CHAPTER 138

The Automatic Telephone

The term automatic telephone means *a telephone system fitted with automatic electric devices such that the user, by means of a* ***numerical dial*** *attached to the instrument can:* **1,** *establish a connection in a large public exchange*, in from three to five seconds; **2,** *be sure that he gets the number he dialed;* **3,** *receive a positive signal, if the line be busy*, and **4,** *break the connection when he desires*—all without the aid of an operator in the central station.

Clearly then the automatic telephone does away with the large force of central station operators, and as the connection is made electrically, instead of by a second person, mistakes are largely avoided, and connections more quickly made. Accordingly, from the standpoint of the user, the appeal of the automatic telephone is due to its speed, accuracy, directness, impersonality and secrecy.

The transmitter, receiver, ringer, and hook switch for an automatic telephone may be of any standard type. The only part of the instrument that is peculiar to the automatic system is the calling device or *dial*. At the central office, the machines which make the connections between subscribers' lines are divided into the following classes:

1. Line switches;
2. Selector switches;
3. Connector switches.

According to the size of the installations the automatic telephone system may be classed as:

1. Single office exchange;
2. Multi-office exchange;
3. Private automatic exchange (P.A.X.).

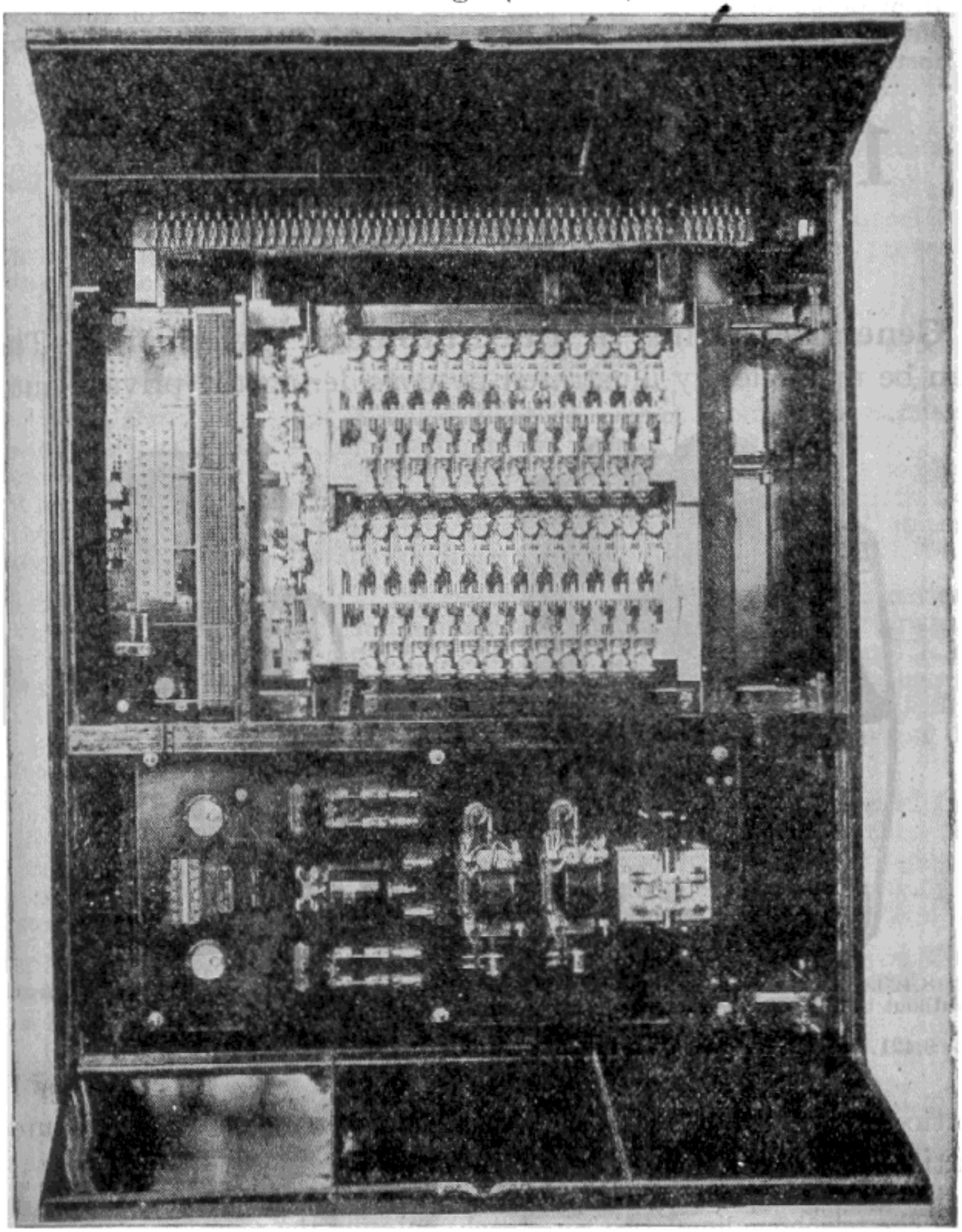


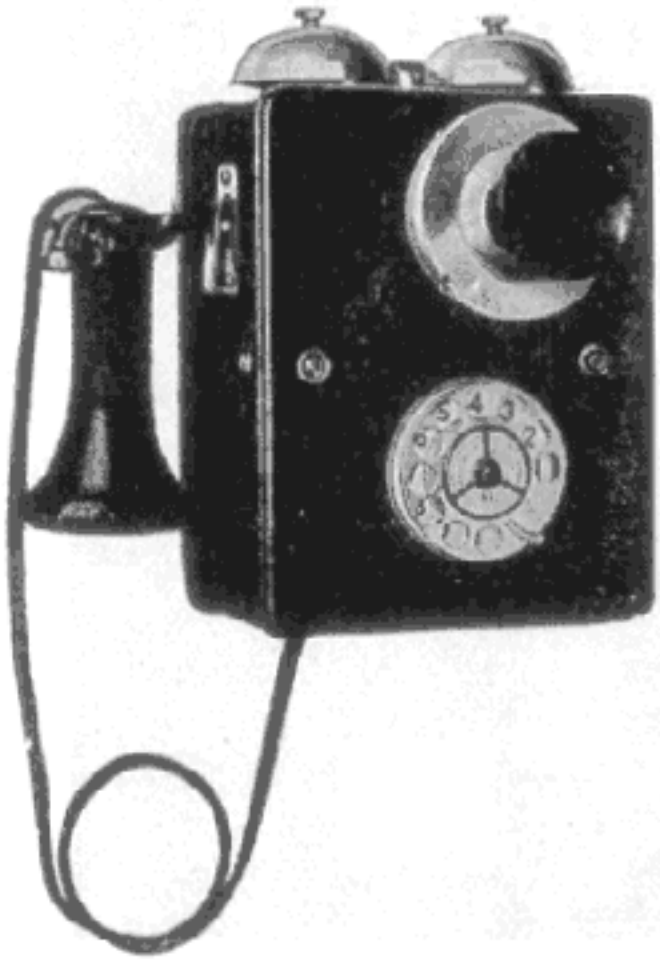
FIG. 8,419—A 50 line private automatic exchange (P.A.X.) equipped for 25 telephones.

The second system is simply a collection of groups of subscribers, each group having its central station and arranged for inter-communication between the several groups.

The private automatic exchange (P. A. X.) is something entirely apart from public exchange operation, being, in fact, a system of automatic electric services designed for private ownership by business or industrial institutions.

1. SINGLE OFFICE EXCHANGE

General Working of the Automatic Telephone.—This can be most clearly illustrated by considering the private auto-



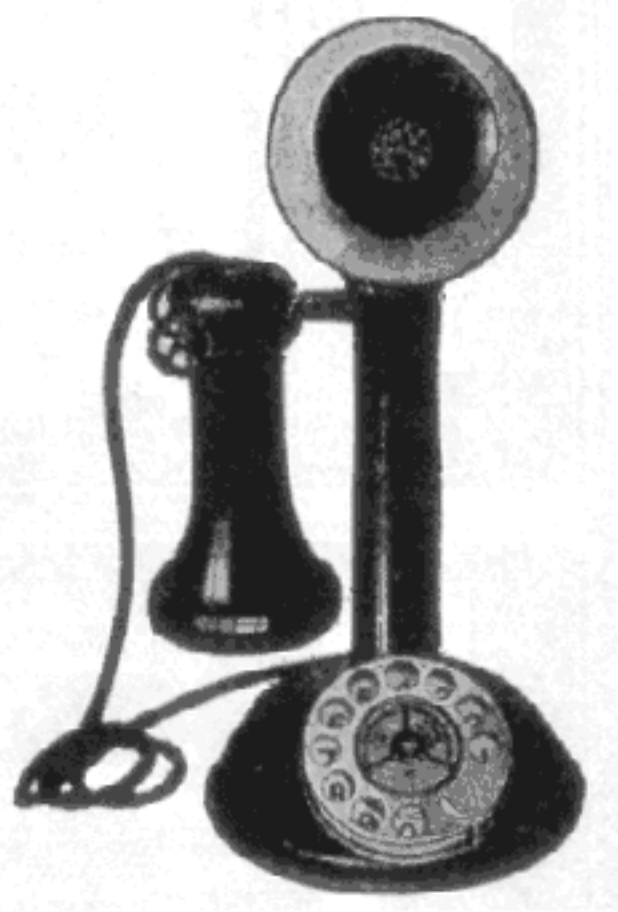


FIG. 8,420.—Automatic telephone wall type showing *dial* by which the subscriber makes calls without the aid of a central office operator.

FIG. 8,421.—Automatic telephone, desk type.

matic exchange system. The exchange consists of the automatic switch board, current supply, terminals, etc.

The telephone lines (two wires each) entering the room, pass through a

main distributing frame and thence to line switches. The line switch is a device for enabling a large number of telephones to use a smaller number of automatic switches, based upon the well-known fact that only a small percentage of the telephones are in use at any one time. Thus fifty subscribers' lines require only seven switches, because no more than seven connections are needed at any one time.

From the line switches wires run to the connector switches, whose function it is to make the connections.

The current is supplied to the automatic switches by a 24-cell lead storage battery, with a controlled pressure of from 46 to 49 volts.

When a user takes the receiver from the hook, the line switch associated with his line extends the latter to an idle connector switch and prevents anyone else using the same switch.

While the first figure of the call number is being dialed, a magnet in the connector lifts the shaft and wiper springs with a step by step ratchet action to a certain row of contacts.

When the second digit is dialed, another magnet rotates the shaft and wiper springs until the latter rest on the pair of contacts to wnich the desired line is attached. The connector switch then tests the line to see if it be busy. If the line be busy, the connector prevents the completion of the connection and sends a distinctive tone to the calling station, so that the calling person knows the conditions.

The busy tone is created by the rapid interruption of direct current through the primary of an induction coil. Mounted on the converter shaft is a commutator with many segments. The 48-volt battery current is led through this in series with the primary of the induction coil and a pair of interrupter springs. The latter makes the tone come and go periodically, causing it to be recognized clearly as a "busy tone." The secondary of the induction coil is led to the connector switches.

If the line be not busy, the connector switch protects the called line from being seized by anyone else, clears it of attachments and rings the bell of the desired station. The calling person can hear that the ringing is actually taking place. When the desired station answers, the ringing is stopped, and conversation proceeds as in any common battery system.

When the conversation is completed and the receivers are hung on their hooks, the connector switch and the line switch both restore to normal, and are at once ready for another oall.

Essential Elements of the Automatic Telephone.—The various devices comprising the automatic system by which telephone connections are made without the aid of an operator at central office are

1. Subscriber's dial;
2. Line switch;
3. Connector switch.

The relay group is considered a part of the connector.

Subscriber's Dial.—The function of this device is *to alter the electrical condition of the line in such a way as to cause the apparatus at the central office to complete the desired connection.*

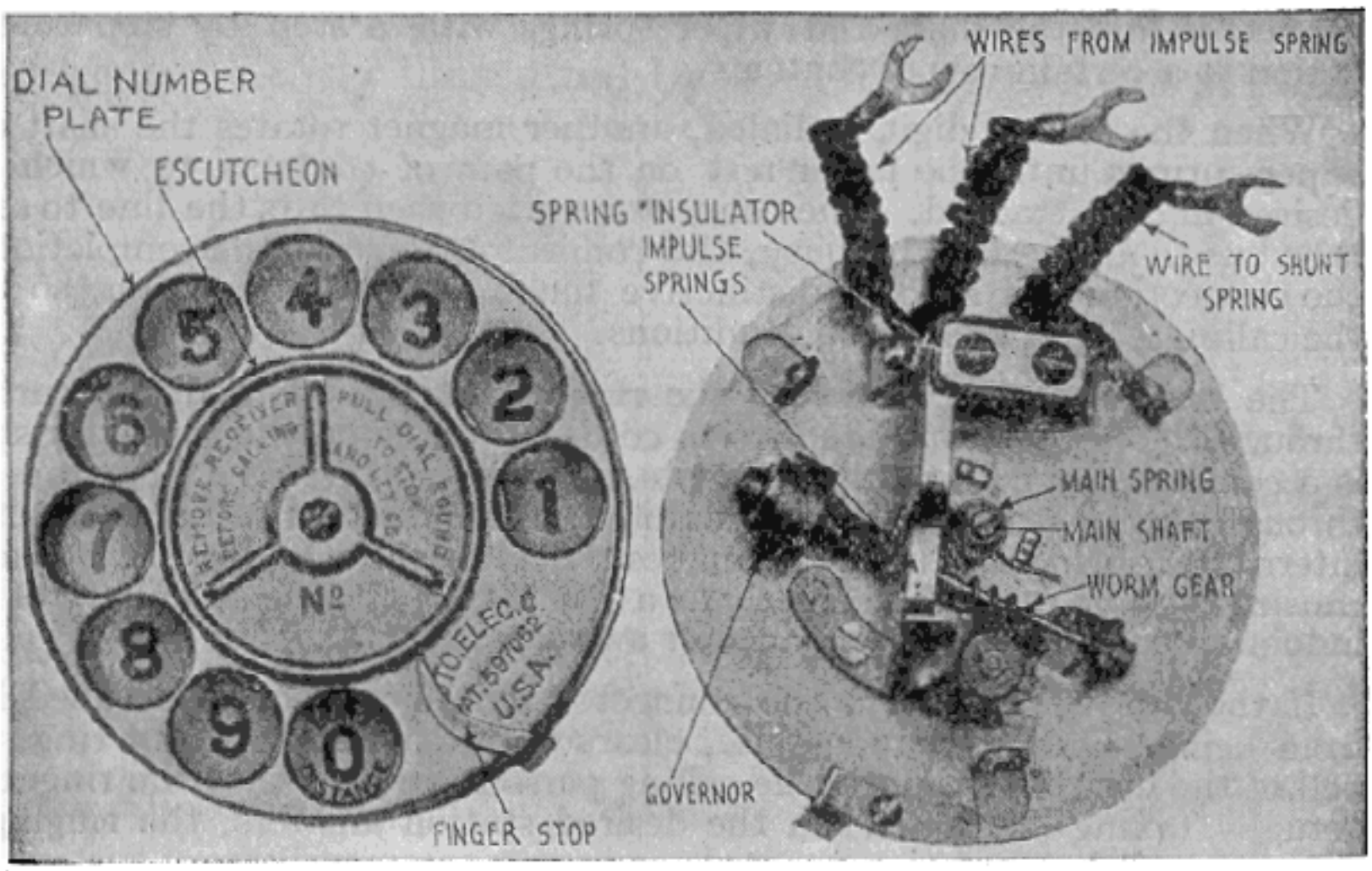


FIG. 8,422.—Subscriber's dial, front view showing holes in disc, numeral sand finger stops.

FIG. 8,423.—Subscriber's dial, rear view showing mechanism.

It consists of a dial pivoted at the center and arranged so that it may be turned in a clockwise direction.

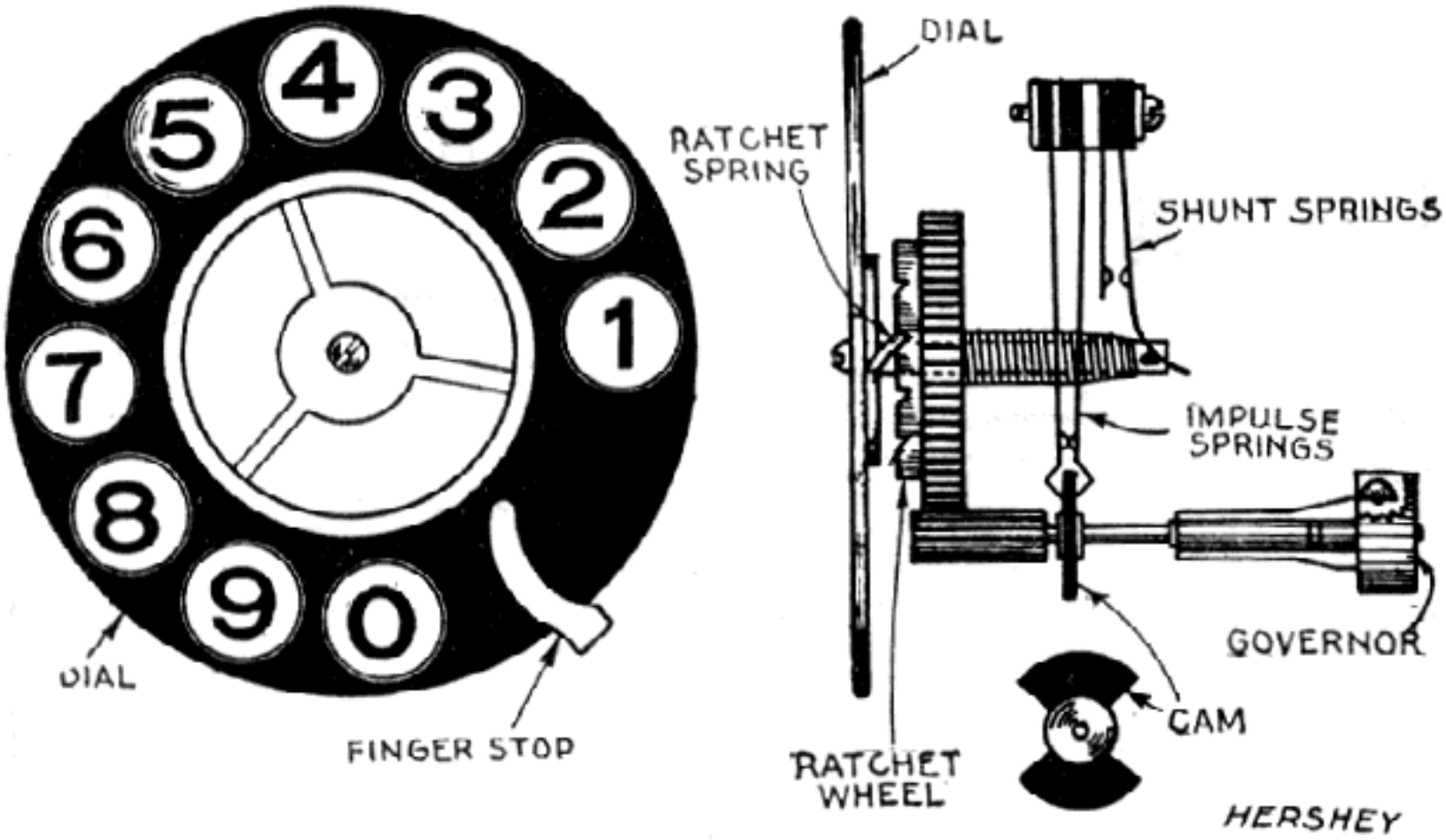
As shown in fig. 8,422 it is perforated with ten finger holes, through which appear the numbers 1,2,3,4,5,6,7,8,9,0.

To call the number, say 53, the subscriber places the tip of his finger in the hole through which 5 appears and turns the dial to the right until his

finger strikes the stop; he then removes his finger whereupon a spring causes the dial to return to its normal position. Similarly the second number, 3, is "dialed," thus completing the manual operations of calling the number 53.

The mechanism of the dial is such that each time the dial is moved, as just described, an electric circuit is opened a number of times corresponding to the number dialed. Thus when the number 5 is dialed the circuit is opened 5 times. This mechanism is shown in figs. 8,424 and 8,425, and in diagram in fig. 8,426.

Subscriber's Circuit.—Included in this is the receiver, transmitter, shunt and impulse springs of the dial mechanism, line and release relays, as shown in fig. 8,426.



FIGS. 8,424 and 8,425.—Front and sectional side view of subscriber's dial, showing mechanism and end view of cam. ***In operation,*** as the dial is rotated by the finger clockwise, a coiled spring is wound, which, after removing the finger on reading the *stop* causes the dial to return to its initial position. This is a ratchet which transmits the return movement to gears and a governor. The gears are in mesh with a pinion on which is a cam which is so geared that when say No. 1 is "dialed," the cam will make one half revolution, opening the impulse spring once. Similarly the impulse spring will be opened a number of times corresponding to the number dialed.

When the subscriber dials a number, *the circuit will be opened a number of times corresponding to the number called* and this is the principle upon which the apparatus at the central station depends to make the connection.

When the dial is moved from the initial position, the shunt springs close contact, maintaining a shunt around the transmitter and receiver until such time as the dial returns to its initial position. This prevents variation of resistace in the subscriber's loop and irregular operation of the central office mechanism.

Connector Switch.—At the central station *the impulses* sent from the subscriber's station by the dial mechanism *act upon a connector switch which makes the connection*

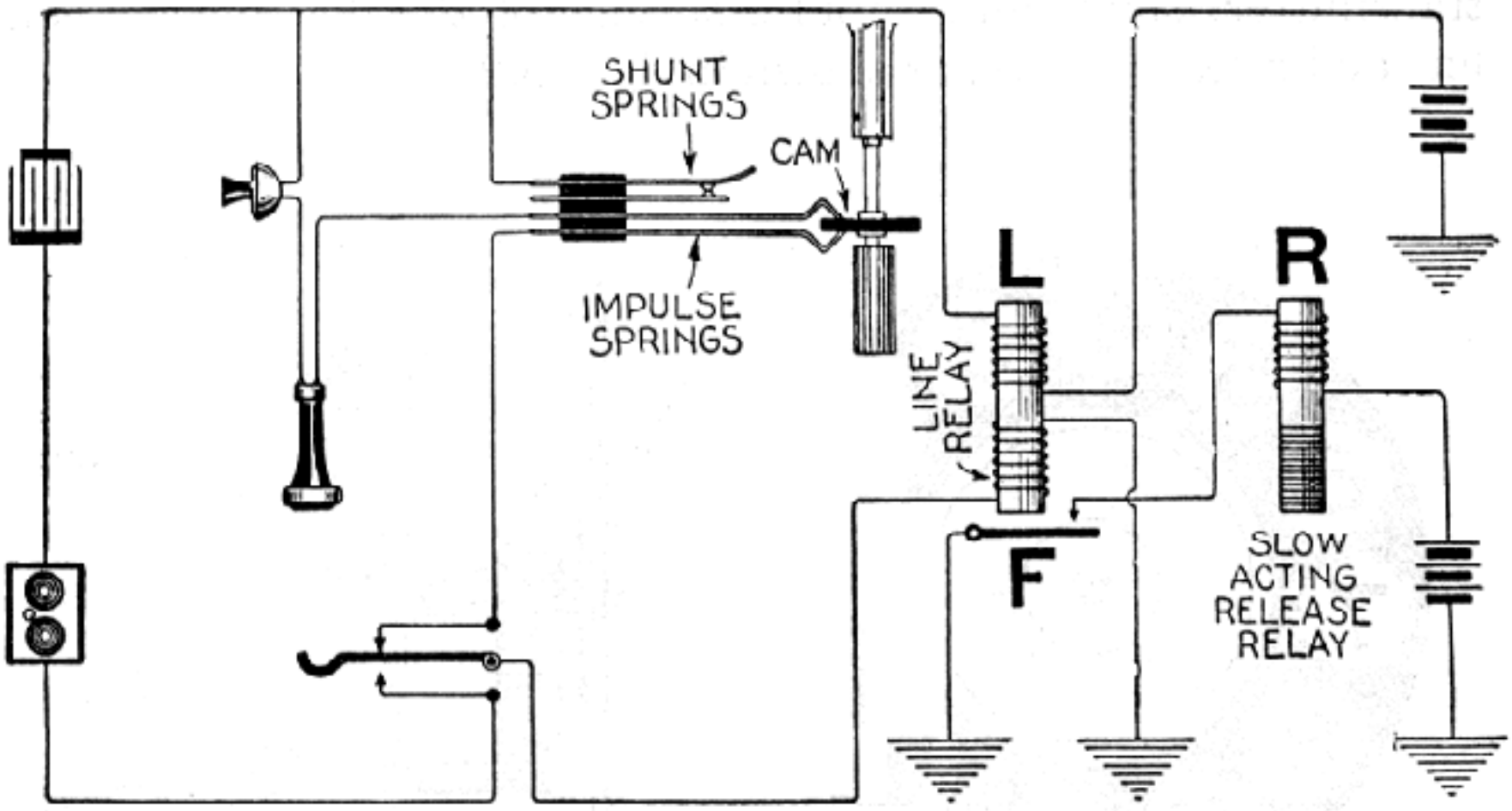
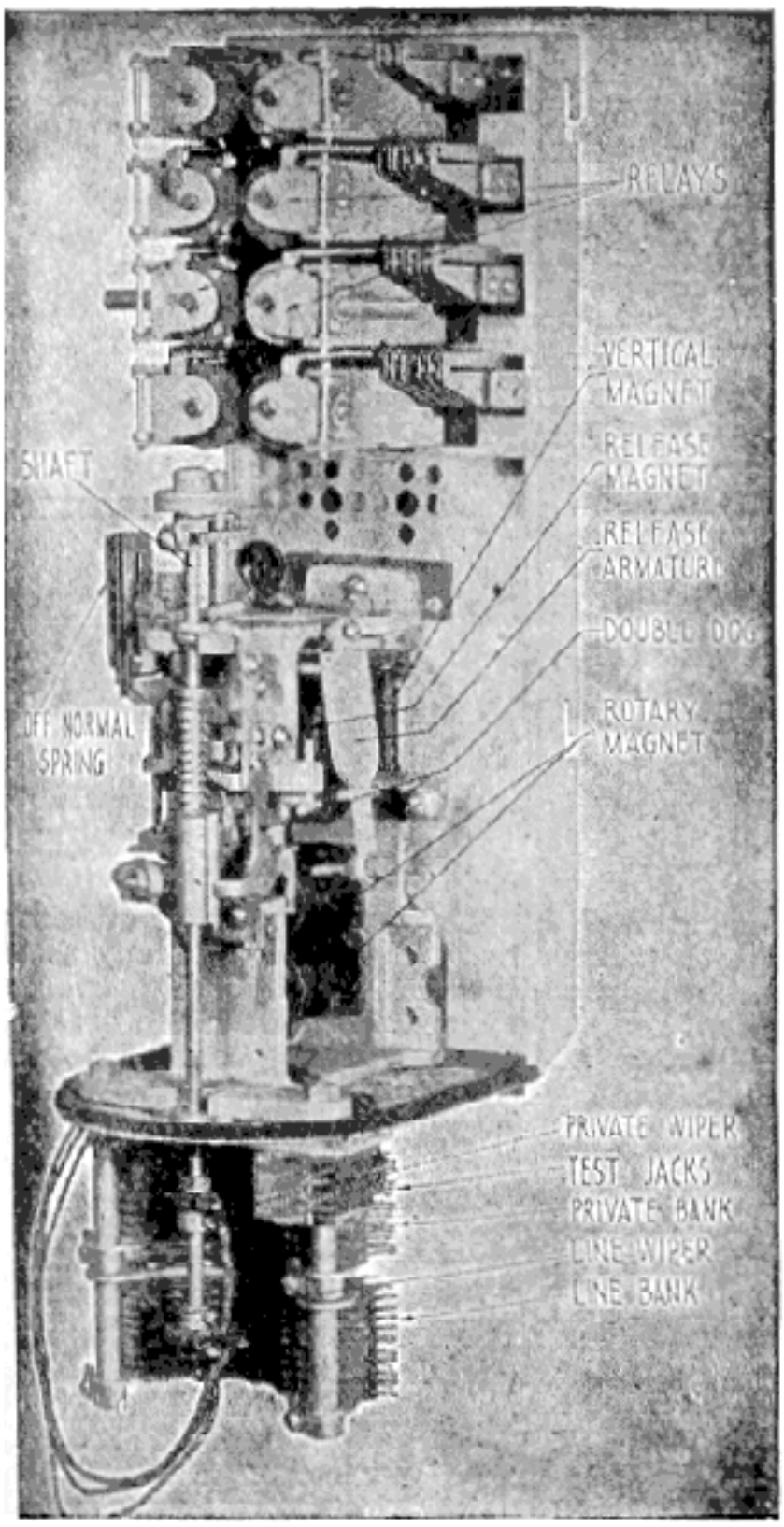


FIG. 8,426.—Subscriber's circuit. ***In operation,*** when the receiver is lifted from the hook, the circuit is through the upper winding of line relay L, transmitter, receiver, impulse spring, upper contact of switch hook, lower winding of L, to ground. When thus, line relay becomes energized and closes the release line relay, whose circuit is from battery through release relay, contact maker F, to ground. When a number, say 1, is dialed, and the dial released, the cam is given one half turn as it returns to initial position, and one of the cam wings momentarily opens the impulse spring as it passes between them. This momentarily opens the circuit of line relay L, which causes L, to disenergize for an instant, and in turn opens the circuit of relay R. The latter being slow acting remains closed even though its circuit was momentarily opened.

There are two principal differences between the work of an operator on a multiple switchboard and that of an automatic connector. The first lies in the difference in the number of lines to which they have access. The operator has within her reach a multiple jack for every line in the switchboard, be the number of lines 1,000 or 10,000. She may therefore make a connection to any line entering the office, but a connector switch has access



to but 100 lines. Secondly, a subscriber's operator takes the orders of and makes the connections for certain predetermined subscribers only. The number she serves seldom exceeds 200 and is often less than 100, but a connector switch is, when idle, ready to handle the order of any subscriber who may wish to connect to any one of the 100 lines to which it has access.

Fig. 8,427 shows a connector switch with cover removed. The lower part of the machine supports two curved banks of contact plates or strips. The under bank, called the line bank, contains 100 pairs of these contact plates arranged in 10 horizontal rows, 10 pairs to the row. These pairs of bank contacts correspond to the line springs in the multiple jacks of a manual board, and may be multipled before any desired number of connector switches.

The upper bank contains 100 single contacts which correspond to the sleeves of multiple jacks. This is the busy test bank, commonly called the "private" bank. The cord and plug of the manual board are represented by the "wipers" on the shaft of the machine.

FIG. 8,427.—Strowger type connector with banks. The connector is the final switch of a series used in making a call. ***It consists of*** a shaft carrying three wiper springs, which by means of a step by step vertical and rotary motion, may be caused to rest on any desired set of contacts in the bank. The relays at the top are used to control the action of the magnets, the busy signal, ringing current, transmission currents, etc.

The lower or line wiper consists, as shown, of a pair of long flexible springs insulated from each other and each soldered to a flexible cord, while the upper or private wiper is a pair of springs connected together to a third cord.

The movement of the wipers, corresponding to those of an operator raising a plug and inserting it into the proper multiple jack, are performed

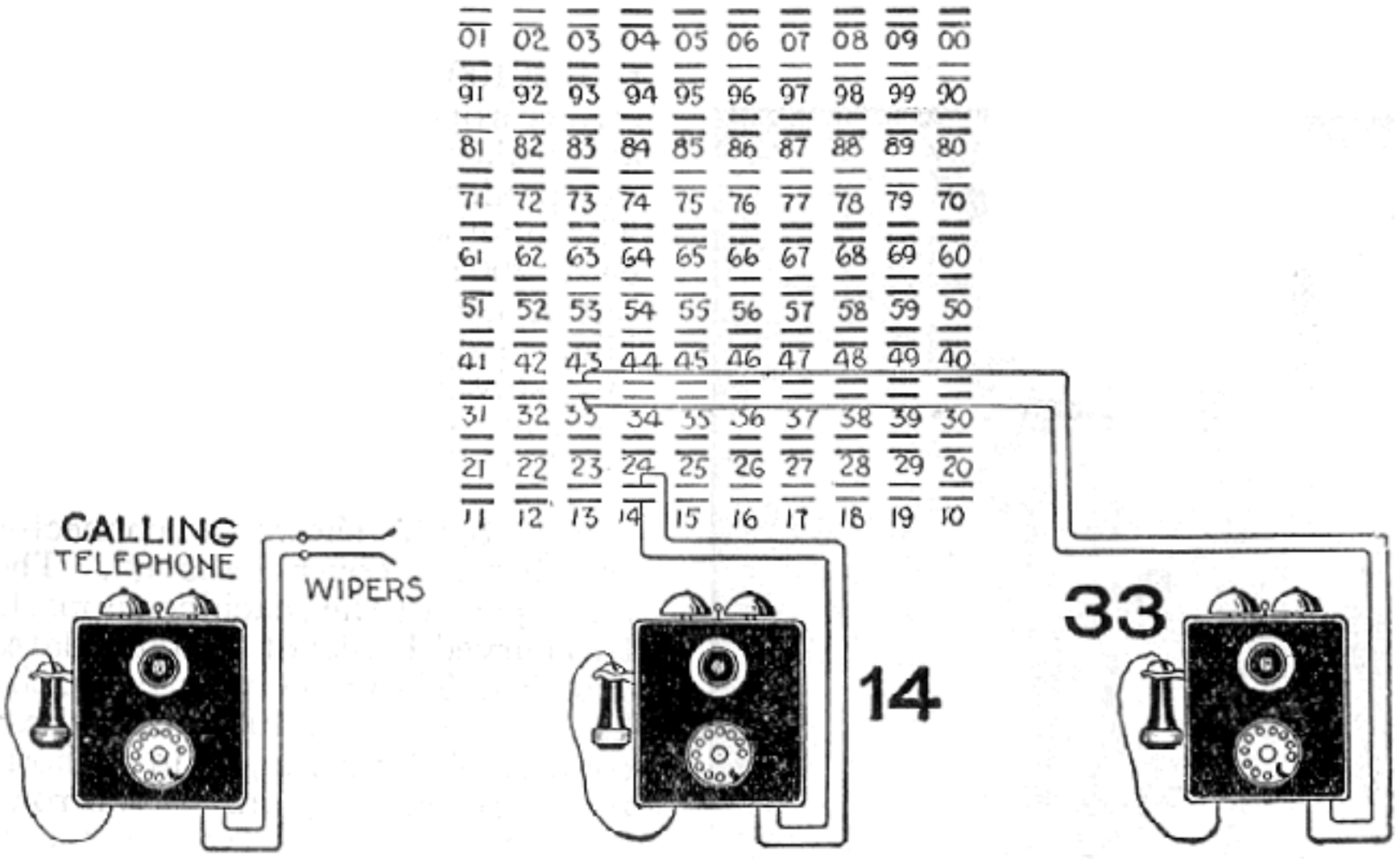


FIG. 8,428.—Diagram of line bank contacts, associated with each connector and numbering system of the telephone lines of which they are the terminals. The number of any set of terminals can be determined by noting the number of vertical and sidewise steps the wipers must be given to reach that set, remembering that ten steps is always represented by zero. Thus six vertical steps and ten rotary steps would cause the wipers to reach contact No. 60.

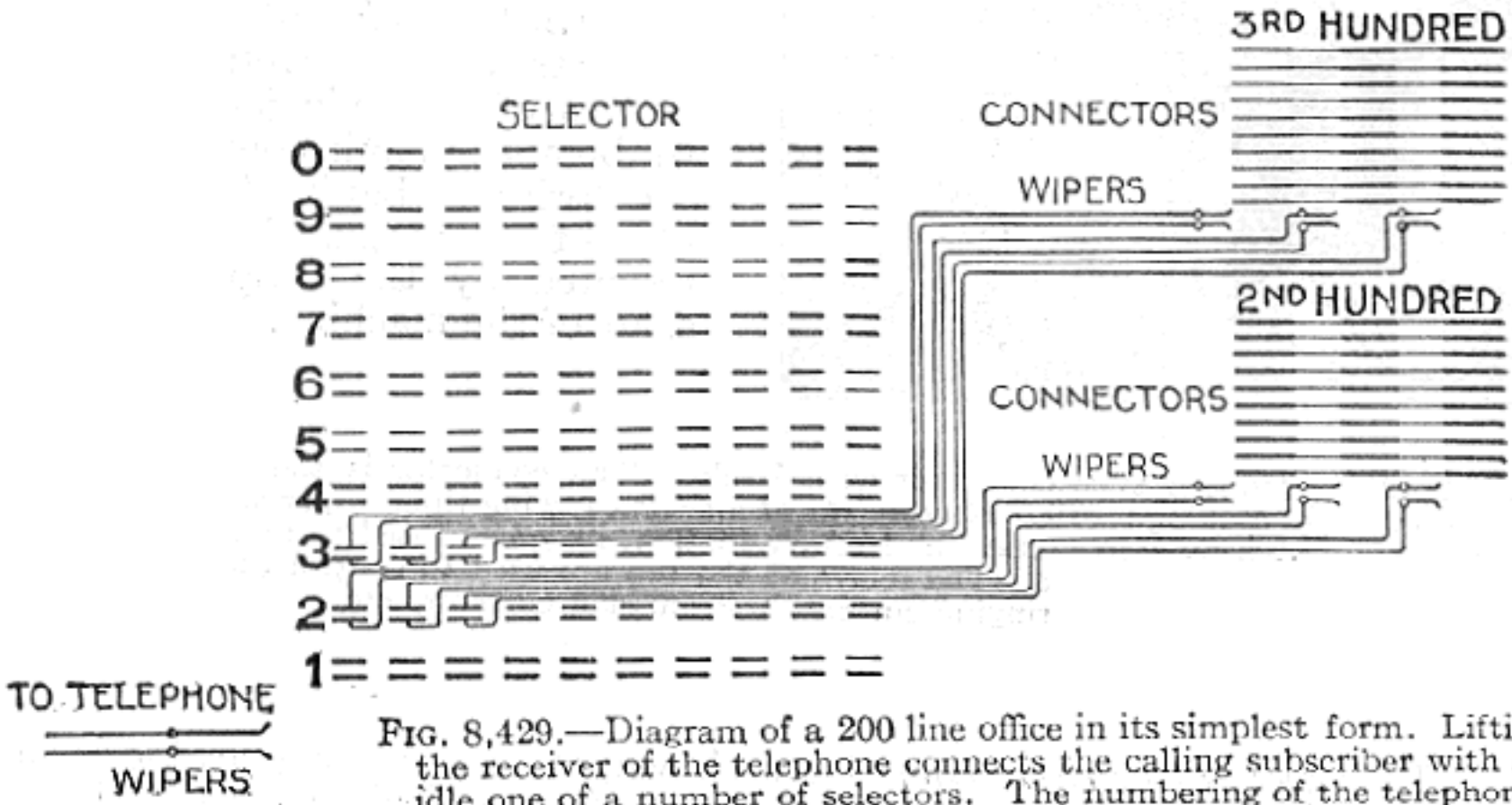


FIG. 8,429.—Diagram of a 200 line office in its simplest form. Lifting the receiver of the telephone connects the calling subscriber with an idle one of a number of selectors. The numbering of the telephones in this office is from 200 to 300 inclusive, since the second and third levels of the selectors are used. Dialing the first figure (a 2 or a 3) steps the selector up to the second or third level and thereby chooses the 200 or 300 group of lines. Immediately the vertical motion of the selector shaft is complete, the shaft and wipers automatically rotate to select an idle connector serving that 100 line group. This action is independent of the calling device. The last two figures dialed cause the connector to pick out the desired line.

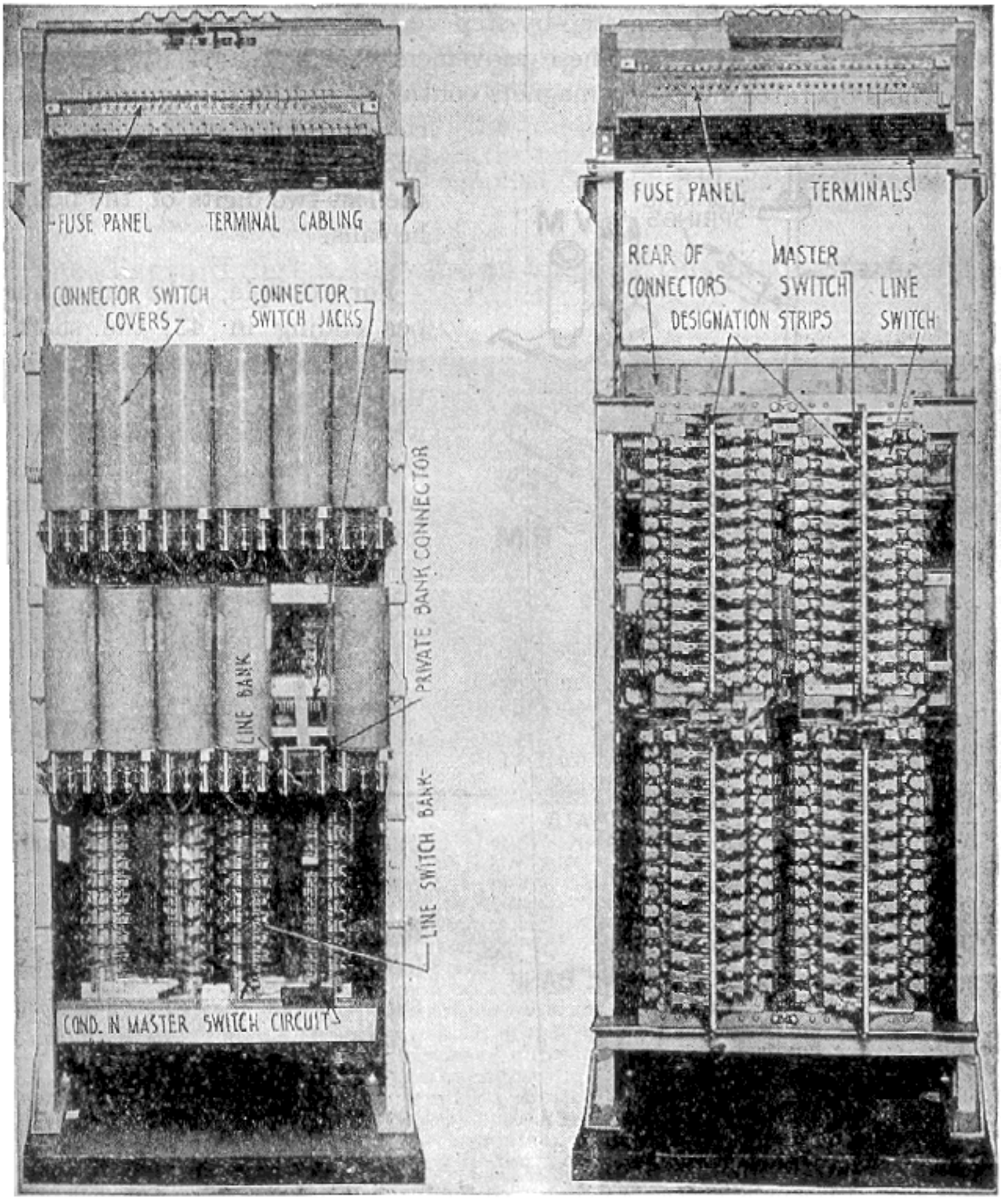
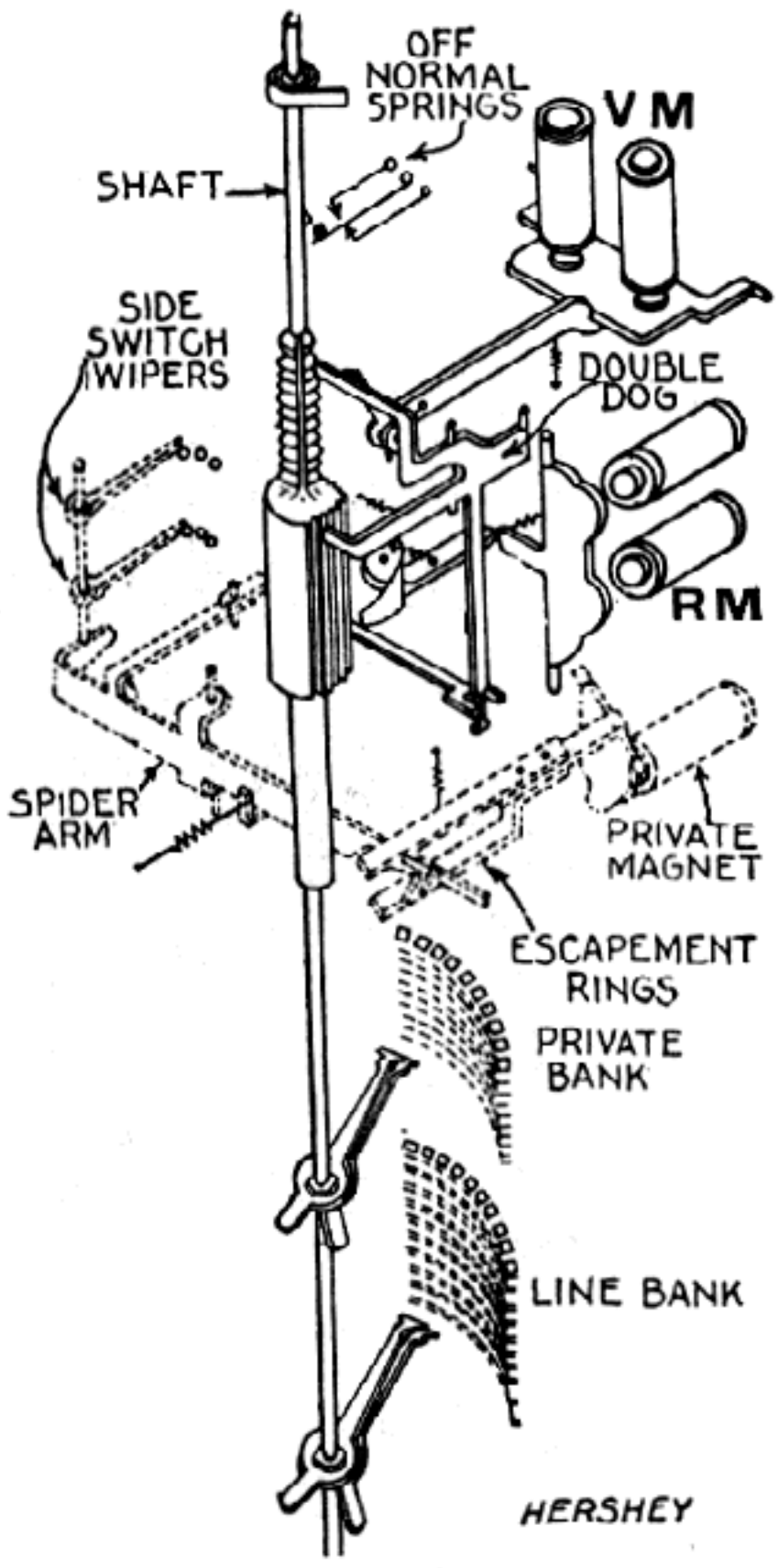


FIG. 8,430.—100 line switch board *front view*. Here are shown 100 subscribers' line switches mounted on a steel frame in four sections of 25. Two sections of 25 are mounted on each swinging shelf and each shelf of 50 are controlled by a master switch. Above the switches may be seen the power panel and terminal assembly.

FIG. 8,431.—100 line switch board *rear view*. On the rear of a line switch unit are mounted the connectors which serve that 100 lines. The incoming subscriber's lines, besides being connected to the line switches are also connected to the connector bank contacts. The capacity of a unit is usually 24 or 28 connectors, although it is seldom necessary to install more than 15 except for party lines.

by the shaft which has a step-by-step vertical movement and a step-by-step rotary movement. These movements are actuated by pawls and ratchets operated by electromagnets controlled by the subscriber from the calling device on his telephone, and are always in accordance with the last two digits of the number he calls.



For example, if he call a number ending in 43, the shaft is raised four steps and then rotated three steps, thus raising each wiper opposite the fourth row of contacts from the bottom of its respective bank and then sliding it over to the third contact in the row.

The machine is then ready to close the circuit of the calling subscriber through to the circuit of the called party, but before doing this it first closes the private wiper circuit only and thus makes an automatic busy test.

If it find the desired line busy, it keeps the connection open and immediately transmits the busy signal back to the calling subscriber.

If the desired line be not engaged, the connector switch immediately

FIG. 8,432.—Diagram of connector switch, and the two banks of contact. The switch consists of a shaft arranged to make under control of magnets, a step by step vertical movement, and a step by step rotary movement. Attached to the shaft near its lower end are two wipers, the lower (double) wiper makes contact with the *line bank*, and the upper (single) wiper makes contact with the *private bank*. Further up on the shaft are vertical teeth by which the shaft is raised step by step, and just below which is a pinion or hub of rotary teeth by which the shaft is rotated step by step. The coiled spring at the top of the shaft causes it to return to its initial position when released. Gravity is utilized to lower the shaft to its initial vertical position.

begins to ring the called party's telephone bell automatically and intermittently. When he answers, the ringing stops and the two subscribers' lines are closed together for conversation.

Talking current is supplied to the transmitters of both telephones from the central office battery through the relay coils of this connector switch, just as in manual practice it is supplied through the relay coils of the cord circuit.

The diagram fig. 8,432 shows clearly the mechanism of the connector switch.

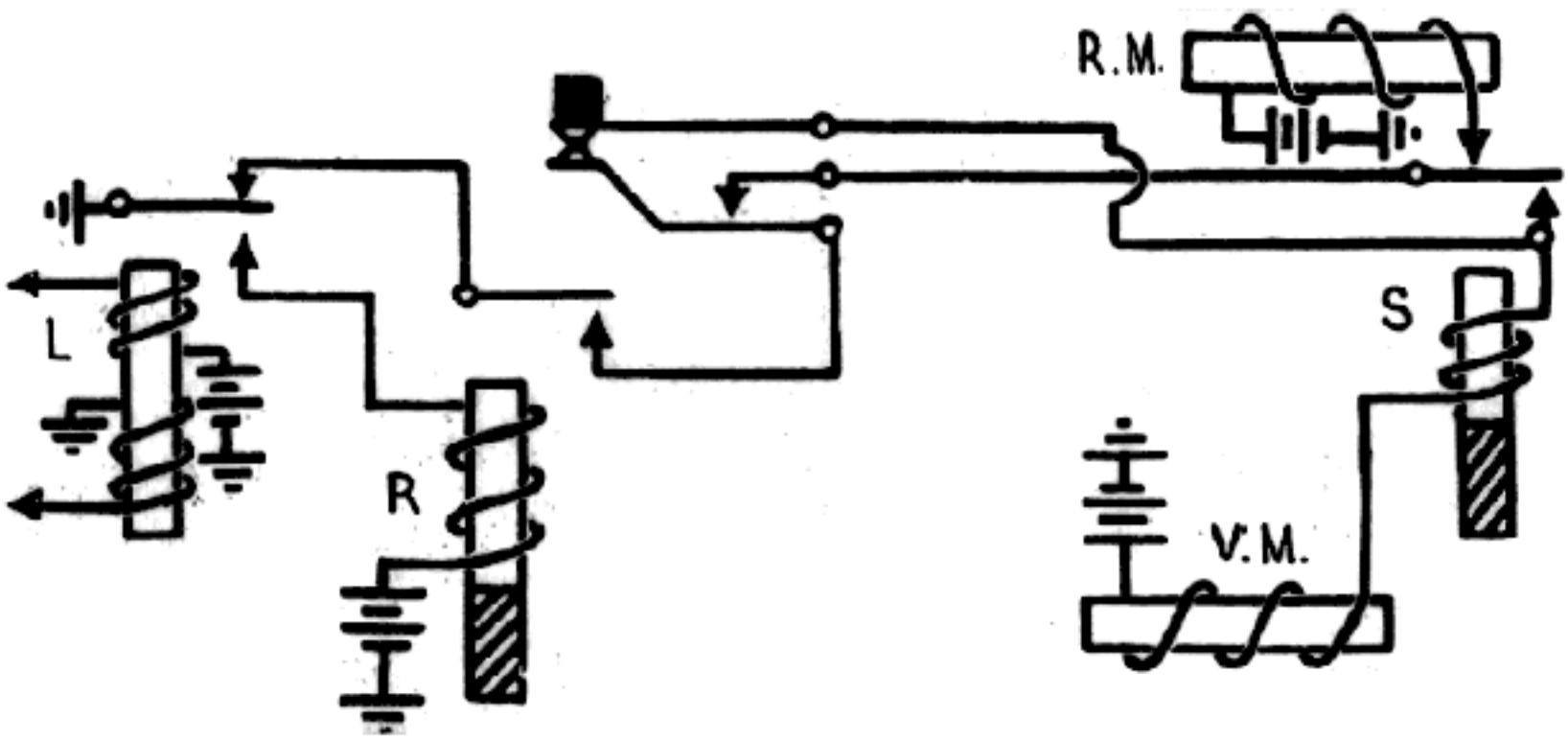


FIG. 8,433.—Connector switch circuit. When the subscriber removes the receiver, relays L and R, are closed as explained in fig. 8,426. Suppose the first number dialed by the subscriber be 4, then the circuit of relay L, is momentarily opened 4 times; which in turn each time opens the circuit of relay R. Since R, is slow acting it does not open. The first time relay L, armature opens a circuit may be traced *from ground, break springs relay L, make springs relay R, break contact "off normal spring" relay S, through vertical magnet to battery.* The current in the circuit causes relay S, and the vertical magnet to operate. S, being slow acting remains in position for fraction of a second. When relay and armature again opens the same circuit is closed, except that since the shaft has already been raised one step, the circuit will pass through the *make contacts of the "off normal spring" and the make contacts of relay S.* Shortly after the last impulse of current has passed through S, it will open and cannot again close because of the open circuit at the off normal springs: When the subscriber dials the second number, each time relay L, opens, a circuit may be braced from *ground break springs relay L, make springs relay R, make off normal springs, break springs relay S, through rotary magnet to battery.* The current in this circuit causes the rotary magnet to close a number of times corresponding to the number dialed, thus rotating the switch to the proper contact.

Connector Switch Circuit.—This circuit includes *the vertical and rotary magnets, which operate the switch.*

Fig. 8,433 shows the circuit, which it should be noted, is a continuation of the subscriber's circuit shown in fig. 8,426, the two relays L and R, of fig. 8,433 being the same relays at L and R, of fig. 8,426.

Private and Line Banks.—As shown in fig. 8,432 these form a part of the connector switch. The diagram fig. 8,434 shows 100 single contacts in the private bank and 100 double contacts in the line bank.

Each telephone is connected to a certain pair of contacts in the line bank. For each pair of contacts in the line bank, there is a corresponding contact in the private bank associated with it.

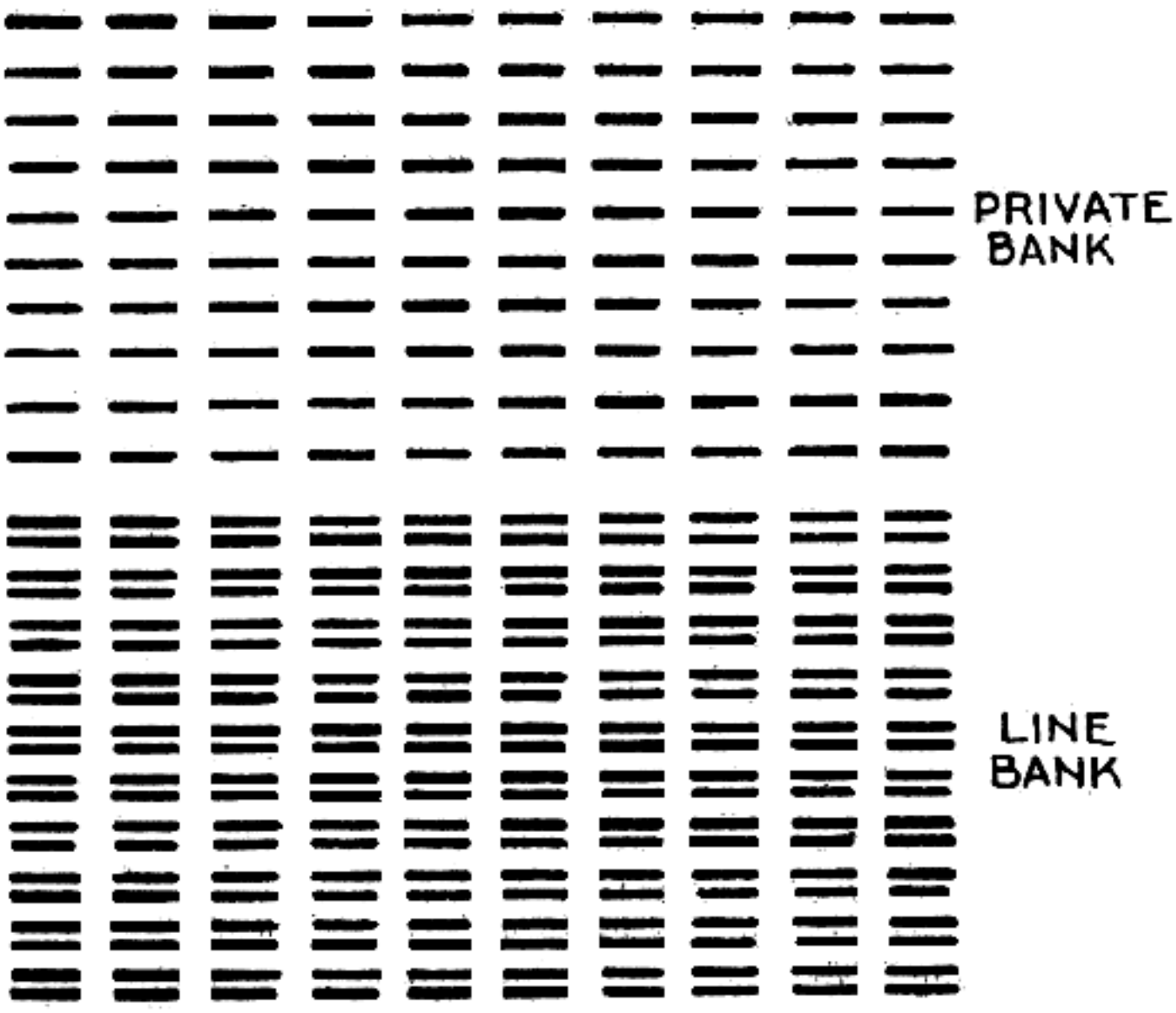


FIG. 8,434.—Diagram showing contacts of line and private banks of a 100 line system. These banks form a part of the connector switch.

The object of the private bank is *to protect a line against intrusion when that line is in use;* it is in other words, a busy test bank and in operation, whenever a telephone is in use the corresponding private bank is grounded.

Private Bank or Busy Test Circuit.—This is shown in fig. 8,435. The spring assembly on relays A, and W, are what are called *make before break* springs.

When current flows through the relay, the make spring strikes the movable spring and causes it to break contact with the stationary spring.

When relay B, is once energized it is independent of the private bank contact ground, hence the busy tone is continued even though the called line becomes idle.

When a busy line is called, the wiper cut off relay W, does not cut the connection through the wipers, hence there will be no interference with those already using the line.

The circuit of the rotary magnet is taken through a pair of break springs on relay B, so that a subscriber, while receiving the busy tone cannot again operate the rotary magnet by interfering with the dial.

The make springs on relay A, prevent opening of the rotary magnets, due

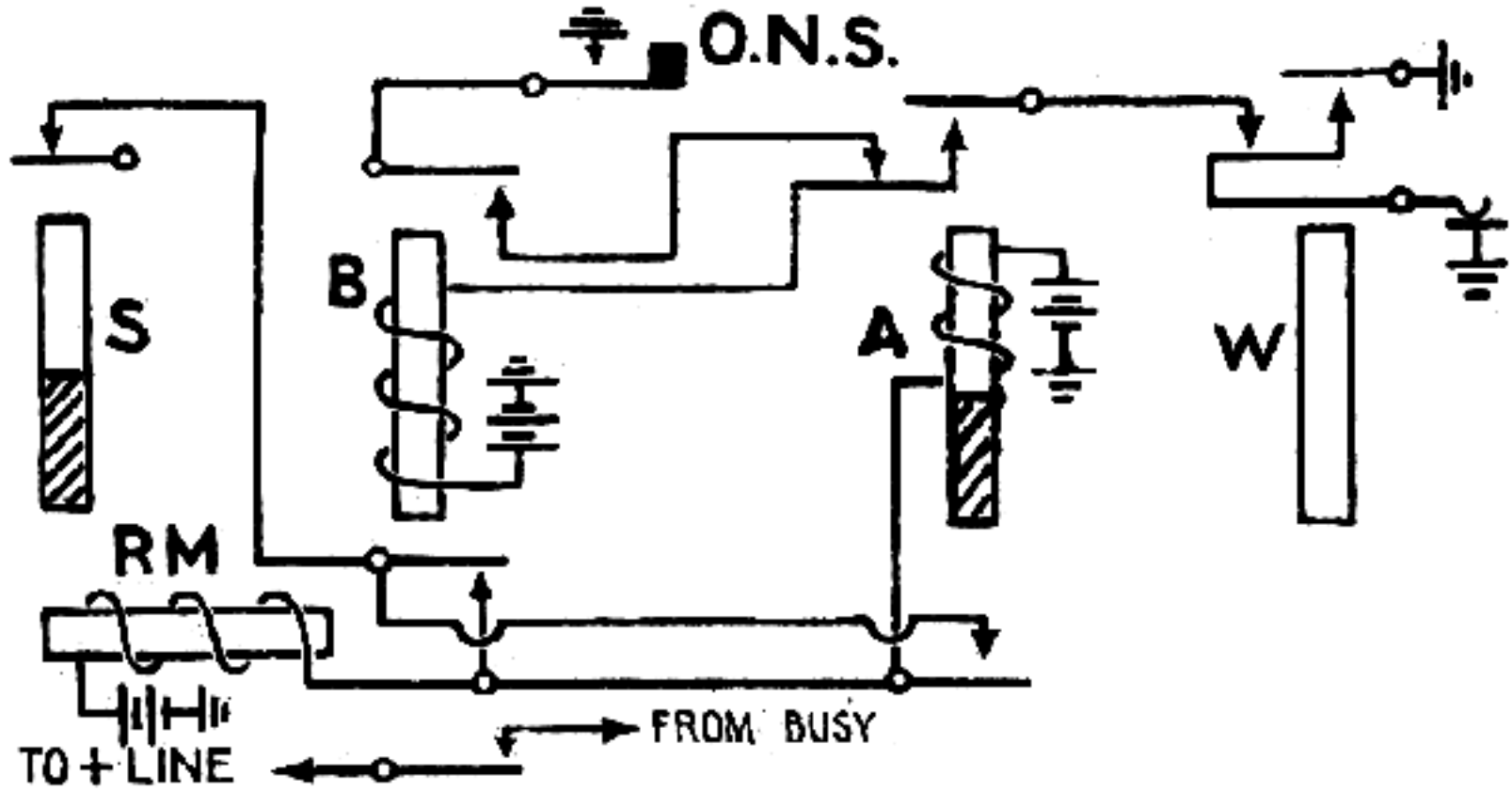


FIG. 8,435.—Private bank or busy test circuit. Assuming a telephone in use and its private bank grounded, relay A, being slow acting, will remain energized momentarily after the completion of the rotary movement. Now a circuit may be traced *from ground at private bank contact, through private wiper, break springs relay W, make springs relay A, through busy relay B, to negative battery.* The current in this circuit will cause relay B, to close forming a locking circuit for itself independent of the ground from the private bank contact. This circuit may be traced from "*off normal spring ground,*" *make springs relay B, break springs relay A* (which by this time has opened) *through relay B, to battery.* Further relay B closes a pan of contact which places the busy time on the line indicating to calling subscriber that the line is busy.

to the tendency of relay B, to operate should the private wiper pass over one or more busy contacts.

If the called line be idle, there will be no guarding ground on the associated private bank contact. After relay A, opens a circuit is closed through the wiper cut off (or ringing) relay W, which grounds the private bank contact, so that any one calling this number will receive the busy tone, thus protecting the busy line against intrusion.

Disconnection of Connector Switch.—After the completion of a telephone conversation means must be provided *for returning*

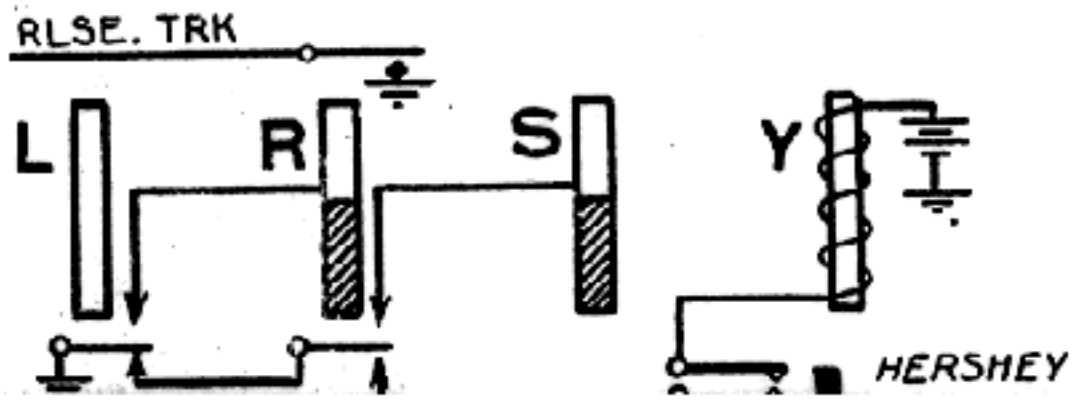


FIG. 8,436.—Release circuit by which the connector switch double dog is operated to restore connector switch to normal. Since during conversation, the line relay remains closed the connector switch release circuit remains open. Now when the receiver is hung on the hook (at the calling station) the line relay opens and a moment after the release relay opens. This completes a circuit *from ground, break springs of line relay, break springs of release relay, off normal springs, through release magnet Y, to battery and ground.* This energizes the release magnet which removes the double dog allowing connector shaft to return to normal position, the release circuit being opened at the off normal springs when the shaft reaches the normal position. On the release relay is a pair of make springs, by which ground is placed upon the release trunk.

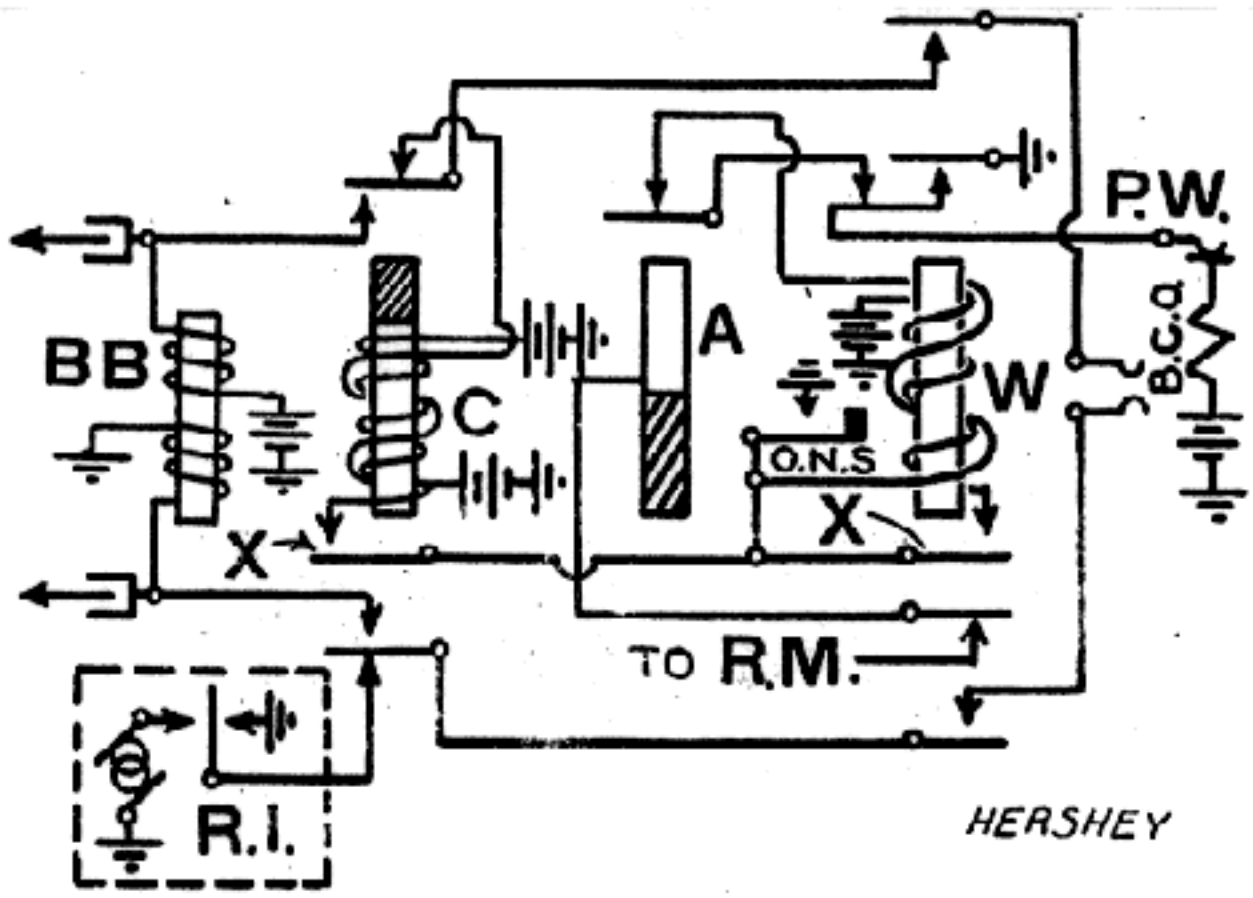


FIG. 8,435*a*.—***Removal of line wipers during rotation.*** When the second number dialed requires several steps of rotation, the line wipers during the rotation make contact with the contacts rotated over. Hence, if any of the lines rotated over be busy an unpleasant sound would be heard as the wipers passed over the contacts unless they be disconnected from the connector during the rotary movement. Assume number 65 has been called and that the line and private wipers are now resting upon the bank contacts associated with telephone number 65. When relay A, de-energizes, following the last rotary impulse, a circuit may be traced from "off normal spring ground," low winding relay W, break springs relay A, break springs relay W, private wiper, private bank contact, through the B.C.O. to negative battery. The lower winding of relay W, will energize sufficiently to close the springs X, thus forming a locking circuit which may be traced *from "off normal spring ground" springs X, through the high winding of relay W, to battery.* The current in the circuit will cause relay W, to fully operate so that the line wipers are cut through to the connector and ground is placed on the private wiper.

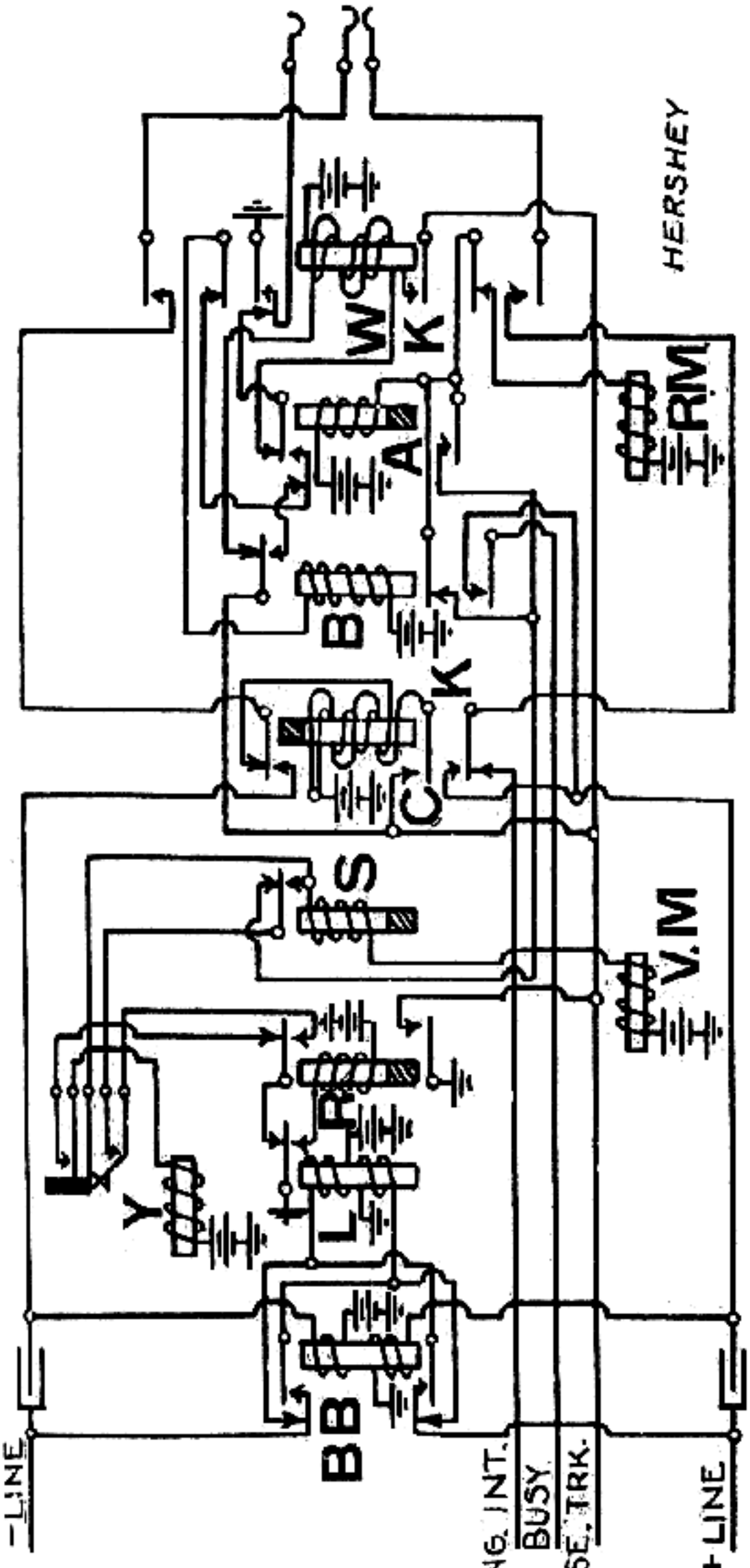


FIG. 3,437.—Diagram of complete connector circuit.

the connector switch to its normal position, ***when*** *the subscriber hangs up the receiver,* thus disconnecting the line.

This is done by a part of the connector switch mechanism called a *double dog* operated by a *release magnet.* The circuit which controls the release magnet, called the release circuit is shown in fig. 8,436.

Complete Connector Circuit.

—Connections in this circuit are shown in fig. 8,437.

Included in the diagram are the familiar line and release relays, also, series relay, instantaneous ring cut off relay, busy relay, back bridge relay, wiper cut off relay, release magnet, vertical magnets, rotary magnets, and slow acting rotary control relay. The duties of these various relays are here briefly given.

Line Relay—Receives the dial impulses and repeats the same to the vertical and rotary magnets; also feeds talking battery to calling subscriber.

Slow-Acting Release Relay—Prepares circuit of the vertical and rotary magnet, and maintains the release magnet circuit open until such time as the conversation is completed.

Slow Acting Series Relay—Used to operate the vertical magnets.

Busy Relay—Used to give a calling subscriber a busy tone in case the line called be busy. It also prevents undue rotation of the shaft by the rotary magnets.

Ring Cut Off Relay—Feeds ringing circuit to the called line and releases ringing circuit when the subscriber answers.

Back Bridge Relay—Feeds talking battery to the called subscriber, and reverses polarity of the calling line.

Wiper Cut Off Relay—Cuts connector through to the wipers when an idle line is reached.

Vertical Magnets—Gives vertical movement to connector shaft when first number is dialed.

Rotary Magnets—Gives rotary movement to connector shaft when second number is dialed.

Release Magnet—Removes double dog to restore connector shaft to normal position when receiver is hung on hook at completion of conversation.

Rotary Control Relay—Operates in parallel with the rotary magnets, and closes the circuit through to the busy relay.

Line Switch.—As must be evident the complicated connector switch is a very costly part of the apparatus, and if, as has been assumed in the previous explanation that each line is provided with one of these connectors, the cost of the installation would be prohibitive. Now since only a small number of lines are in use at one time, it will suffice *to employ only a few connectors in*

proportion to the number of lines, if there be provided means by which when a subscriber removes his receiver from the hook, his line will be connected to an idle connector switch. This is accomplished by what is called the *line switch.*

With this device, it has been found in practice that only ten connector switches are needed for each 100 line installation.

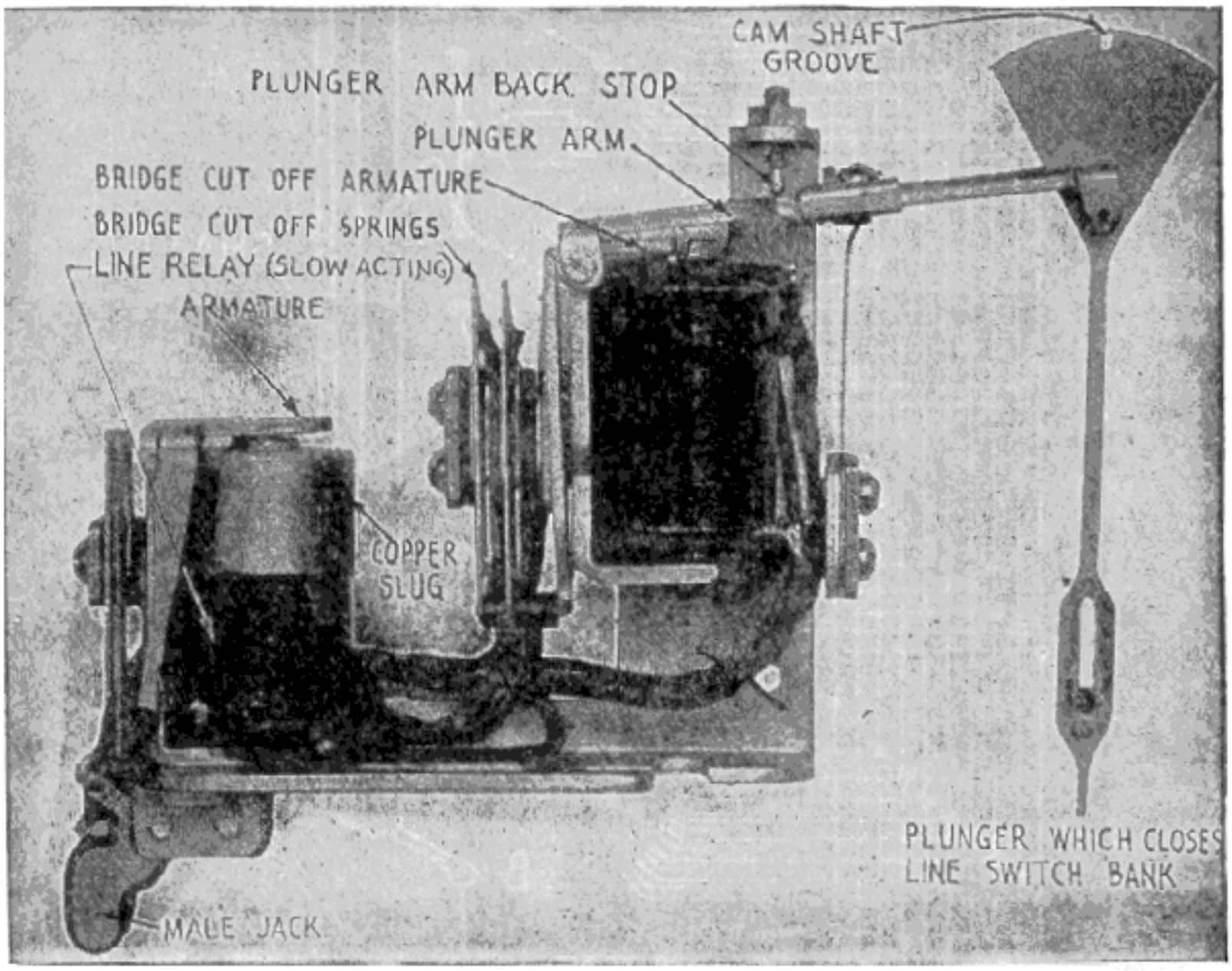


FIG. 8,438.—Line switch. ***It consists of*** a line relay and a combination "pull down coil" and "holding coil" carrying two armatures. The larger armature carries a plunger, which is pivoted so that its point may be swung by the master switch in front of a bank of contacts. The bank consists of 10 sets of contact springs with which are associated ten trunks. Line switches are mounted in groups of 25, four groups being provided for each 100 line unit. One master switch may be provided for any number of groups of line switches depending upon the trunking capacity desired, since each master switch controls ten trunks. Normally the plungers are at rest poised over bank contacts multiplied to an idle trunk. When a subscriber removes his receiver from his telephone switch hook preparatory to making a call, a circuit is thereby closed which causes the plunger arm of his line switch to be at once pulled down, carrying its plunger out of engagement with the master shaft and thrusting it into the bank. The effect of this is to connect the subscriber's line to a trunk leading to an idle first selector switch, as shown diagrammatically in the right hand portion of the figure. The instant that one line switch thrusts its plunger into the bank, thus occupying the trunk over whose multiple all idle plungers have been poised, the master switch operates and swings the remaining idle plungers forward over the next multiple of bank contacts. If this trunk should be busy, the movement proceeds until an idle trunk is found. It is to be noted that a line switch always uses a pre-selected idle trunk instead of making a selection after a subscriber starts to call.

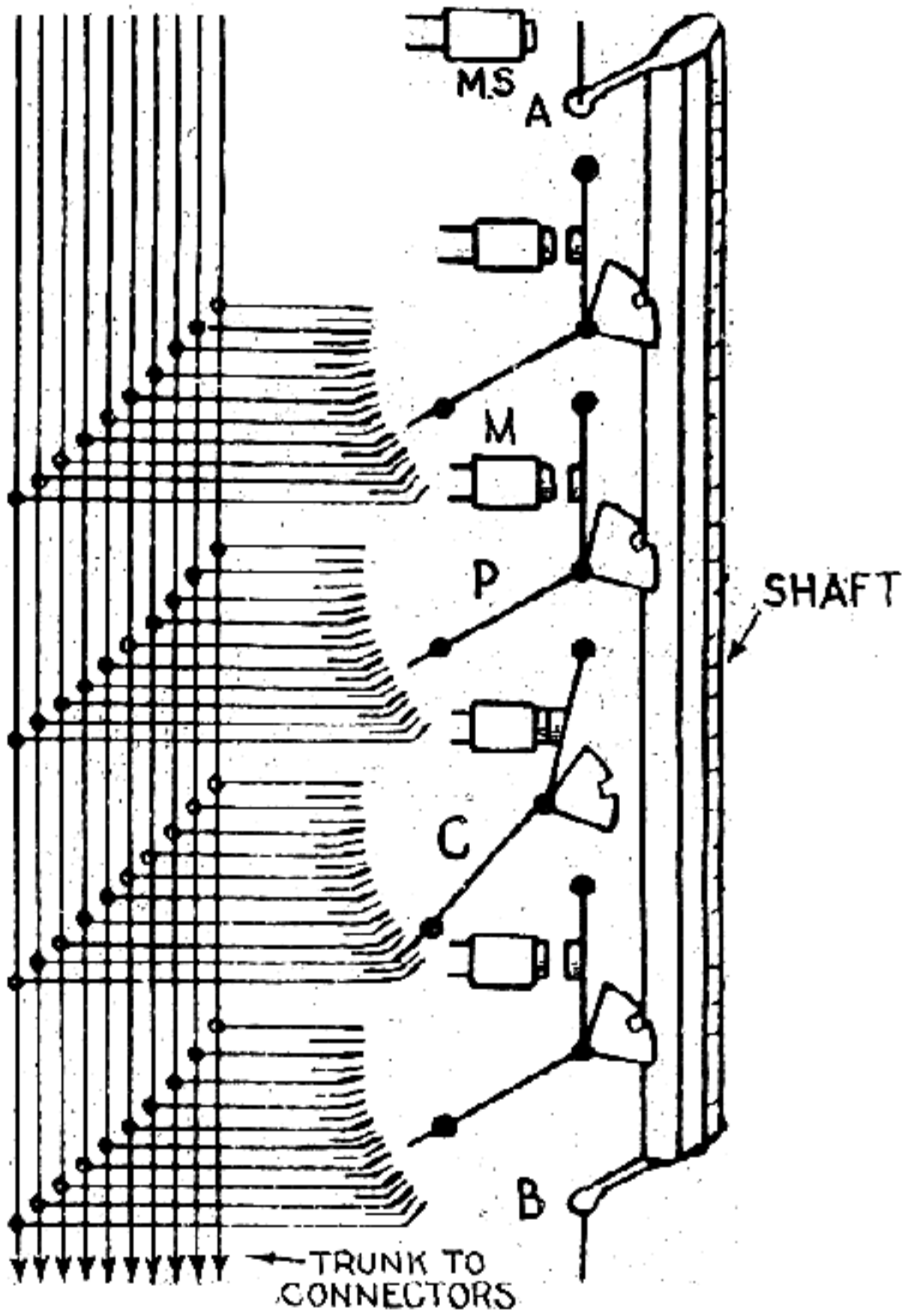


FIG. 8,439.—Diagram of line switch and connections. The switch *consists of,* a magnet M, and plunger P, whose head or wing is slotted so that it may engage a projecting edge of the shaft. The shaft is pivoted at A and B, and is capable of a rotary motion of about 40 degrees under control of a master switch MS. The rotary motion causes the plungers of the various line switches to oscillate in front of the terminal of the trunks to the connector switches. Under control of the master switch the shaft comes to rest *only* opposite an idle trunk. If the shaft be holding all the plungers opposite, say the second trunk, and a subscriber remove his receiver, the corresponding plunger will *plunge in* and extend the connection to the connector associated with trunk number two. The plunger when *plunged in* is now free of the shaft as shown at C. The master switch, by means of the shaft moves the remaining plungers opposite an idle trunk, giving what is called *pre-selection of trunks*. When the subscriber who plunged in on trunk No. 2, hangs up his receiver, his plunger will come out of the bank but the slot in the wing of the plunger will not engage the shaft at this time. Hence this plunger will remain opposite trunk No. 2, until the shaft again swings in front of this trunk and picks it up. To prevent a caller connecting on a busy trunk, a plunger must not plunge in while the master switch is seeking an idle trunk. This requirement is met by what is called the *open main battery feed.*

In making a connection, after the line switch (also called the *non-numerical switch*) connects the line with an idle connector, the connection is completed by the connector switch as already described.

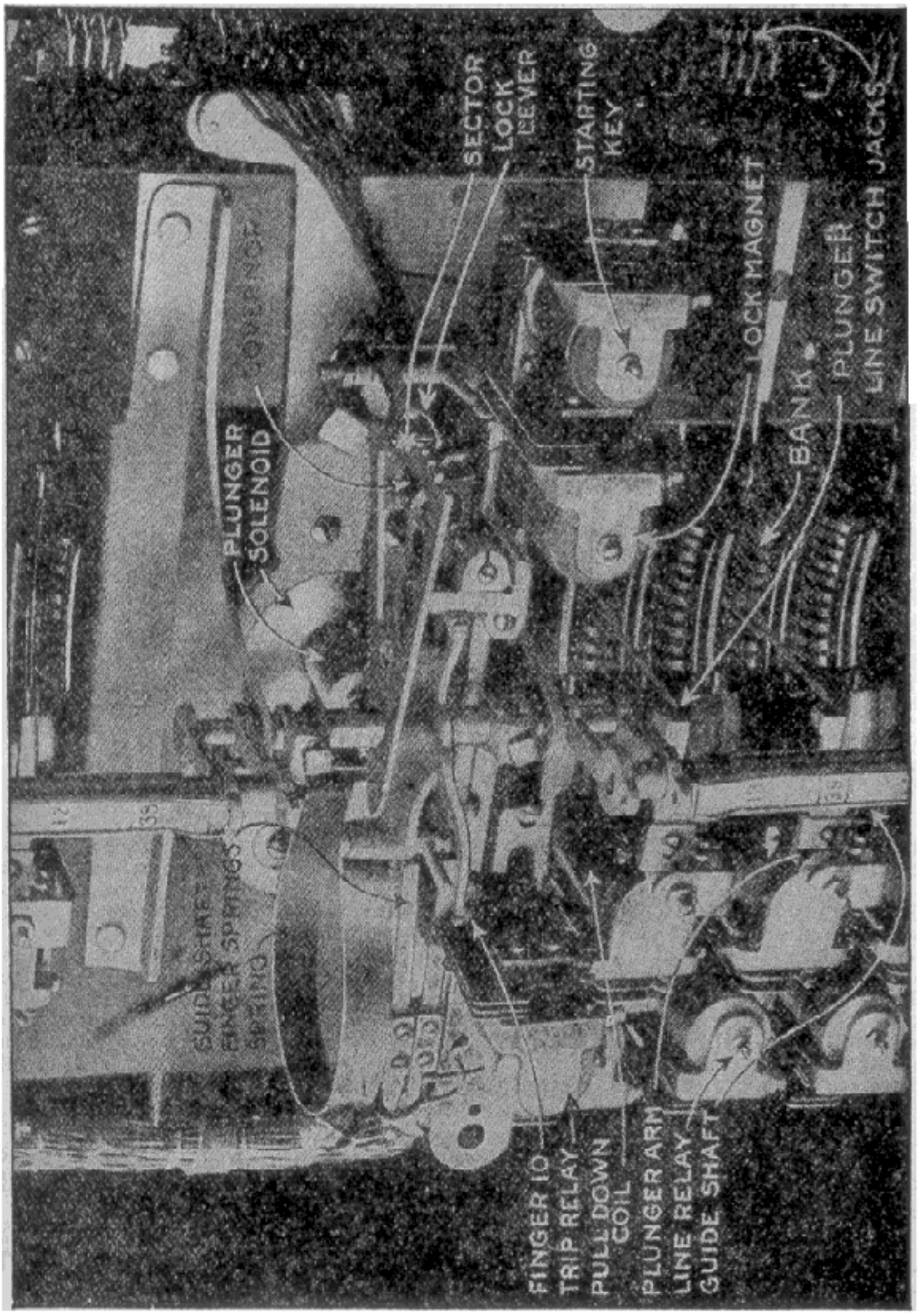


FIG. 8,440.—Mechanism of line switchboard.

Fig. 8,439, shows the working of the line switch, and fig. 8,440, its general appearance.

An important part of the line switch is the solenoid, which operates the shaft of the line switch in seeking trunks and the locking mechanism. This part of the mechanism with its circuit is shown in fig. 8,442.

The shaft of the line switch is moved counter clockwise by a spring, and clockwise by the solenoid. One arm of the locking segment L, is arranged to face springs Y, into contact when the switch is standing opposite the first trunk.

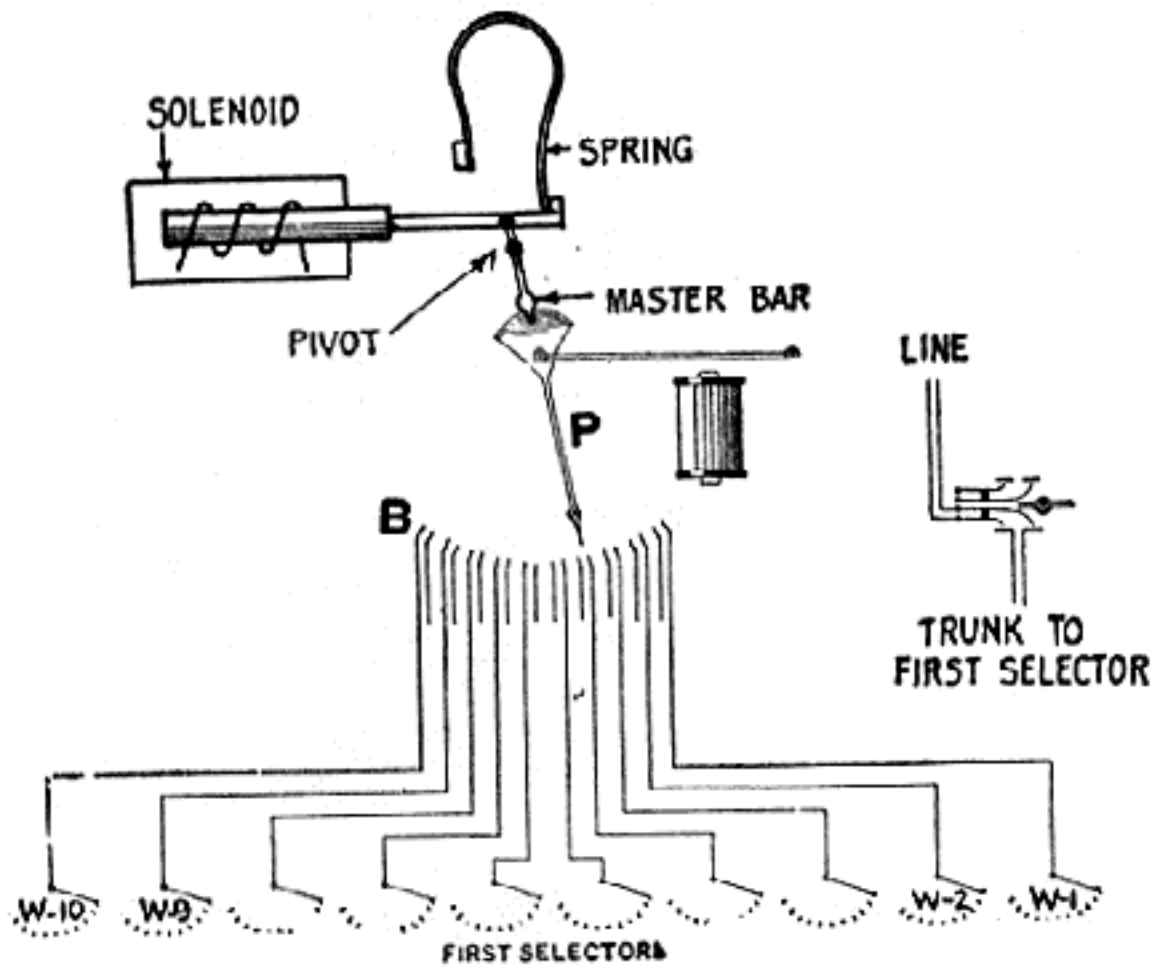


Fig. 8,441.—Master switch mechanism of line switch and diagram of trunks to first selectors. In the line switch, the notch in the head of each plunger meshes with a rocking bar or "master shaft" as it is called. A step by step device called a master switch (seen in the upper part of the figure) is connected to each pair or to each four master shafts and by means of them can swing the plungers back and forth, step by step over the banks of contact springs. The plungers are normally held in position by the master bar, which carries a feather fitted into the slots at the rear of the plunger. When the line switch operates, the plunger point is thrust into the bank, connecting the line to the connector or selector trunk, and at the same time disengaging itself from the master bar. The master switch is now automatically unlocked and begins to move under the action of the curved spring until an idle trunk is reached. When the master switch reaches the end of its stroke, the solenoid is energized and this pulls the shaft back in the opposite direction against the action of the spring.

The trip relay T, has a mechanical locking feature, which after it is once energized, will hold the springs in an operated position until mechanically released.

A section of L, is so formed as to release the springs of the trip relay T, when the master switch comes opposite the tenth trunk.

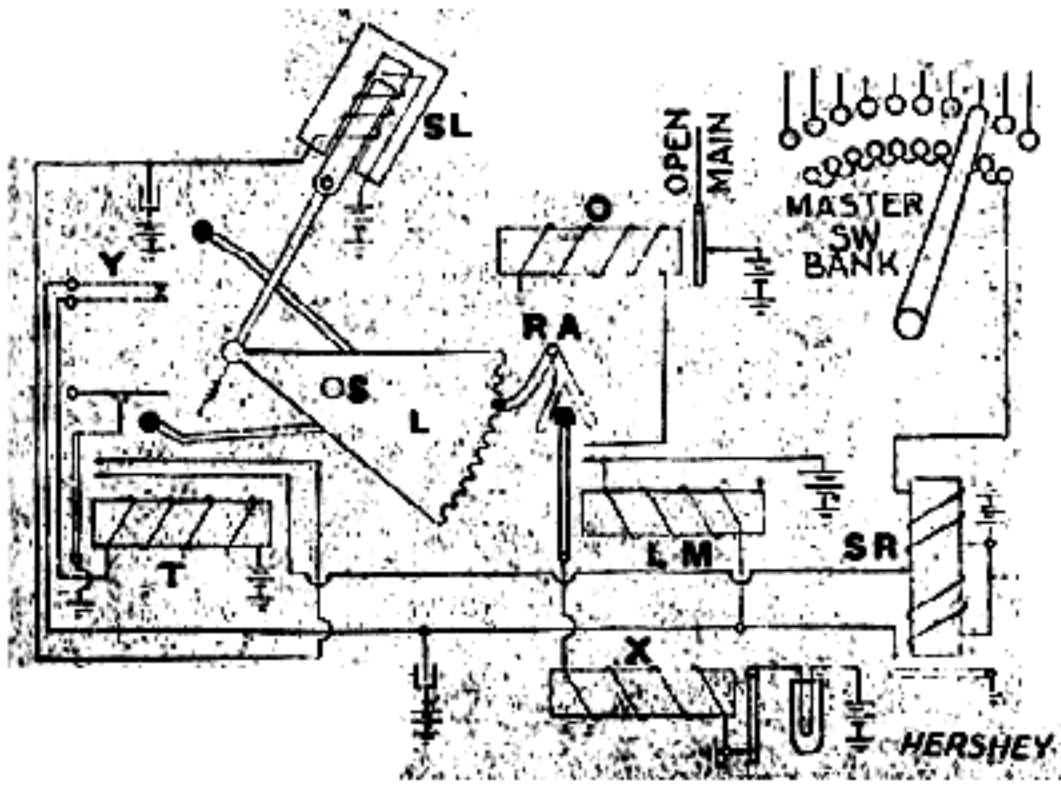


FIG. 8,442.—Solenoid control of line switch shaft, locking mechanism and circuit. If the line switch be standing opposite, say trunk No. 8, and a plunger plunges in on the trunk, a circuit can be traced from *release trunk ground, through master switch wiper and starting relay SR, to battery and ground.* SR, will energize and close a circuit *from ground through springs of relay SR, locking magnet ML, to battery and ground.* The locking magnet will operate to remove the retaining air from the locking segment, which now being free, to move, under the action of the spring will swing switch wiper and plungers in front of trunk No. 7. If this trunk be idle, the associated bank contact will not be provided and relay SR, will open and break the locking magnet circuit allowing the retaining arm to drop into the seventh slot of the locking segment. This arrests the rotation of the line switch shaft and holds the plungers opposite the seventh trunk until that trunk becomes busy. If this trunk had been busy the circuit of relay SR, would not have been opened, and the rotation would have continued until an idle trunk was reached. A plunger cannot plunge in while the master switch is moving for during the motion the open main circuit is open at the springs of relay O. The springs of the locking magnet, when in an operated position, also close a circuit through the supervisory relay X.

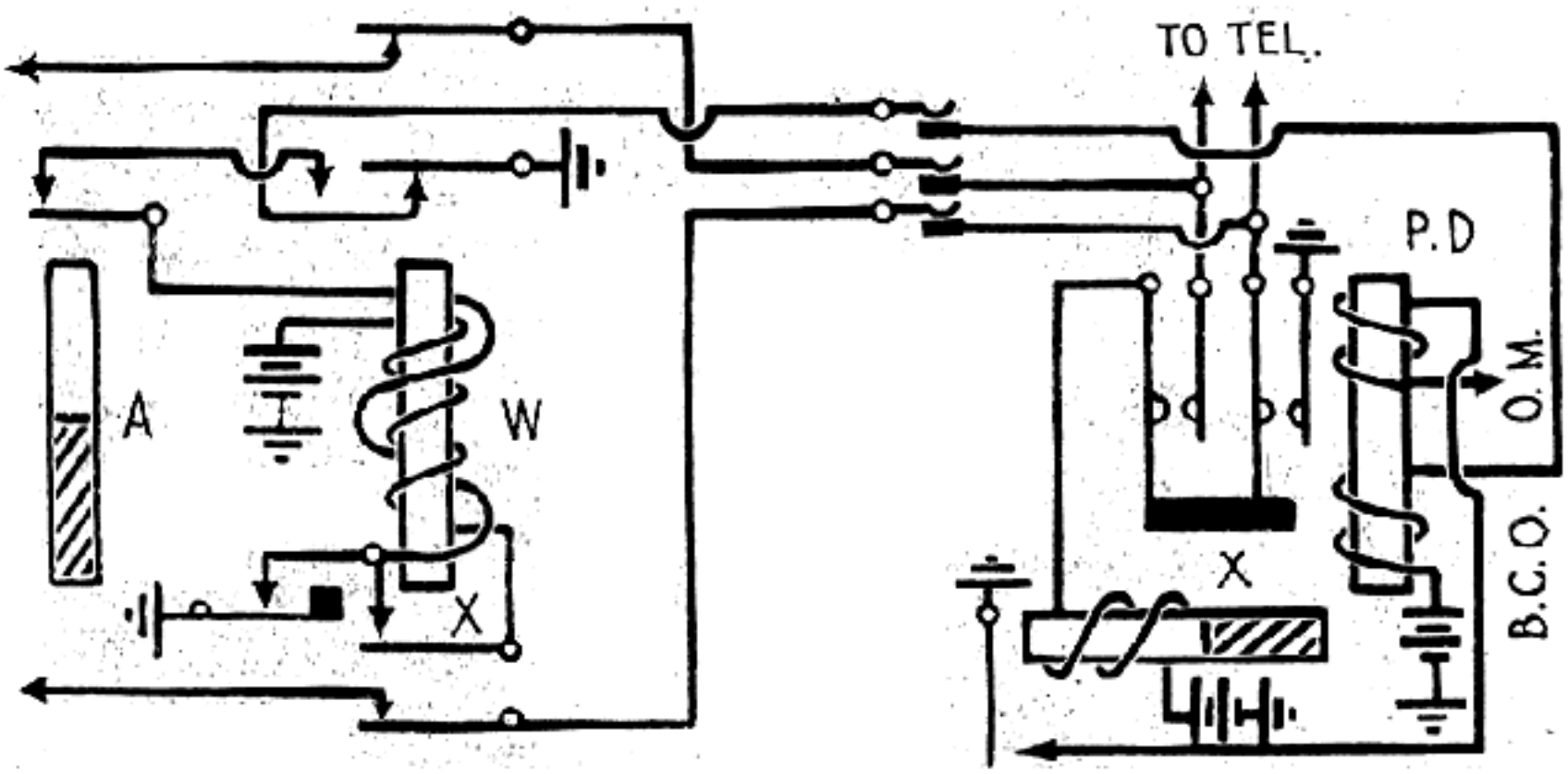


FIG. 8,443.—Diagram of portion of a connector switch circuit illustrating *clearing the called line of attachment.* Suppose a called line found to be idle and relay W, cut the connector

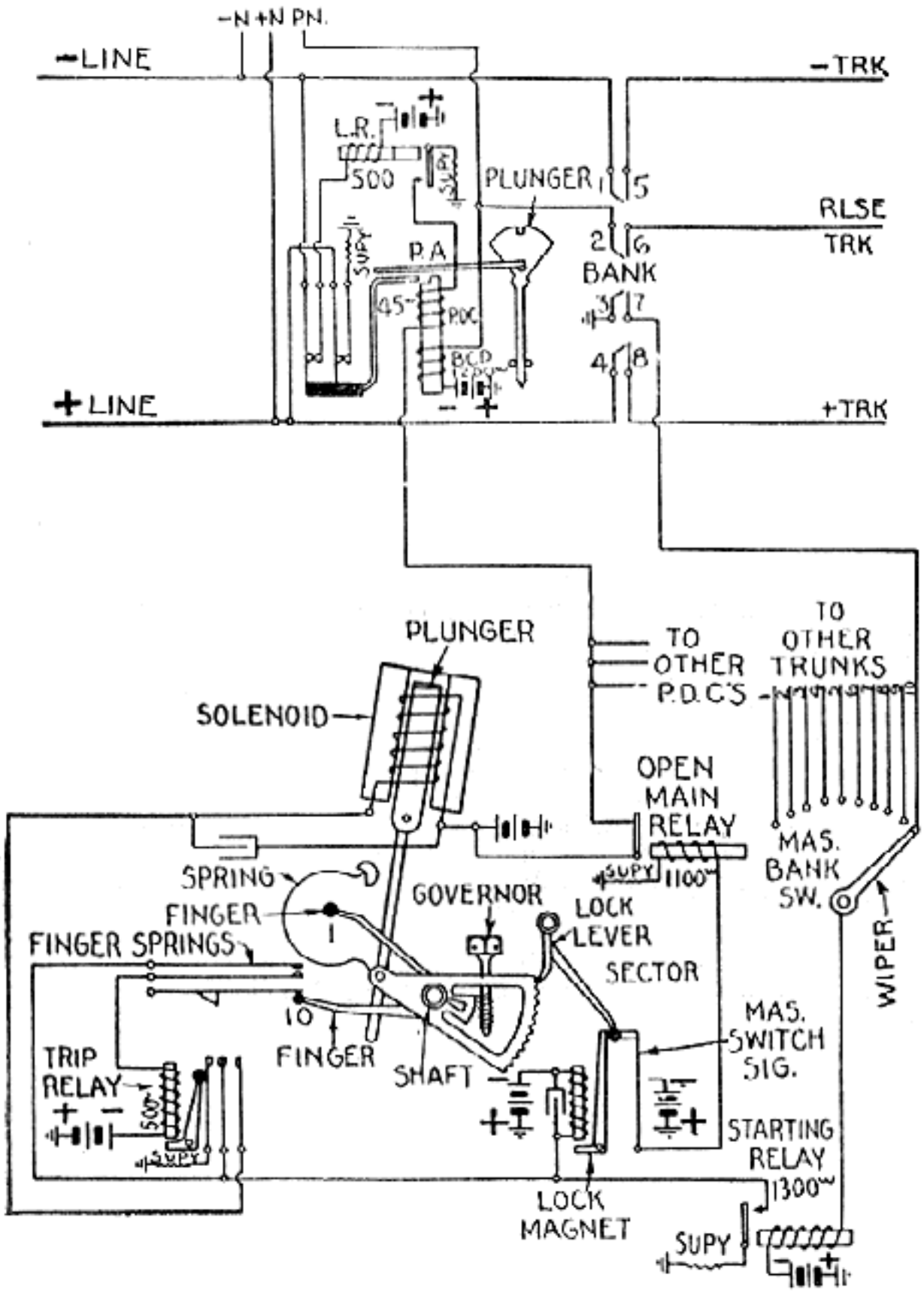


FIG. 8,444.—Line relay and master switch circuits.

There are ten sets of double contacts in the master switch bank, the lower contact being multiplied together. Each contact of the upper row is associated with one of the line switch trunks.

The switch wiper short circuits the upper and lower bank contact associated with the trunk upon which it happens to be standing.

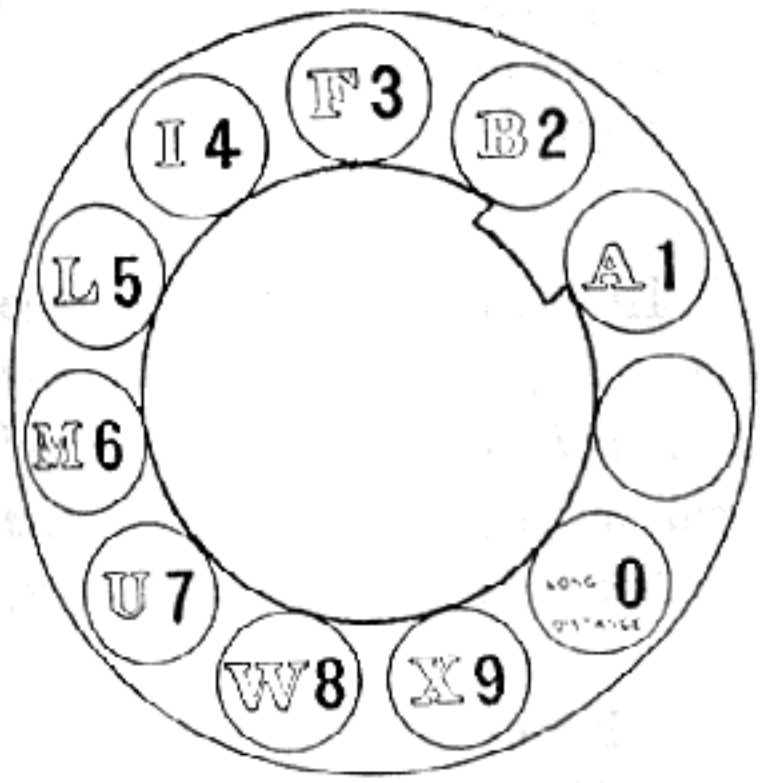
The locking magnet LM, operates to force its springs together and draw retaining arm RA, from locking segment L. Again if the retaining arm be resting against locking segment L, but has not yet fallen into a slot, it will hold the springs of relay LM, in contact. The operation of the solenoid control is explained in fig. 8,442.

FIG. 8,443.—*Text continued.*

through to the wipers. A part of the plunger circuit associated with the called line is shown at the right. When relay A, releases after dialing, a circuit may be traced from "*off normal spring ground*", *low winding of relay W, break springs relay A, break springs relay W, private wiper, through the B.C.O. of the called plunger to battery and ground.* The B.C.O. of the called plunger will clear the called line of attachments, and relay W, will operate sufficiently to close springs X. When this condition obtains, a circuit may be traced from "*off normal spring ground,*" *make springs relay W, high winding of relay W, to battery and ground.* The current in this circuit fully operates relay W. Direct ground is now placed on the private bank contact by springs of relay W, *so slowly* that the B.C.O. of the called plunger will have sufficient time to clear the called line of attachments before W, cuts the connector through to the wipers. The springs of W, are of the *make before break* type so that the B.C.O. will not be opened.

Clearing the Called Line.—When a telephone is called it is necessary that the line be cleared from battery and ground feed. This is called "clearing the line of attachments" and is illustrated and explained in fig. 8.443.

2. MULTI OFFICE SYSTEMS



Up to this point only a 100 line, single office exchange system with 10 connector switches has been considered However, in practice, a single office may contain any number of lines. There is no limit either way. A recent single office installation at Norfolk, Va., of 11,500 lines is at the present, the largest single office in existence.

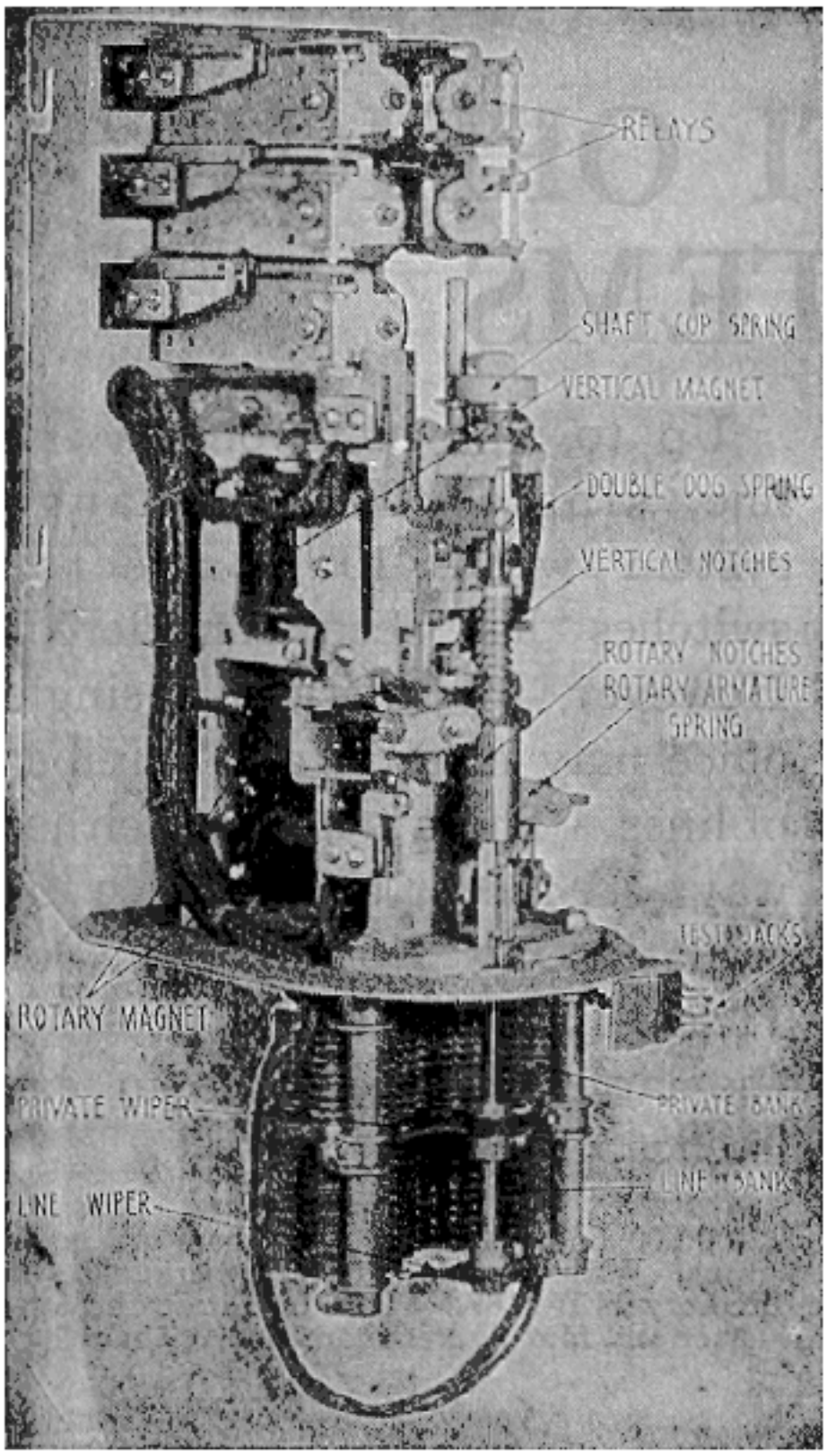
FIG. 8,445.—Multi-central station dial. On all 100,000 line systems the numbers are made up of a letter and four figures instead of five figures. With this method of numbering 26,187 would, for instance appear in the telephone directory as B-2187. When operating the calling device many subscribers will remember a letter and four figures more clearly than they will five figures.

The grouping of lines in multi-office exchange system is, with respect to the exchanges strictly according to number.

Thus, assuming 100 line units, telephones numbered 1 to 99 are wired to exchange A, those numbered 100 to 199, to exchange B, etc. At each of these exchanges is a set of ***connector switches, through which connection is made with any subscriber's line which terminates at the same exchange.***

Now if a subscriber whose line terminates at exchange A, desire

to talk with a subscriber where line terminals at exchange B, *he must first obtain connection to an idle connector switch in exchange B*, and in order to do this a new piece of apparatus *called a* ***selector switch*** *is necessary*, as shown in fig. 8,446.



It looks, and is very much like a connector switch; in fact the mechanism and banks are the same. Its mechanism gives the familiar vertical and rotary motion to a shaft and wipers and differs from the selector switch in the circuits and relays only.

In any multi-exchange system, the selectors *are divided into a number of classes according to the size of the group they are to choose.*

For example, in a 10,000 line system first selectors would choose the 1,000 line group, and second selectors the 100 line unit.

FIG. 8,446.—Stronger type selector with banks. ***It consists of*** a group and trunk choosing switch. Like the connector it comprises the usual shaft, bank, and wipers, and a mechanism whereby the shaft can be lifted and rotated step by step. Unlike the connector, however, it is a one digit switch. The vertical motion is controlled from the calling device and serves to pick out a certain group of lines. The rotary motion is automatic and picks out an idle trunk leading to that group.

The bank contacts of the selector switches are terminals of trunk lines instead of subscribers' lines.

The first or lower row of first selector bank contacts constitutes the terminals for a group of 10 trunk lines leading to second selector switches in the **1,000** section of the plant.

The second row represents another group of 10 trunk lines to second selectors in the **2,000** section of the plant, the third row represents a group of trunks leading to second selectors in the **3,000** section of the plant, etc., so that through the 10 rows of bank contacts the first selector has access to 10 second selectors in each of the 10 sections of 1,000 lines which make up a 10,000 line office.

The first selector switch used by a calling subscriber is operated *in accordance with the first digit of the number he calls.*

Suppose, for example, he is calling the number **2,543.** The impulses sent in by the first movement of his calling device will raise the shaft, and accordingly the wipers of the first selector switch two steps, placing each wiper opposite the row of bank contacts second from the bottom in its respective bank.

Now the selector switch unlike a connector switch, does not wait for the subscriber to make another turn of his dial before rotating its shaft, but the rotation is automatic and beyond the subscriber's control.

The rotation starts the instant the vertical movement is completed, and, in the particular case which is here used as an example, sweeps the wipers step by step over the row of bank contacts connected to trunks leading to the **2,000** section.

At each step of the rotation, the bank contacts on which the wipers then rest are given the busy test, and as soon as a disengaged trunk line is found the rotary movement stops and the connection is completed to an idle second selector. This is all accomplished in a fraction of a second, so that the second selector is operated by the subscriber's calling device impulses corresponding to the second digit **5,** of the number **2,543** which he is calling.

The wipers of the ***second*** *selector* are accordingly raised five steps and are then automatically rotated just as the first selector wipers were. The bank contacts of this second selector are the terminals of the trunks to the 10 sets of connectors which complete the connections to the line groups making up the **2,000** section of the plant. Consequently when the second selector wipers stop on an idle trunk in the fifth multiple, the calling subscriber is placed in connection with an idle connector in the **2,500** group; that is, a connector which has access to the desired subscriber's line No. **2,543.** This connector is then operated by the last two movements of the subscriber's calling device, and performs the functions of an operator in the manner already described at some length.

Fig. 8,447 illustrates this grouping arrangement and shows the connection just described from the calling telephone to a first selector, then from the second row of first-selector bank contacts to a second selector in the **2,000** section of the exchange, then from the fifth level of this second selector's bank contacts to a connector switch in the **500** group of the **2,000** section, and then through the fourth row of the bank contacts of this connector to the called telephone.

It is readily understood that by thus using a first selector to

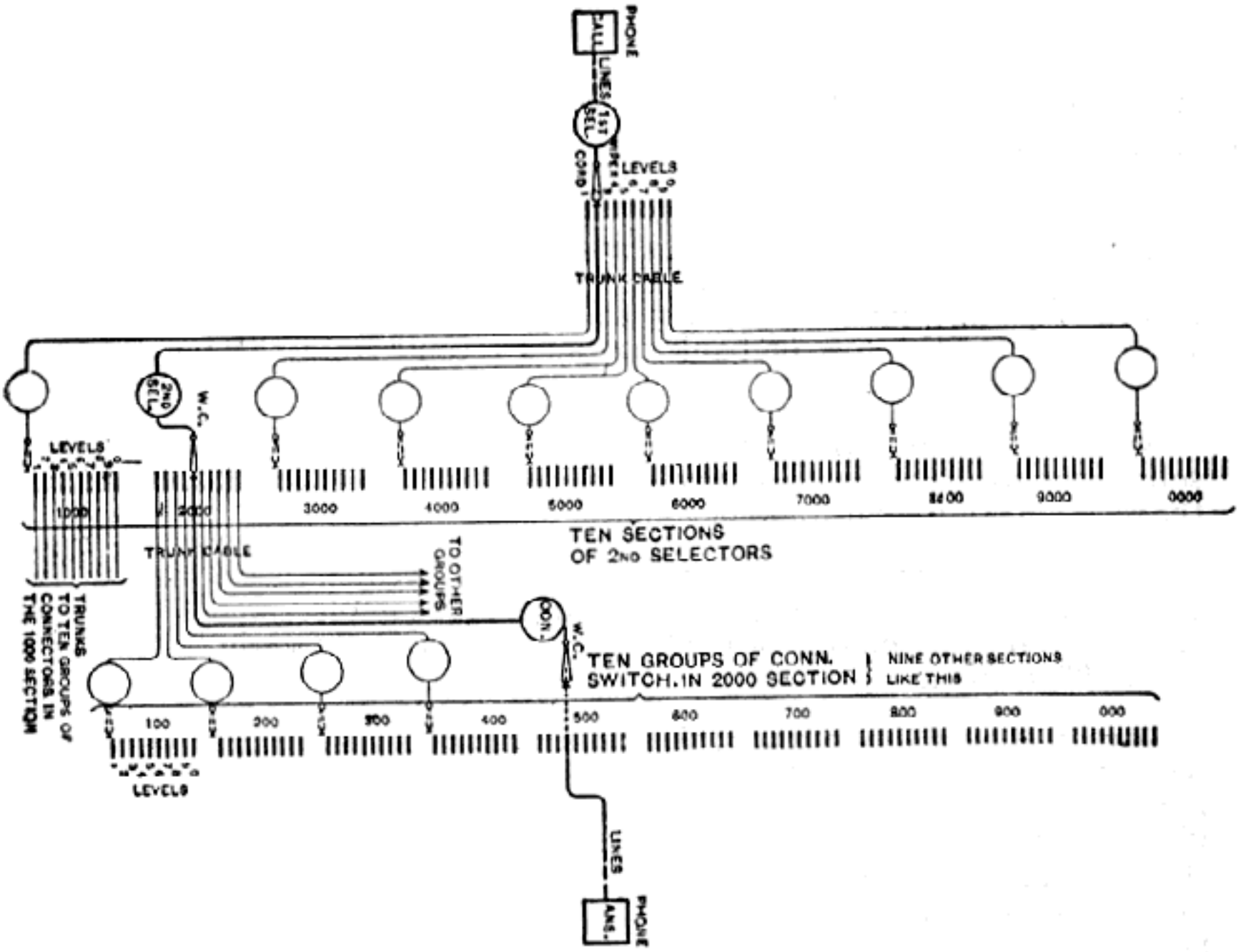


FIG. 8,447.—Diagram illustrating working of the multi-exchange system *by means of* ***selector switches.*** As shown, connection has been made by a subscriber with phone No. 2,543, by means of ***first*** and ***second*** *selector switches* and a connector switch, the latter located at the central station at which the line of the subscriber called terminates.

pick out a trunk to any one of ten different **1,000** sections, second selectors in each section to pick out trunks to any **100** group in each **1,000**, and then by using the connectors to complete calls to individual lines in each **100**, that connection may be made by the use of three switches from any calling telephone

to any number from **0000** to **9,999** or in other words to **10,000** different numbers.

It will also be readily understood that by using a fourth switch, called a third-selector switch, and using numbers with five digits instead of four, that the capacity of the system will be multiplied by ten and will be 100,000 lines instead of 10,000.

In a system of 100,000 lines, **10,000** numbers are generally set aside for

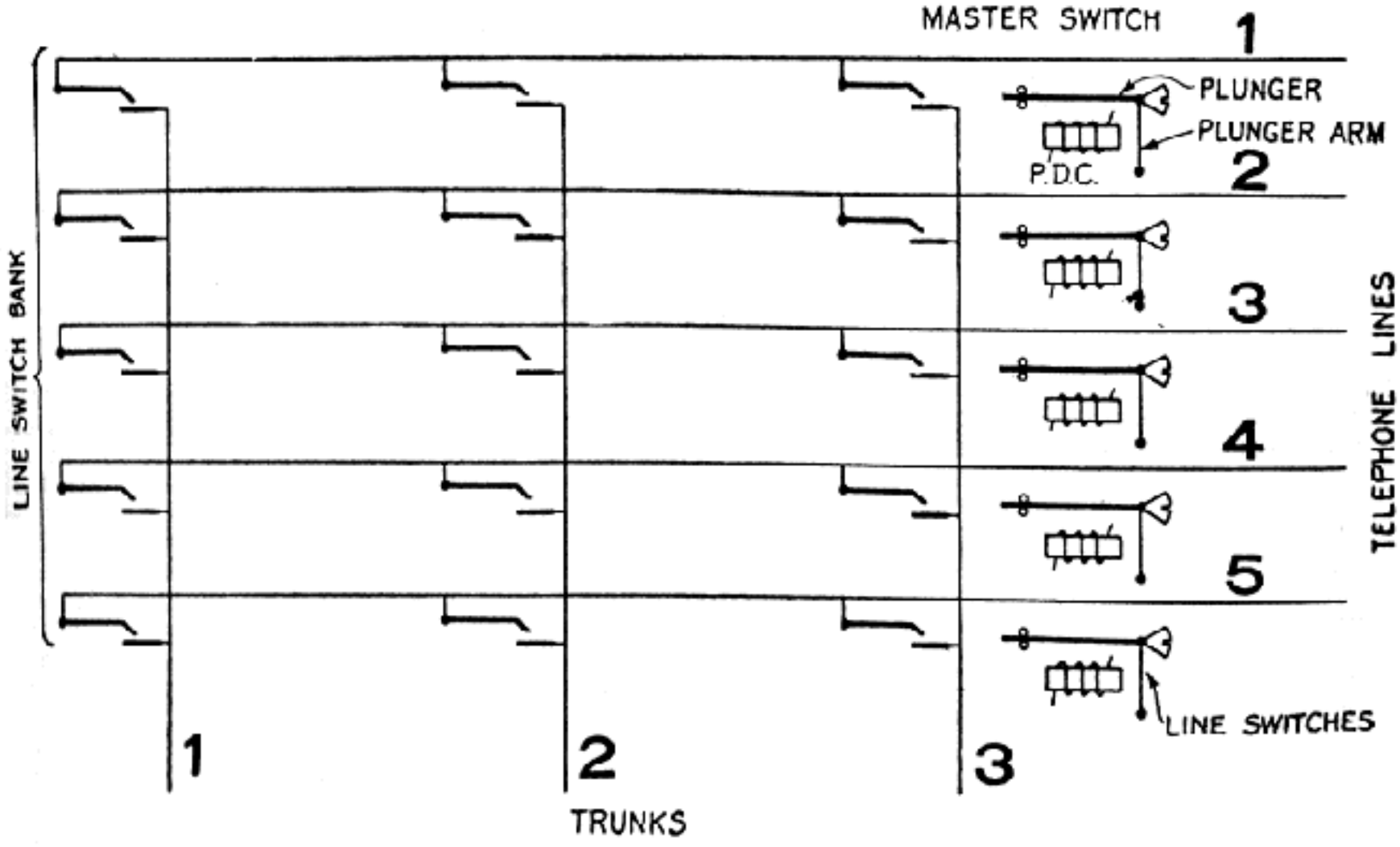


FIG. 8,448.—Diagram showing relation between the lines and the trunks at the line switch banks. Although only three trunks are shown, it must be understood that there are always ten, and the number of lines may be anywhere from 25 to 100. Assume that the position of the master switch is such that each line switch plunger is pointing opposite its set of contacts belonging to trunk No. 3. If a call be originated on say line No. 3, the plunger of that line switch will operate to close its pair of contacts on trunk No. 3, thus connecting the line with the trunk. At the same time the master switch operates to move the remaining plungers until they are resting opposite the contacts of line No. 2, (assuming that trunk to be idle). The next line switch being used will take trunk No. 2 and the rest of the plungers will take up a position opposite the next idle trunk. It must be understood that the trunk finding movement takes place from No. 10 to No. 1. The master switch does not preselect trunks in moving from No. 1 to No. 10, but passes over them without stopping.

each main central office. Consequently on each call the first selector picks a trunk to the desired office, the second selector picks a trunk to the desired **1,000** in that office, the third selector picks a trunk to the desired **100** and the connector completes the connection to the desired line.

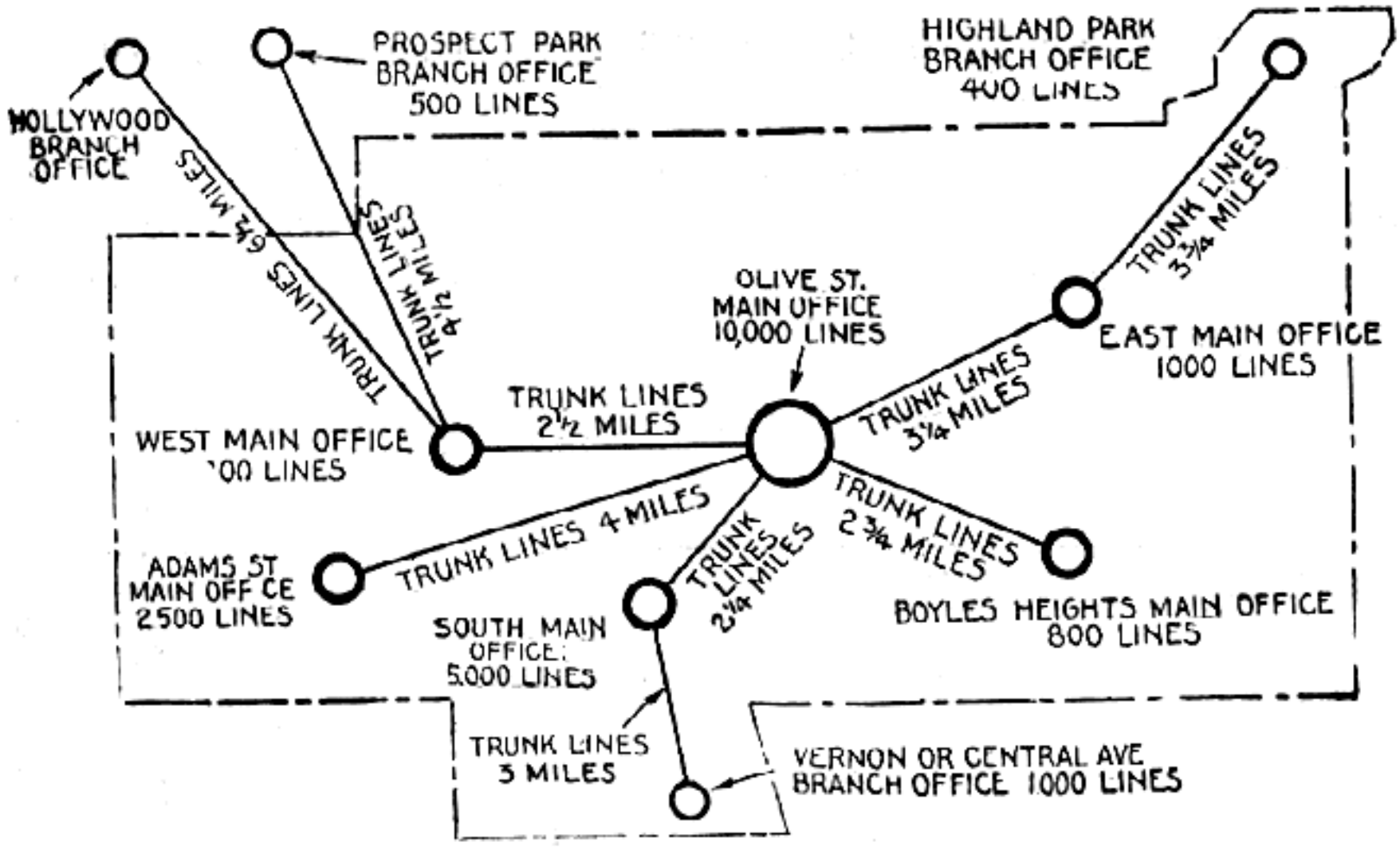
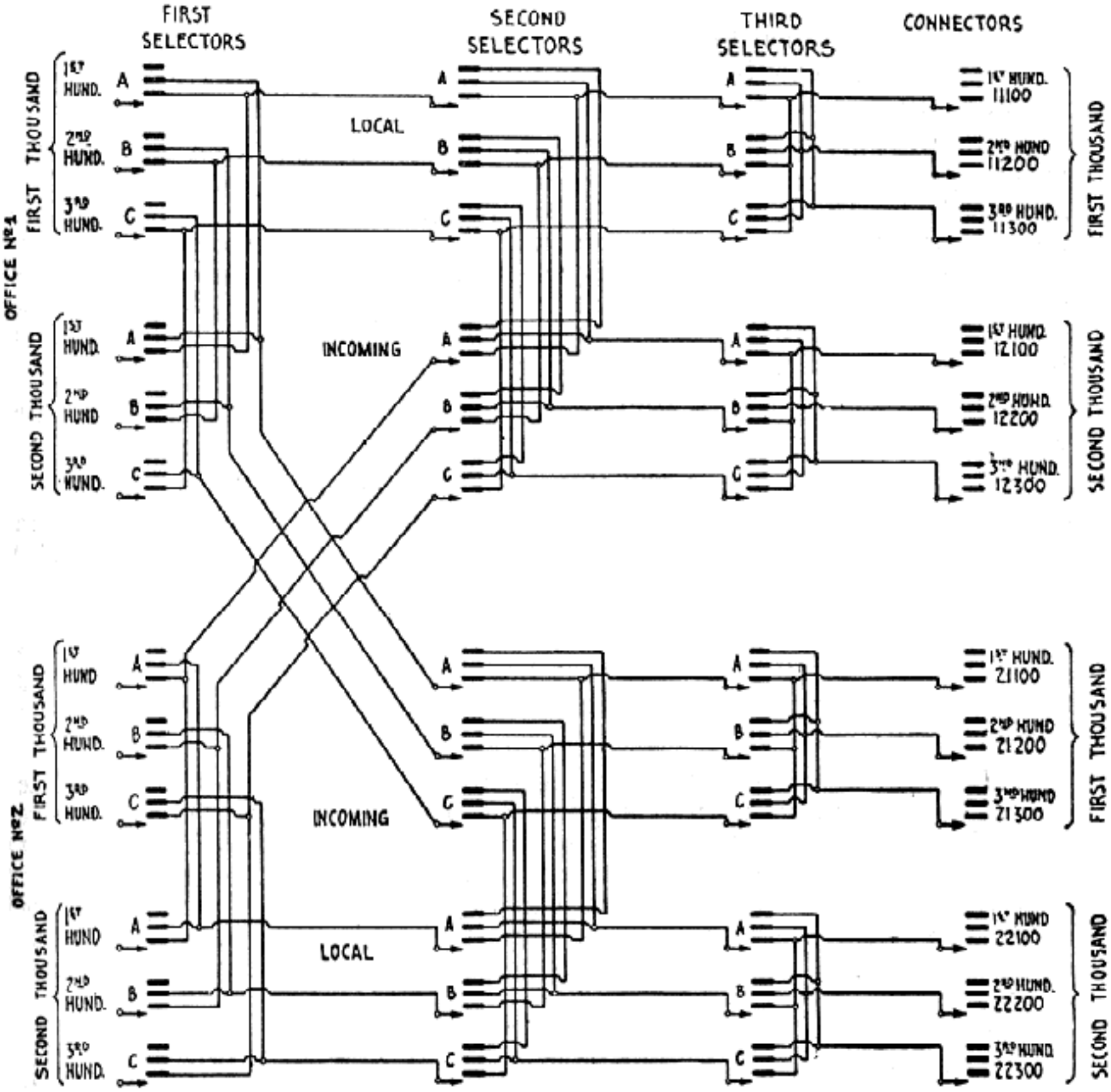


Fig 8,449.—Diagram of automatic telephone system installed at Los Angeles, Cal. As shown there are six main offices, each with an ultimate capacity of 10,000 lines. The Olive Street main office is now equipped for 10,000 lines, West for 4,000 lines, Adams for 2,500 lines, South for 5,000 lines, Boyles for 800 lines and East for 1,000 lines. The numbers in the South Office all commence with **29,000**. Those in Olive Street Office all commence with **60,000** etc. South office has a branch office called Vernon; West office has two branches which are called Prospect Park and Hollywood; East office has a branch called Highland Park. The numbers in each branch office commence with the same digit as the numbers in the main office to which it connects. That is: one of the sections of **1,000** numbers are taken from the main office and are set aside for use in the branch. For example: the lines now equipped in South office are numbered from **21,000** to **25,000** and the numbers in its branch Vernon run from **29,000** to **29,999**. It is ,of course, unnecessary for a calling subscriber to know to which office he is connected or to which office the party he desires to call is connected. The trunking between offices is all automatic. A subscriber, for instance, in the South office, who, on the first move of his dial turns it from the number **2**, will automatically select a local trunk line to a second selector in South office. If he make the first turn from the number **3**, a first selector at South office will automatically connect him to a trunk line terminating in a second selector at East office. Or, if he make the first turn from the number **6**, the first selector at South Office will automatically select an idle trunk to Olive Street office, etc. Suppose, a subscriber connected to the South Office wish to call **62,127**, which is an Olive Street office number. The first movement of the dial operates a first selector at South office, and extends the connection over an idle trunk to a second selector switch in the Olive Street office. The second digit **2** will operate the second selector at Olive Street office, and extend the connection to a third selector in the **2,000** section of the Olive Street switchboard. The third digit **1** will extend the connection to an idle connector switch in the **100** group of the **2,000** section. The last two digits will operate this connector switch and complete the connection to **27** in this particular **100**. Suppose, again, that a South office subscriber is calling **39,143** which is in the Highland Park branch office. The first movement of the dial operates a first selector in the South office and selects a trunk to a second selector in the East Main office. The second movement of the dial raises the shaft of this second selector nine steps, and selects an idle trunk to a third selector in the Highland Park branch office. The third movement extends the connection through a local trunk in the Highland Park branch office, to an idle connector in the **100** group, and the last two motions of the dial result in the completion of the connection to **43** in that particular hundred. The time required to complete a connection and the number of machines used is independent of the number of offices through which a connection may be trunked.



INTER OFFICE TRUNKING (100.000 LINE SYSTEM)

FIG. 8,450.—100,000 line automatic telephone system. Such a system is necessarily divided up into several offices, because it is too large to be placed in one. The ideal distribution would have 10 offices of 10,000 lines each. The details of switch connections may be illustrated by using only two offices. Each office is somewhat like an ordinary 10,000 line exchange. There are 10 connectors for each 100 lines and there are 100 selectors which deliver traffic in a given thousand, consisting of 10 hundreds. These selectors are now called third selectors, although their function is exactly the same as that of the second selectors in a 10,000 line system. Back of the third selectors are other selectors whose duty it is to choose thousands. The banks of the first selectors in the 100,000 line system distribute traffic to the offices of levels. One level will be the local level, because it runs to second selectors in the same office. All the rest of the levels trunk out to other offices. All the trunks from the given level of first selector banks run to a given office and any trunk serves as well as any other. They can all be formed into one group by means of secondary line switches. This is common practice. The incoming trunks end on incoming second selectors. Their banks are multiplied to the banks of the local second selectors in such a manner as to mingle the traffic as uniformly as may be done.

Systems of 100,000 lines capacity have been installed in a number of different cities. One of the most notable is that in Los Angeles, as shown in fig. 8,449.

In multi-central installations, each line terminates at a line switch. The line switch is not under the control of the subscriber, but connects him automatically to an idle first-selector switch the instant he removes his receiver from his switch hook preparatory to making a call. The first-selector is, therefore, operated by the first impulses transmitted from the subscriber's calling device just as in the older systems. When the line switches are used, 10 first selectors for each 100 lines are generally sufficient to handle the traffic.

Each line switch (fig. 8,438) includes the line and cut off relays with which each line is equipped just as in manual practice.

Ordinarily the banks of 100 line switches are multiplied together and connected to 10 first selector trunks, but for four-party line service or extra heavy traffic, the number in one multiple is often reduced to fifty. Fig. 8,430 shows a front view of a complete line switch unit with 100 line switches and two master switches mounted. Only one master switch is used at a time the other being held in reserve. Fig. 8,431 is a rear view of the same unit showing how the 10 connector switches used for handling calls incoming to any 100 lines are mounted on the same upright as the line switches handling their outgoing calls.

While the primary object of the line switches was to reduce the cost of the switch board by eliminating 90 per cent of the comparatively expensive first selector switches, they have also simplified the central office equipment and have reduced the space required for it. Further, they have resulted in several new and somewhat radical departures in the art of building automatic telephone systems. The most important of these is the line switch district station which enables very considerable savings to be made in underground and aerial cable.

A district station is installed by placing one or more line switch units complete with connector switches in a small building at the telephonic center of a district, generally a mile or more distant from the nearest central office. The lines of all telephones in the district are brought to the district station and are there connected to the line switches. The first selectors to which these line switches are trunked remain at the nearest large central office, consequently when a district station subscriber removes his receiver from his switch hook preparatory to making a call, his line switch instantly puts him into connection by means of a trunk with a first selector switch at central office. The connector switches for handling the calls to the district station telephones are mounted in their usual places on the back of the line switch units, and are connected by trunks to the banks of second selectors, also located at the nearest central office. Thus all calls from and to the district are handled over trunks instead of over subscribers' lines.