one, two, and three digit subscribers numbers may be eliminated. Furthermore, due to the liability of introducing false pulses into the system when removing the receiver preparatory to dialing, it is considered standard practice to discontinue all four and five digit subscriber's numbers beginning with the figure one.

Party Line Service

Party line subscribers may call other subscribers on the same line by dialing a special number. In order to take care of this feature, each party line subscriber is furnished with a card which lists the other subscribers on his line and the corresponding special number to dial when connection is desired.

Subscribers' Station Equipment

Developments in the telephone art previous to the advent of machine switching have in general been of such a nature that they have not materially changed the methods used by subscribers in making calls. The introduction of this system has, however, necessitated a change in the station equipment and the manner in which calls are originated.

Machine Switching Substations

While the general type of station equipment will be the same as that now used in manual offices, each station in a machine switching office will be provided with a "dial", by means of which subscribers are enabled to control the operation of the mechanical switches.

Description of Dial

In Figure 1, is shown a front, side and rear view of a typical dial, which consists of a number plate, a finger wheel, motor spring, driving gear, governor and impulse wheel mounted on the main shaft. Two sets of springs are mounted on the back of the dial called "pulse" and "off normal" springs. The construction of the dial is such that the number plate does not rotate with the finger wheel, the stationary position of the plate tending to expedite the dialing operation in that the subscriber is enabled to locate the next digit to be dialed, during the return of the finger wheel.

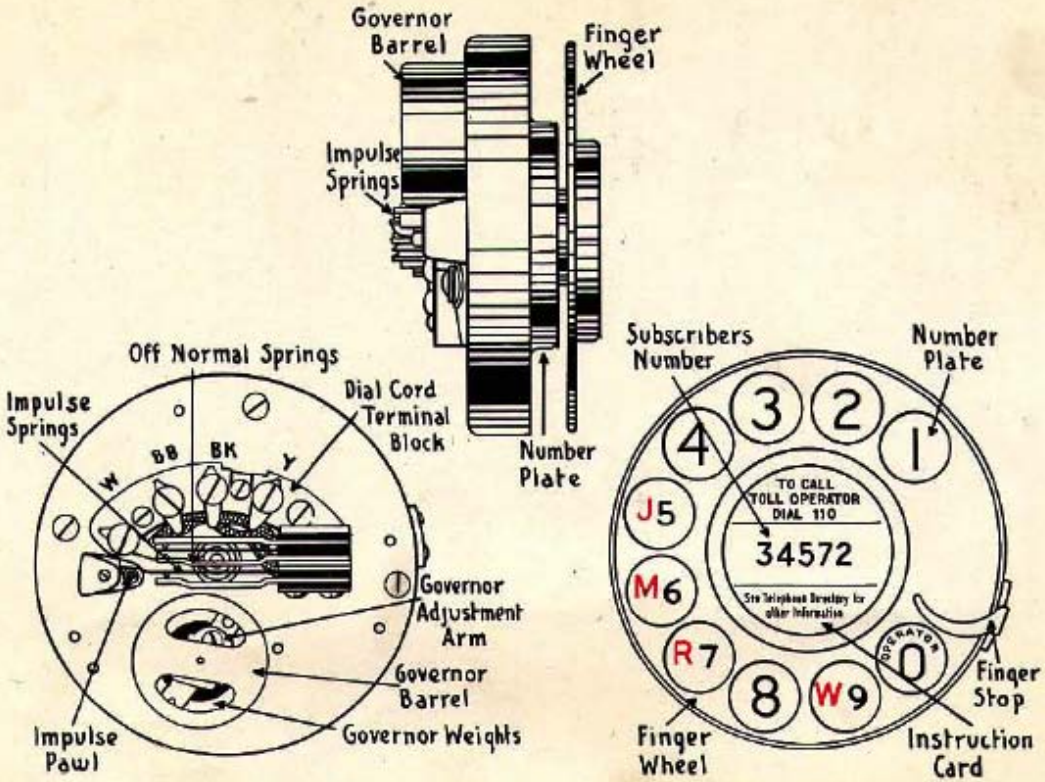


FIG. 1 — REAR, FRONT AND SIDE VIEW OF THE DIAL

The tension of the dial motor spring is such that when dials are used on desk stands, the stand is not turned by the dialing operation, and at the same time the likelihood of overthrowing the finger wheel, so as to obtain a false impulse, is avoided. The tension of the dial spring, together with the adjustment of the governor, causes the finger wheel to return to its normal position rapidly. When dialing a subscriber's number, the actual time of dialing the entire number is a very few seconds, even if the dialed numerals appear under the last finger holes.

Use of figures and letters on the Dial.

Other advantages in the design of the dial are the readily replaceable number plate, the instruction card holder affording a clear space for the instructions and the station number, the terminal arrangement permitting dial replacement without changing the dial cord, and the fact that no oiling of the dial parts at the subscriber's station is necessary. Under the 10 holes in the finger wheel of the dial are the figures 1 to 0. In addition to the figures under holes 5, 6, 7 and 9 are the letters J, M, R and W respectively.

The figures are black and are used for dialing subscribers numbers. The letters are red and are used for dialing office codes and station designations in manual exchanges.

Location of Dial on Desk Telephone.

On desk stands, the dial is mounted near the base at an angle convenient for dialing, as shown in Figure 2. The post on these stands is located near the outer circumference of the base, which reduces the chance of injury to the dial should the stand fall to the floor.

Location of Dial on Wall Telephone

A wall type telephone with the dial mounted above the transmitter is shown in Figure 3.

Functions of the Dial

When the dial is rotated in the process of dialing (the receiver having previously been removed), three functions are performed. First, the transmitter is short circuited, insuring pulses through a constant resistance at the subscriber's station. Second, the receiver circuit is opened, thus preventing noises and

annoying clicks in the receiver when the dial is returning to normal. Third, during the return of the finger wheel to normal, the circuit is interrupted, the number of interruptions corresponding to the digit dialed.

Caution: Do not disturb dial while returning to normal

In order that the digits dialed may be properly recorded on the central office switches, it is necessary that the interruptions or pulses be uniform.

It is obvious that should the switchhook be disturbed while dial pulses are being transmitted, the line circuit would be opened and an incorrect number recorded on the central offices switches.

Therefore, it is imperative that the switchhook should not be disturbed while dialing, and that the dial after being operated should be permitted to return to its normal position without forcing, or retarding it in any way.

It is important that employees, as well as subscribers consult the information section and listings in the telephone directory before making calls from dial stations.

How to Call a Number

To call a number, remove the receiver from the hook. As soon as the central office mechanism is ready to receive the dial pulses, a steady humming sound will be heard. This is called the dial tone. The interval between removing the receiver and the return of the dial tone is short, so that ordinarily the tone will be heard at once upon raising the receiver to the ear. The importance of waiting for the dial tone before starting to dial cannot be too strongly emphasized, inasmuch as dialing before hearing this tone will either place the apparatus in trouble or cause a wrong number to be called.

Method of Dialing

The digits of the number called should then be dialed in the same order as listed; for example, a subscriber dialing 3579 should put his finger in the hole over the digit 3 and move the finger wheel in a clockwise direction to the finger stop and let go, repeating with 5, then 7, then 9.

FIG. 2 — DESK STAND COMPLETE WITH DIAL

FIG. 3 — WALL SET EQUIPPED WITH DIAL

Number Must be dialed without Delay between Digits.

It is important that a number be dialed without appreciable delay between digits; otherwise the central office equipment may not function properly.

Errors in Dialing

If a subscriber discovers that an error has been made in dialing, the receiver should be immediately replaced on the switchhook for a few seconds. This permits the apparatus in the central office to return to normal, after which the call may be dialed again.

Cord Type P.B.X. Switchboards

Private branch exchange switchboards of the cord type are equipped with a dial per position. The dial is mounted on the keyshelf at an angle convenient for dialing. Ordinarily, calls from the stations will be given to the P. B. X. attendant, who will associate the position dial with one of the cord circuits (by operating the listening key), plug into a trunk line jack, and dial the called number. The switchboard is so arranged that when desirable a P. B. X. station may be equipped with a dial so that calls may be dialed direct from the station by requesting the P. B. X. attendant to "plug up" the P. B. X. station to a trunk line.

Cordless P. B. X. Switchboards

P. B. X. boards of the cordless type are arranged to permit similar operating features to those described for cord equipments, except that the attendant's dial is associated with the desk stand that comprises a part of the operator's set.

No. 2 P. B.X. Systems

All telephone sets associated with intercommunicating (P. B. X. No. 2) systems will be provided with regular station dials.

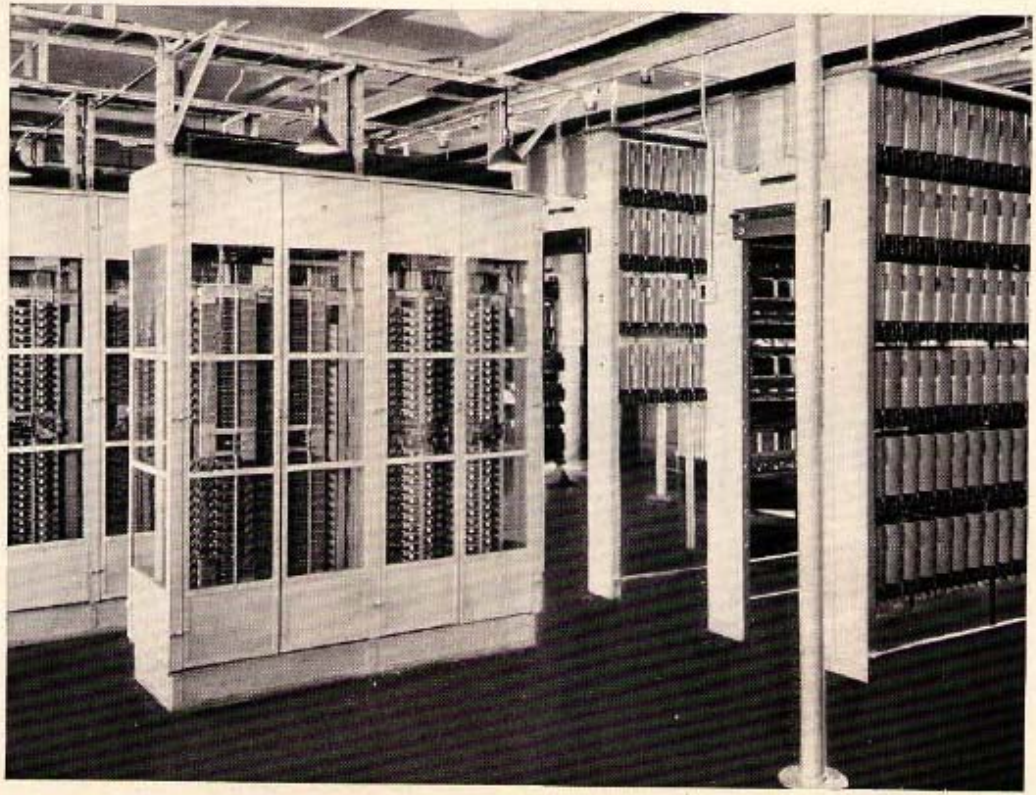


FIG. 4—GENERAL VIEW OF A STEP-BY-STEP MACHINE SWITCHING OFFICE

Machine Switching Central Office Equipment

A general view of a step-by-step machine switching office is shown in Figure 4.

The equipment differs materially from that of a manual office and is made up largely of line switches, selectors, and connectors mounted on frames which are enclosed to protect the apparatus from dust and moisture.

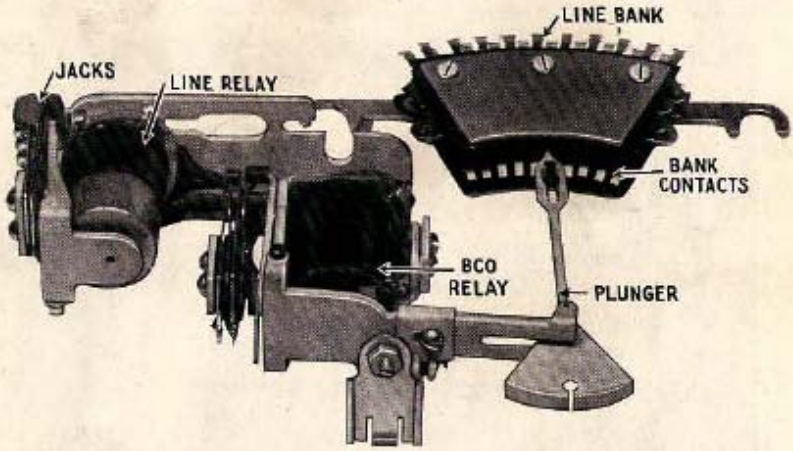


FIG. 5 — VIEW OF PRIMARY LINE SWITCH AND LINE SWITCH BANK

Primary Line Switch

In Figure 5 is shown a primary line switch and associated bank, one of which is provided for each subscribers line. These switches are used as connecting links between subscribers lines and secondary line switches or first selectors.

The principal parts of the primary line switch are the line relay, magnet and plunger. The line relay is operated by the removal of the receiver at the calling subscribers telephone. The plunger magnet which is operated by the line relay forces the plunger into the associated multiple bank; thus the subscribers line is connected to the central office equipment.

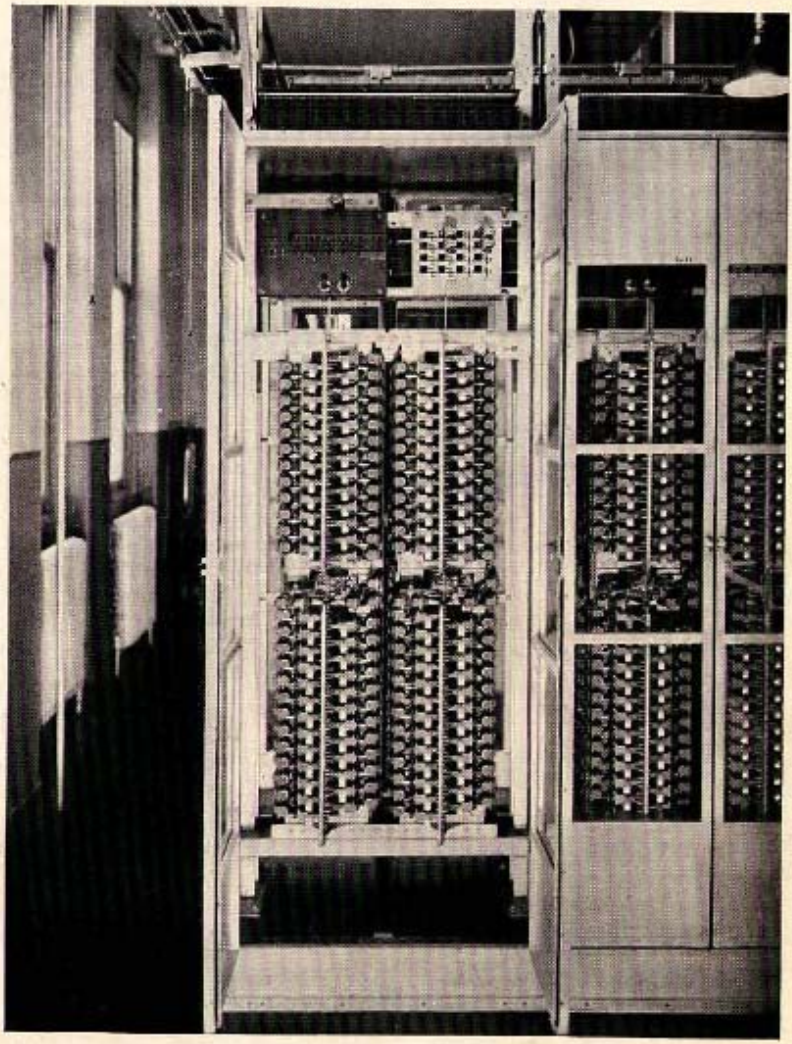
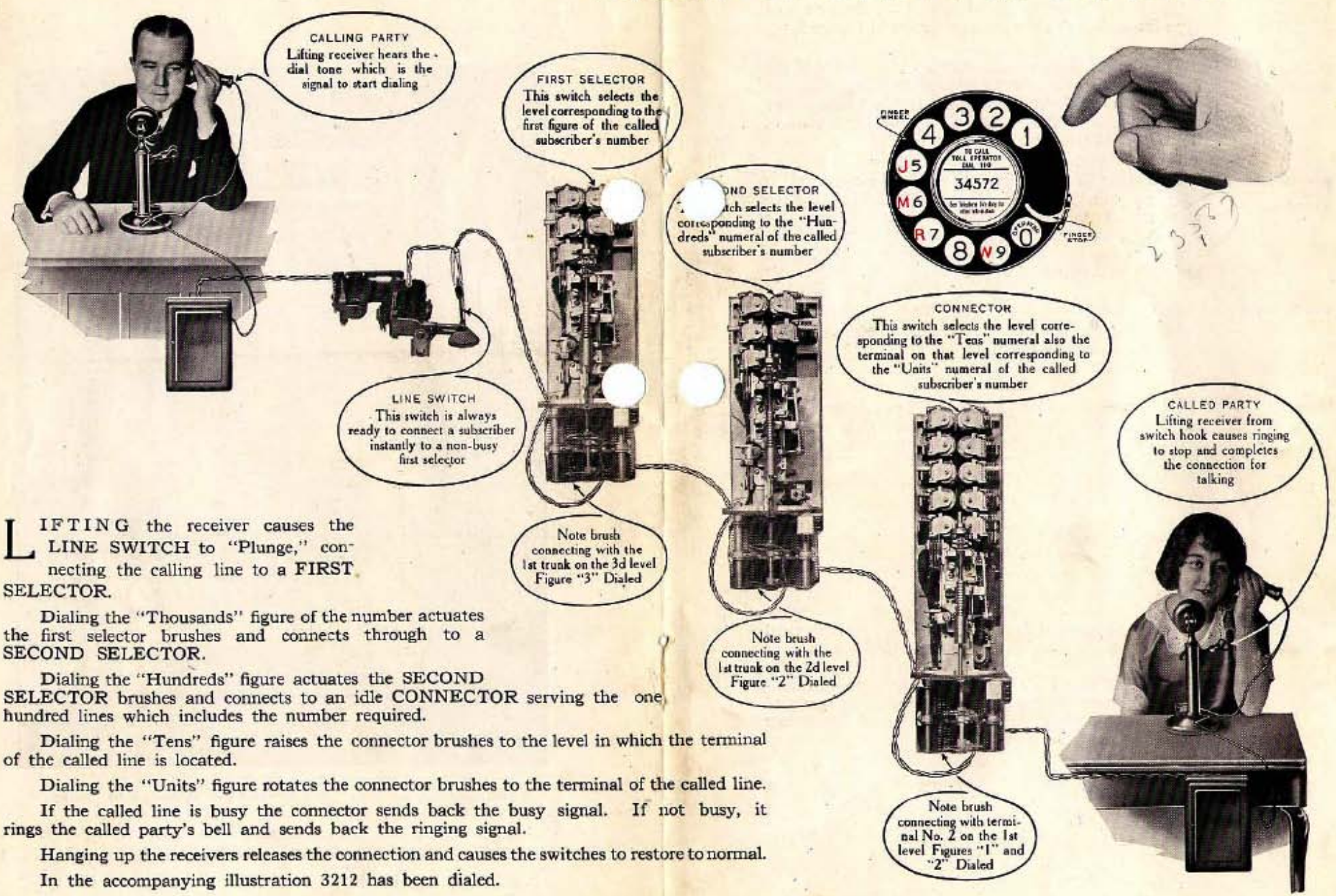


FIG. 6—GENERAL VIEW OF LINE SWITCHES MOUNTED ON FRAME

WHEN A CALL IS DIALED



LIFTING the receiver causes the LINE SWITCH to "Plunge," connecting the calling line to a **FIRST** SELECTOR.

Dialing the "Thousands" figure of the number actuates the first selector brushes and connects through to a SECOND SELECTOR.

Dialing the "Hundreds" figure actuates the SECOND SELECTOR brushes and connects to an idle CONNECTOR serving the one hundred lines which includes the number required.

Dialing the "Tens" figure raises the connector brushes to the level in which the terminal of the called line is located.

Dialing the "Units" figure rotates the connector brushes to the terminal of the called line.

If the called line is busy the connector sends back the busy signal. If not busy, it rings the called party's bell and sends back the ringing signal.

Hanging up the receivers releases the connection and causes the switches to restore to normal.

In the accompanying illustration 3212 has been dialed.

Line Switchboard

The switches are mounted in vertical rows on unit type frameworks in the manner shown in Figure 6.

Master Switch

The plunger of each line switch is under control of the master switch which moves idle line switch plungers to a position directly in front of idle trunks to secondary line switches or first selectors. An enlarged view of the master switch is shown in Figure 7.

Secondary Line Switches

Secondary line switches are similar in construction to primary line switches and are mounted in the same manner. A secondary master switch holds all idle secondary line switch plungers standing in front of idle trunks which extend from the secondary line switch multiple banks to first selectors.

The Selector

The selector is a device controlled directly by dial pulses to select a group of trunks and under the control of a local circuit to select an idle trunk in a group to another selector or connector.

Each selector consists of a number of relays, a vertical shaft, brushes and a multiple bank. The multiple line bank is a unit of 100 sets of terminals arranged in 10 rows or levels of 10 trunks per level. Figure 8 shows a front and side view of a selector and associated multiple bank.

The selector shaft is so controlled by a magnet and pawl that it may in response to dial pulses, be raised vertically one step at a time to any of the 10 different levels of the multiple bank. If there is a break in the series of pulses, such as occurs when the subscriber pulls the dial around for the second digit of the called number, the selector shaft and associated brushes will travel horizontally through the arc of a circle until an idle trunk is found. The brushes then remain stationary until the calling party hangs up. Selectors and associated multiple banks are mounted on selector frames as shown in Figure 9.

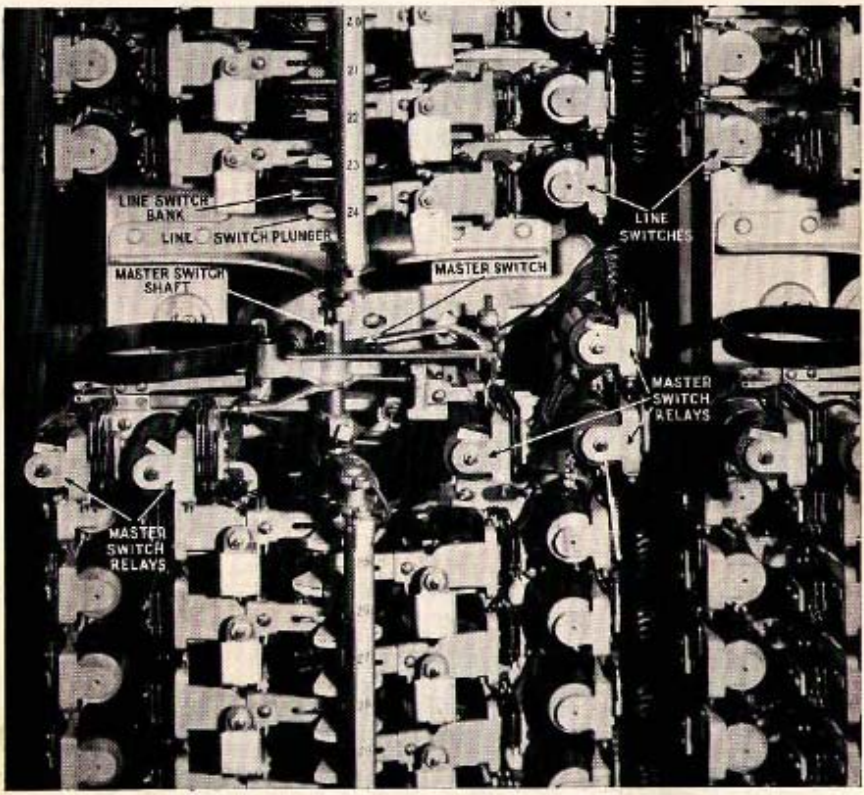


FIG. 7 — ENLARGED VIEW OF LINE SWITCHBOARD SHOWING MASTER SWITCH

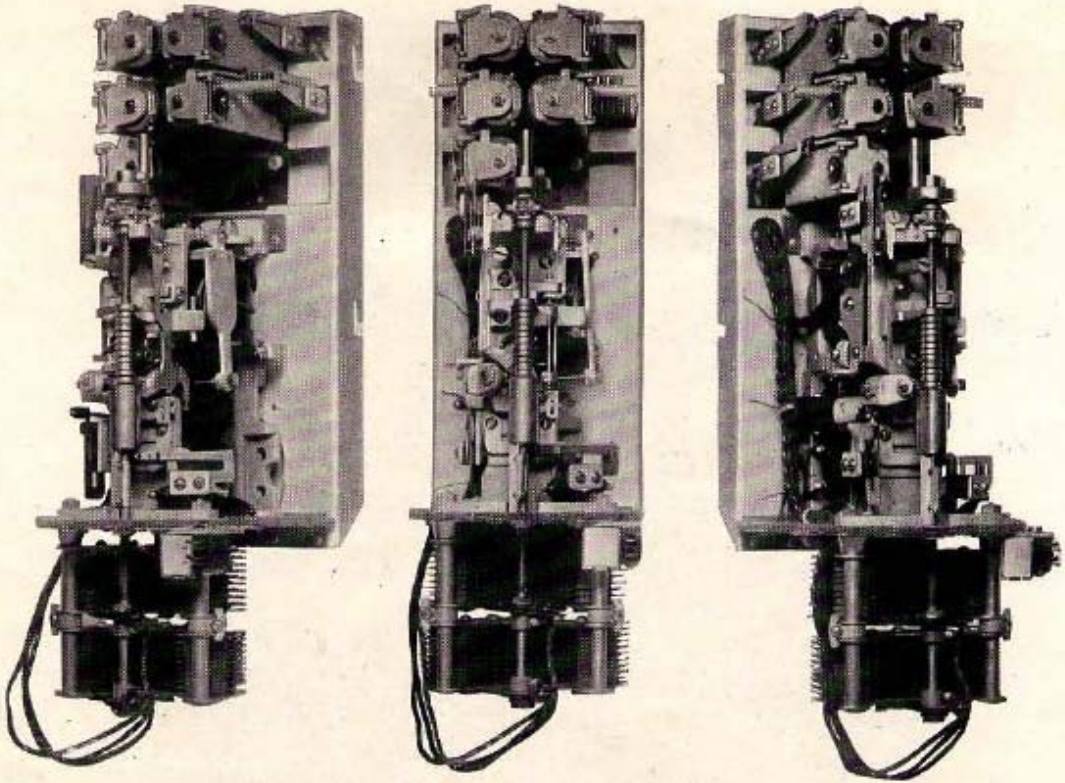


FIG. 8—FRONT VIEWS OF STEP-BY-STEP SELECTOR

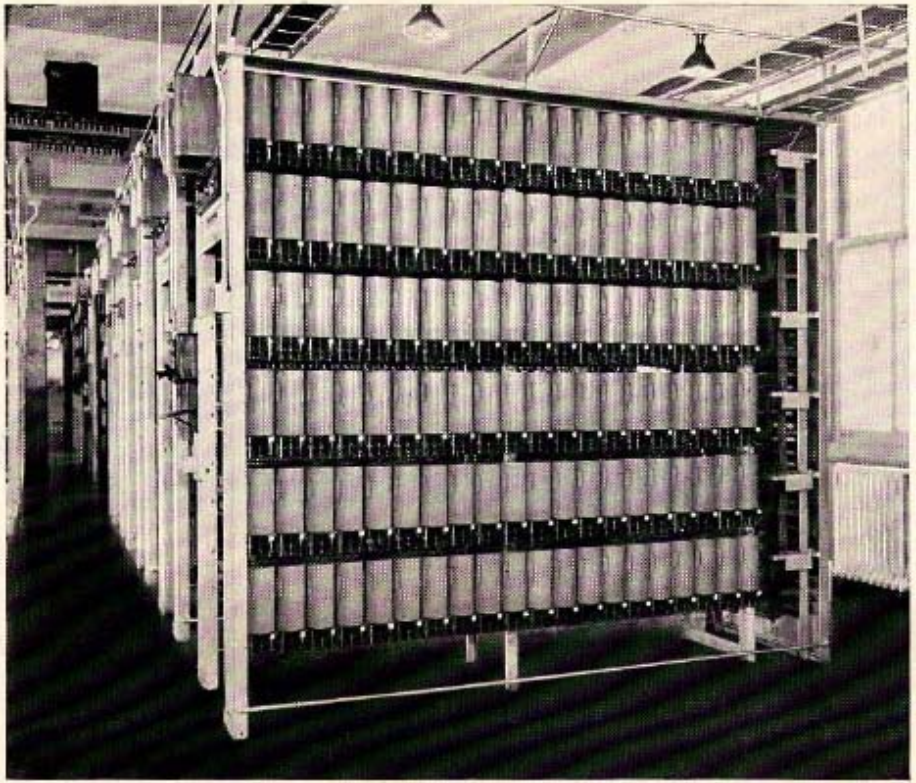


FIG. 9—GENERAL VIEW OF SELECTORS MOUNTED ON FRAME

The Connector

Figure 10 shows two views of a connector which is mechanically similar to the selector but differs from the selector in operation, in that it requires one set of pulses from the dial to operate the shaft and brushes vertically and another set of pulses to move the brushes horizontally to the called line.

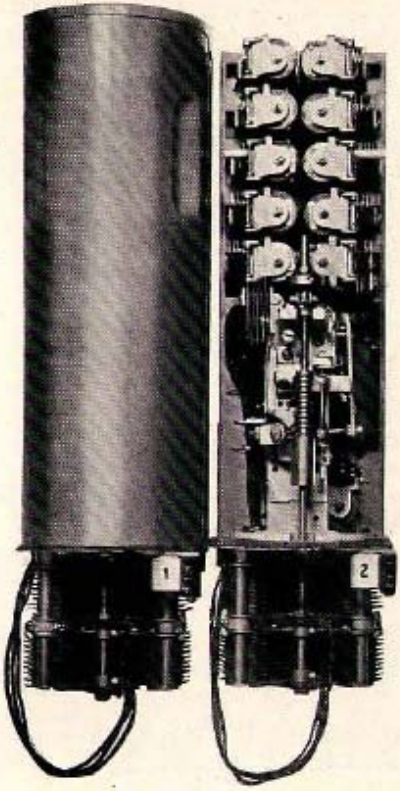


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FIG. 10 — VIEW OF STEP-BY-STEP CONNECTOR

Routing of Calls

Local Calls within the same Machine Switching Office

The transmission of a telephone number from the subscribers station to the switches in a machine switching office is a simple telegraph problem.

In telegraph systems a series of dots and dashes are used to represent figures and letters. In step-by-step machine switching systems dashes only are used, and as previously pointed out, one dash is dialed for each unit in a telephone number. The digit 2 which consists of two units is represented by 2 dashes, the digit 3 by 3 dashes, etc.

The dashes are formed by the operation of the dial when returning to normal. For instance, if the finger is placed in No. 3 hole of the finger wheel, and the wheel is pulled around to the finger stop and then released, three dashes will be transmitted to the central office during the period that the dial is returning to normal. In dialing the No. 3212 the code --- -- - -- would be transmitted.

When the receiver is removed at the calling station, the primary line switch "plunges" and extends the calling line over a preselected trunk to an idle secondary line switch. The secondary line switch plunges instantly and extends the calling line over a preselected trunk to an idle first selector.

As soon as the first selector is connected with the line, the calling subscriber will hear a steady humming sound called the dial tone, which indicates that the apparatus is ready to receive the called number.

The train of switches required to select the number 3212 is shown on pages 16 and 17.

The first digit dialed (3) will cause the first selector to move upward 3 steps to the third level, which the 3000 level.

During the period that the dial is being turned in dialing the second digit (2) of the called number, the first selector will move over the terminals of the third level until a trunk to an idle second selector is found

While the dial is returning to normal for the second digit (2), the two pulses transmitted will cause the second selector to move upward 2 steps to the second level, which is the 200 level.

While the dial is being turned for the third digit of the called number (1), the second selector moves over the second level until a trunk to an idle connector is found.

While the dial is returning to normal for the third digit (1) the one pulse transmitted will cause the connector to move upward to the first level which is the tens level.

The dial pulses for the final digit (2) of the called number will cause the connector to step around twice to the 2nd terminal of the connector bank to which is connected the called line (3212).

The following items show the relation of dialing a telephone number (3212) to the action of switches in the central office:

Action of Subscriber	*Operation of Central Office Switches*
1. Subscriber removes the receiver and listens for the dial tone.	1. Primary and secondary line switches select a first selector which connects dial tone to the calling line.
2. Subscriber dials the digit 3.	2. First selector takes three steps upward and rotates on the third level to an idle trunk to a second selector.
3. Subscriber dials the digit 2.	3. Second selector takes two steps upward and rotates on the second level to an idle trunk to a connector.
4. Subscriber dials the digits 1, 2.	4. Connector takes one step upward and two steps to the right and connects the calling party with the desired line.

The routing of calls between two machine switching offices follow the same procedure as explained above for local calls except that trunks from the first selector levels extend to selectors in the distant office instead of second selectors in the same office.

Interoffice Calls Between Two Machine Switching Units.

Calls Between Machine Switching and Manual Subscribers

As the introduction of machine switching will extend over a considerable period of years, it is necessary to provide some means for the interchange of calls between manual and machine switching subscribers.

Manual to Machine Switching Calls

Subscribers in manual offices calling machine switching stations give the called number to an operator as at present. Dial equipment is provided on certain manual switchboards by means of which the manual office operators are enabled to call machine switching stations over trunks between the two offices and complete the connection in the ordinary manner.

Machine Switching to Manual Calls

In small mixed manual and machine switching districts, subscribers numbers are either prefixed with a figure indicating the office number as 8-4321, or office names are assigned that begin with the letters, W, R, J or M. In large central office areas where office names are retained under machine switching operation it is the the usual practice to use a dial that is arranged with 24 letters in addition to the usual figures 1 to 0.

With a dial of this type the 24 letters used consist of the alphabet with "Q" and "Z" omitted, these letters are omitted for the reason that they are seldom used as initial letters in central office names.

Where the numbering practice is followed the number 8-4321 indicates telephone 4321 in office 8, where letters are used J-4321 indicates telephone 4321 in the James office.

At the manual office it is necessary to provide a mechanical means of indicating to an operator the number called. This is accomplished by equipping certain "B" positions in the manual office with apparatus termed "call indicator."

Call Indicator Equipment

In Figure 11 is shown the call indicator position equipment which consists of a number of indicator lamps mounted on the keyshelf. The lamps are arranged beneath the glass plate shown in the center of the shelf in six groups contained in lamp sockets; the lamp socket mountings are made of hard rubber similar in construction to answering jack lamp strips used in manual switchboards. Resting above the lamp sockets is an opaque glass cover (with a black background) on which the translucent figures and letters are arranged as follows:

0	0	0	0	0	M
1	1 2 3	1 2 3	1 2 3	1 2 3	J
	4 5 6	4 5 6	4 5 6	4 5 6	R
	7 8 9	7 8 9	7 8 9	7 8 9	W

When a lamp is lighted the figure or letter directly above that particular lamp is illuminated.

The group at the left consists of two lamps which are directly beneath the characters "O" and "1" on the glass plate, and is used for indicating the ten thousands digit of the called number.

To the right of this group are four groups of ten lamps; each group of which is used for displaying the thousands, hundreds, tens, and units digits of the called number.

The next group consists of four lamps used for displaying the station designation W, M, R and J on party lines. As only five lamps, corresponding to the five possible digits of the called number can be displayed for each call it is evident that party line numbers in the manual office must be under 10,000.

When the call is for an individual line of less than 10,000 the "0" ten thousands lamp is lighted, and when for an individual line number of 10,000 or greater the "1" ten thousands is lighted.

When the call is for a party line (which must be less than 10,000) neither of the ten thousands lamps is lighted, but one of the station lamps, *i. e.*, W, M, R, or J is lighted.

In Figure 12 is shown diagrammatically the routing of a call originated by a subscriber in a machine switching office for a number in a connecting manual office.

It will be noted that the call proceeds in the same manner as explained in the foregoing for an interoffice call between two machine switching offices, except that at the first selector, a trunk is selected which terminates in a cord and plug at a call indicator position in the manual office. Associated with this cord and plug is a lamp called an "assignment lamp", and a key termed the "display key."

Depressing the display key causes the various relays in the call indicator equipment to operate under control of a mechanical device known as recorder in the manual office and display the number called on the indicator. The operator then completes the connection to the desired line in the multiple before her.

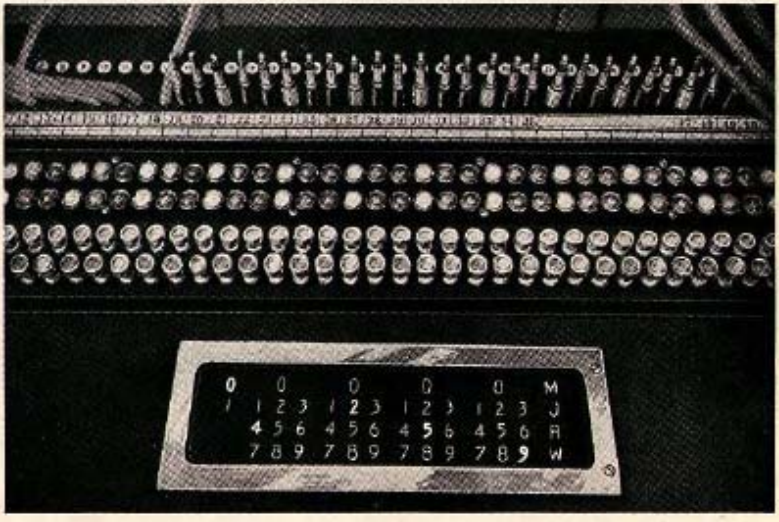
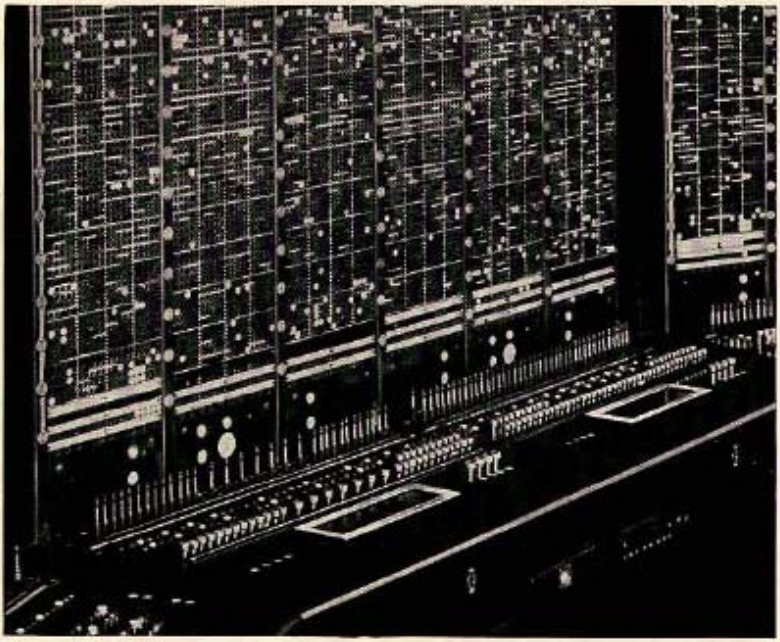


FIG. 11 — CALL INDICATOR POSITION KEYSHELF

If the called line is busy, the operator inserts the trunk plug in a busy back jack, sending back a busy signal to the calling subscriber. Plugging into a line or busy jack, or depressing the display key associated with another trunk on which a call is waiting for display, "wipes out" the number on the call indicator, making it available for the next call.

When more than one call is received at the same time at a call indicator position, the calls are "stored up" and displayed in turn on the indicator as the operator disposes of the preceding calls.



CALL INDICATOR POSITION IN MANUAL OFFICE

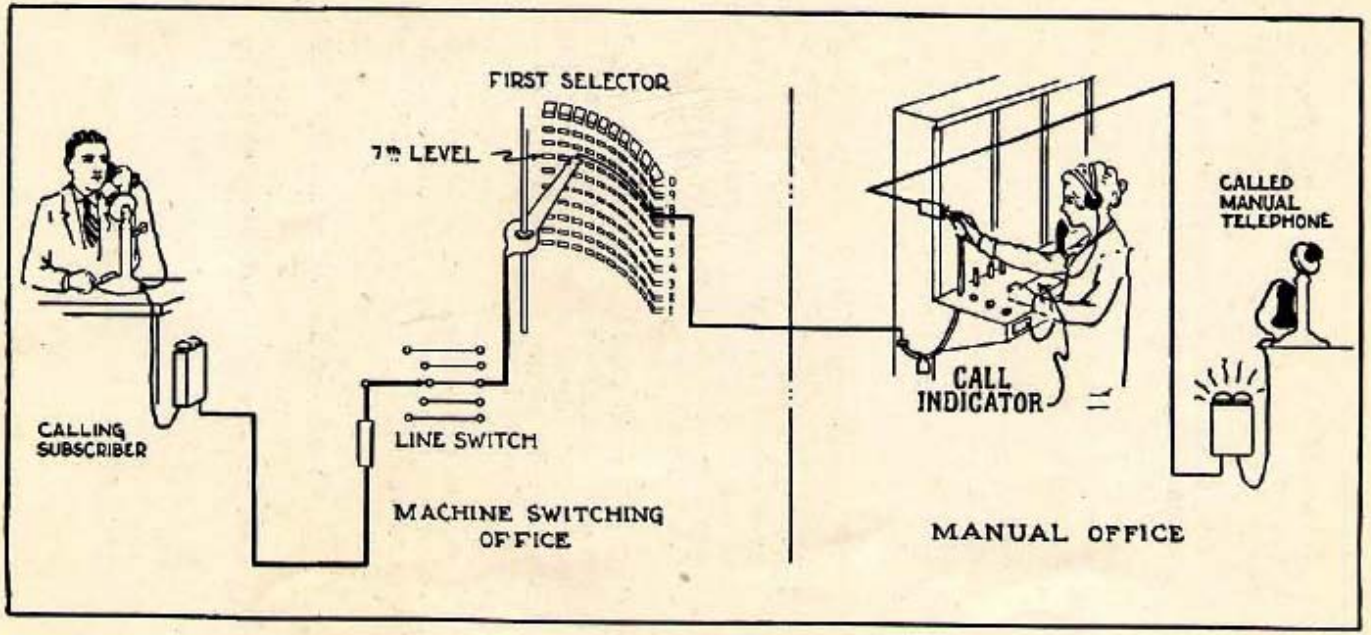


FIG. 12—ROUTING OF CALL FROM MACHINE SWITCHING TO MANUAL CENTRAL OFFICE

Machine Switching "A" Board

As mentioned in the foregoing, it is not practicable to complete all classes of calls mechanically. Special manual "A" positions will therefore be provided in machine switching offices to care for calls to points outside the local service area, which are ticketed and on which a toll charge is made.

Calls of this nature are handled on the AB, and two-number toll basis, which may be illustrated by the following examples:

A subscriber in the "A" machine switching office having unlimited suburban service will be required to pay a toll charge on calls to office "B". In order that tickets may be made on such calls it will be necessary to route them via operators.

AB Toll Call

The subscriber upon dialing the "AB" code will be automatically connected with an operator at the special "A" board, to whom he will give the called number as well as that of the telephone from which he is calling. The operator, after testing to make sure the calling number has been correctly given, will make a ticket and complete the connection.

Calls for Stations which Have Been Removed

Certain positions of the special "A" switchboard are arranged for intercepting calls to stations which have been removed, numbers which have been changed, or the incoming service to which it is desired for any other reason to intercept.

Assistance Calls

Calls on which subscribers, for any reason, desire the assistance of an operator are also handled at this switchboard.

Provisions for Testing and Maintaining

Testing

Owing to the many channels through which calls may be routed and the careful adjustments required in a machine switching office, the preliminary testing previous to an office being cut into service, requires considerably more time than is ordinarily demanded for a manual office of the same size.

Maintenance

The general plans for maintaining machine switching equipment do not differ in kind from those used for manual equipment.

Testing devices have been developed and arranged so that each circuit or unit of equipment may be tested under conditions somewhat more severe than those met with in actual service.

In addition to this equipment, test desks, apparatus and relay adjusting test sets, and a vast number of tools and gauges are required for the proper maintenance of machine switching equipment.

Cautions to Employees
Who Have Occasion to Perform Work on Outside Wires or Central Office Wiring

As grounds, opens, and crosses, even momentary, on conductors connected with machine switching central offices seriously interfere with the sending and receiving of pulses, the following cautions must be observed.

Sub-station Men

Care must be exercised not to open or cross a line, or to ground it at any point either directly with a ground source or through a test set, unless absolutely necessary for a test or directed to do so by a testman.

Linemen

Care must be exercised not to open, cross or ground at any point subscribers' lines or trunk circuits, either incoming or outgoing, connected with a machine switching central office, except for testing or as directed by a testman or wire chief.

If there is a possibility of grounding, opening, or crossing of wires in the course of your work, notify the testman so that arrangements may be made to cause as little interference with service as possible.