AUTOMATIC TELEPHONE PRACTICE

BY

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TO
MY FATHER

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Chapter I

Theory of the One Hundred Line System.

In order to reduce the subject of automatic telephony to such a form as can be readily understood, we will, for some time to come, limit ourselves to a discussion of a one hundred line system. Imagine, if you will, one hundred telephones scattered around the city, each telephone being connected with the Central Office by two wires. The first question that confronts us is the arranging of the terminals of these wires in some systematic manner. By referring to Fig. 1 it will be seen that we have provided what is termed a line bank, which consists of one hundred sets of double contacts. These double contacts are placed in rows, ten wide and ten high. The two wires from each telephone are connected to the pair of contacts corresponding to the number of that particular telephone.

Numbering Scheme Used in Automatic.

This brings us to a consideration of the system of numbering used in an automatic switchboard. At first thought you will probably conclude that the original designer was endeavoring to find the most complicated numbering system possible. But after becoming acquainted with its peculiarities you will begin to see the simplicity of the arrangement. Assume that we are standing just below the lower left-hand corner of the rectangle. If we take one step up and one step to the right we are connected with a telephone whose number is 11. From the same position as before, if we take three steps up and four steps to the right, we are connected with telephone number 34. Thus it will be seen that the number of any telephone may be found by noting the number of steps up (vertical steps) and the number of steps to the right (rotary steps) necessary to reach its terminals. Thus 1 vertical step and 0 rotary steps gives us telephone number 10, since in automatic practice 0 always means 10. Again, 0 vertical steps and 1 rotary step gives us telephone number 01.

Functions of the Connector Switch.

Since we have obtained an idea of the arrangement of the terminals in the office we will now discuss the means by which a subscriber can cause his telephone to be connected with any other telephone. Since this is an automatic exchange, it has no operators, so it is necessary to provide a mechanical and electrical mechanism which may be controlled by the

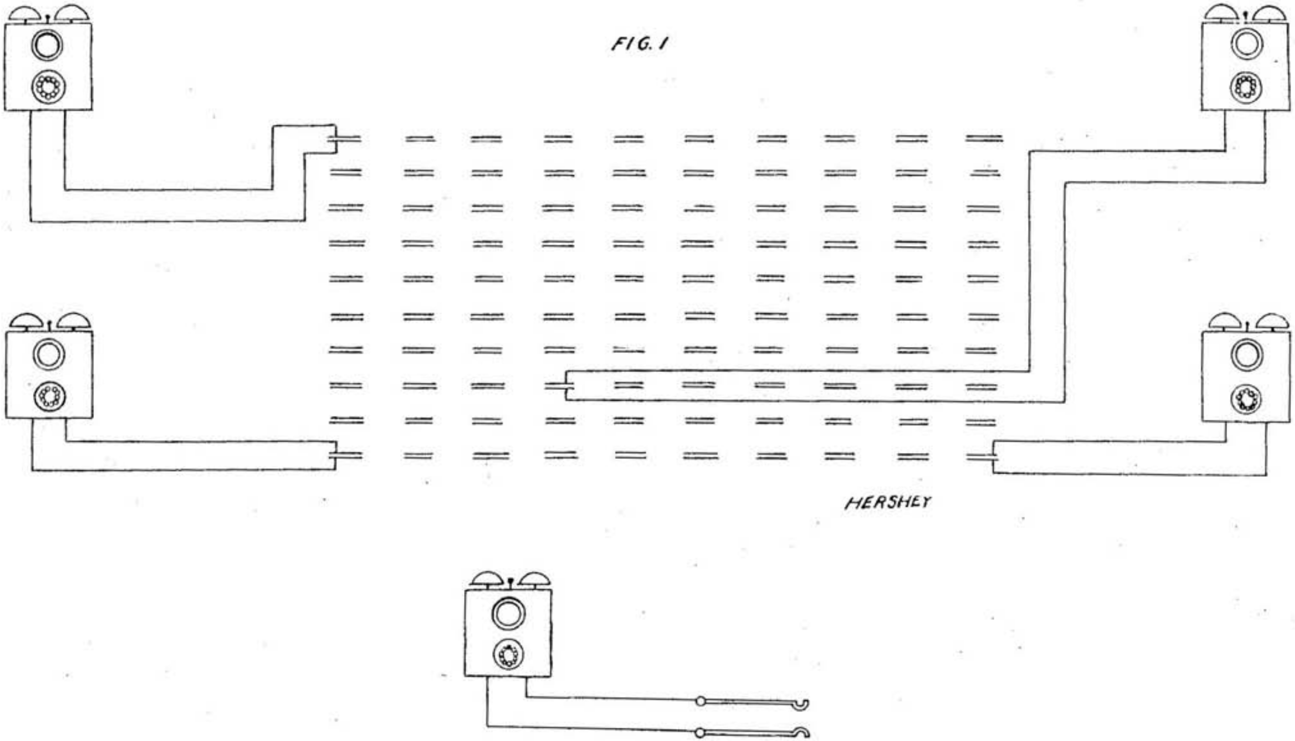


FIG. 1

subscriber in such a manner as to accomplish the following results, which are usually spoken of as the functions of the Connector Switch:

A. **Reach the called line.** Means by which the wires from the calling telephone may be moved up and in, to make contact with any desired telephone.

B. **Test the called line to see if it is busy.** This must be done without disturbing the subscribers who are using the line, should it be in a busy condition. If the called line is busy the machine must advise the calling subscriber of the fact, and must prohibit the subscriber from calling another number until after he has released the present connection.

C. **Protect the called line from intrusion.** That is, it must arrange matters so that should a second party attempt to call this line he would find it in a busy-condition.

D. **Clear the called line of attachments.** Which means to disconnect the mechanism which is normally attached to the called line.

E. **Signal the called subscriber.** The ringing to be done intermittently until the subscriber answers, or the calling party releases. When the called party answers, the ringing must cease without annoying the called subscriber.

F. **Feed talking battery to the calling and called subscribers.** The mechanism must furthermore provide what is termed supervision, in case the call originated at a toll board.

G. **Release of the connection.** The machine must provide means by which the restoration of the receiver to the switch hook at the calling telephone will release the mechanism and place it in readiness to make another call.

Questions.

A. In Fig. 1 point out the terminals of the following telephones: 19, 81, 23, 99, 50, 12 and 00.

B. In a one hundred line system how many line banks would you expect to find?

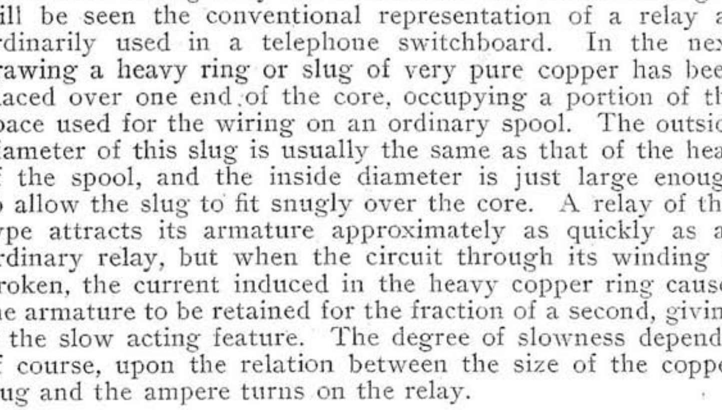
C. What is meant by the term, "individual connector"?

Chapter II

Theory of the Slow Acting Relay.

Before proceeding further with our study of the Connector Switch it is essential that the operation of the so-called slow acting relay be understood. At the left in Fig. 2 will be seen the conventional representation of a relay as ordinarily used in a telephone switchboard. In the next drawing a heavy ring or slug of very pure copper has been placed over one end of the core, occupying a portion of the space used for the wiring on an ordinary spool. The outside diameter of this slug is usually the same as that of the head of the spool, and the inside diameter is just large enough to allow the slug to fit snugly over the core. A relay of this type attracts its armature approximately as quickly as an ordinary relay, but when the circuit through its winding is broken, the current induced in the heavy copper ring causes the armature to be retained for the fraction of a second, giving it the slow acting feature. The degree of slowness depends, of course, upon the relation between the size of the copper slug and the ampere turns on the relay.

FIG. 2



Mechanics of the Subscriber's Dial.

A fundamental requirement in automatic telephony is that a device be provided at the sub-station by means of which the subscriber can 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. This device takes the form of a dial, pivoted at the center so that it may be turned in a clockwise direction. (See Fig. 3.) For convenience in turning it has finger holes, ten in number, around its outer edge. Through each hole a figure appears; these figures run consecutively from 1 to 0 as shown. To call the figure 3, for instance, the subscriber places the tip of his finger in the hole through which the 3 appears and turns the dial to the right until his finger strikes the stop, where-

FIG. 3.

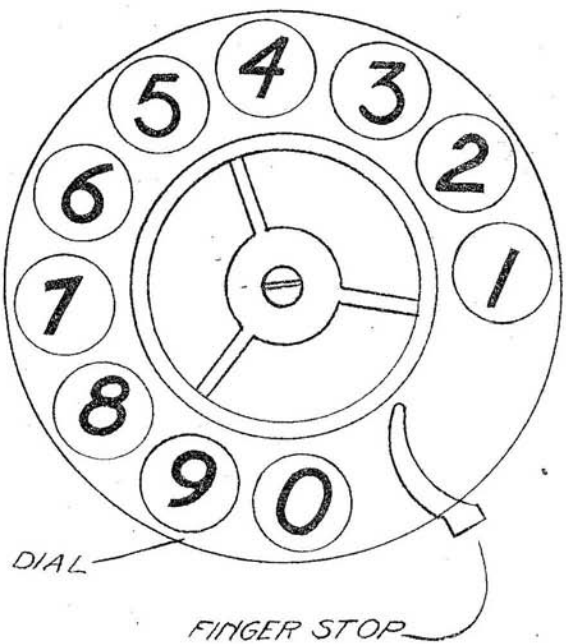
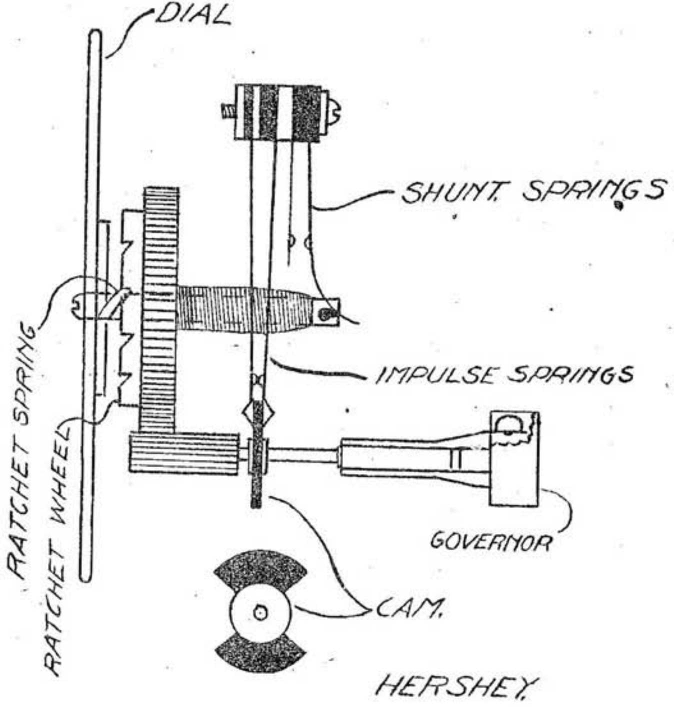

5
4
3
2
1
6
7
8
9
0
DIAL
FINGER STOP

FIG. 4.


DIAL
SHUNT SPRINGS
IMPULSE SPRINGS
RATCHET SPRING
RATCHET WHEEL
GOVERNOR
CAM.
HERSHEY.

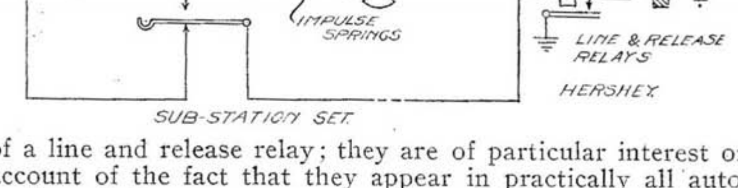
upon the finger is removed and the dial returns to normal under the influence of a spring, which was wound as the dial was turned in a clockwise direction.

In Fig. 4 we have another view of the same calling device. At the left may be seen the moving element or dial. As the dial is rotated in a clockwise direction no motion is transmitted to the gear train; the only result obtained is the winding of a coiled spring. Upon the removal of the finger after it has reached the stop, the dial will return to normal under the influence of the previously mentioned spring. By means of a ratchet this counter-clockwise movement is transmitted through the gear train to the governor, which will insure a uniform speed. In addition to operating the governor, the gear train causes the cam to be revolved in such a manner that it opens the impulse springs. The gear ratio is such that when 1 is called on the dial the cam will make one-half revolution, thus opening the impulse springs once. Thus it will be seen that whatever number may be called on the dial, the impulse springs will be opened a like number of times.

The Relation of the Subscriber's Dial to the Line Relay.

In Fig. 5 is shown a diagram which represents the circuit arrangement at a sub-station. This consists of the ordinary switch hook, transmitter, receiver, ringer and condenser, and in addition a set of impulse springs and a set of shunt springs. At the right of Fig. 4 is shown the circuit

FIG. 5



SUB-STATION SET

of a line and release relay; they are of particular interest on account of the fact that they appear in practically all automatic switches.

When the receiver is removed at the sub-station a circuit may be traced from negative battery, through the upper winding of relay L, transmitter, receiver, impulse springs, upper contact of switch hook, lower winding of relay L to ground. The current flowing in this circuit will cause relay L to energize. Relay L, upon energizing, will close a circuit from negative battery through relay R, make springs on relay L to ground, whereupon relay R will become energized. Now let us assume that the subscriber dials the figure 1. When the dial is released and as it returns to normal, the cam is given a half turn, and one of its wings momentarily forces the impulse springs apart as it passes between them. This momentarily opens the circuit of line relay L, relay L de-energizes for an instant and in turn opens the circuit of release relay R. Relay R remains energized even though its circuit was opened momentarily, for the reason that it is a slow acting relay. If the subscriber had dialed the figure 4, the cam would have been rotated twice, thus opening the line circuit 4 times. From the foregoing we can conclude that for each figure called by the subscriber the line circuit will be momentarily opened a like number of times. From the discussion so far it is evident that each time the dial is operated a series of clicks will be heard in the receiver. To overcome this a pair of shunt springs are provided as shown. As soon as the dial is moved to an off-normal position these springs come together and maintain a shunt around the transmitter and receiver until such time as the dial returns to normal. It is evident that if the shunt springs were not used, the resistance of the subscriber's loop might vary, during the dialing period, due to a change of resistance in the transmitter. This would tend toward irregular operation of the Central Office mechanism and is obviated by using a shunt around the receiver and transmitter during the dialing period.

Questions.

A. Assuming that the ampere turns remain the same, what would be the effect of increasing the amount of copper in the slug?

B. Assume that the coil is to be wound with 28 gauge wire and that the slug is one-half inch long. If we double the length of the slug will it double the slow acting feature of the coil?

C. What will be the effect if the slug is ever so slightly cracked?

D. What would be the effect if a subscriber attempted to force the dial back to normal? If the subscriber retarded the return of the dial?

E. If the subscriber should hold the dial in an operated position, would be be able to talk?

F. If the shunt springs failed to make contact, what would be the result?

Chapter III

Mechanics of the Connector Switch.

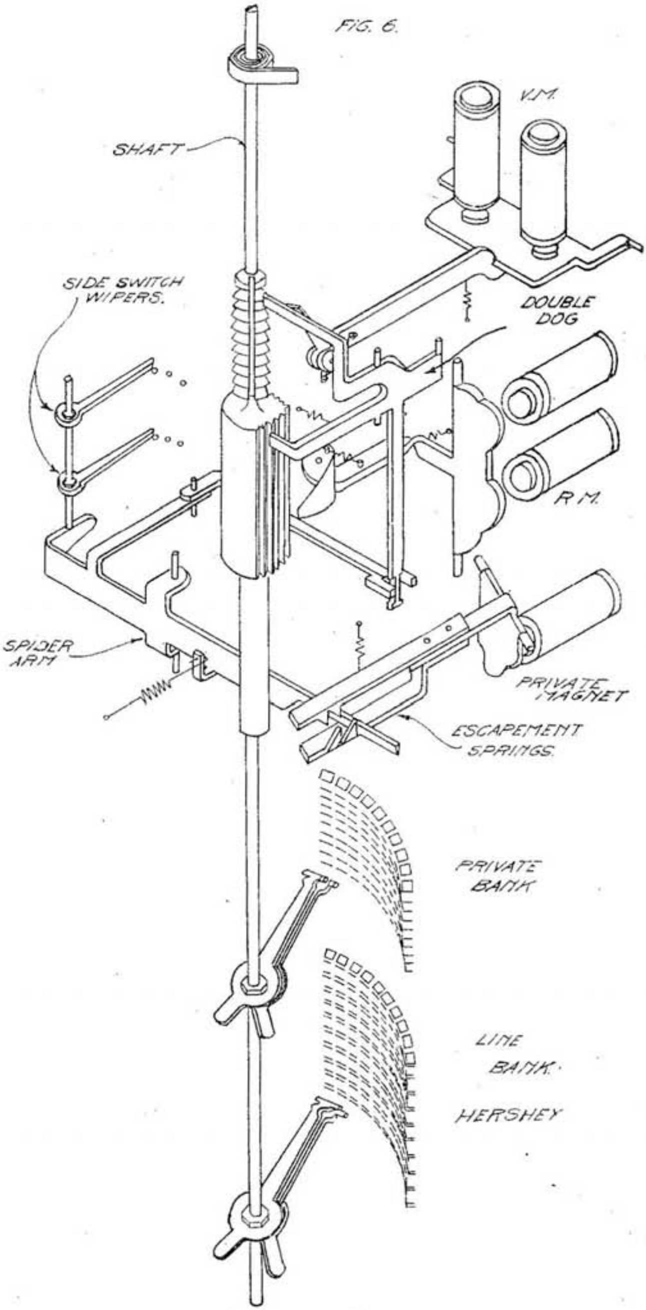
The connector switch as shown in Fig. 6, consists primarily of a shaft which is capable of a step by step vertical movement, following which it is capable of a step by step rotary movement. The lower extremity of the shaft carries two wipers; the lower or line wiper is a double wiper and is intended to make contact with the bank shown in Fig. 1. The upper or private wiper is a single wiper and is intended to make contact with a bank similar to the one shown in Fig. 1, except that it is made up of 100 single contacts and is always placed directly above the line bank. Midway of the shaft may be seen the vertical teeth by means of which the shaft may be raised step by step; just below is the hub which bears the rotary teeth, by means of which the shaft may be rotated step by step. At the top of the shaft may be seen a coiled spring.

It is this spring which causes the shaft to return to normal from a rotated position. Upon releasing, the force of gravity is utilized to lower the shaft from a raised position. At VM is shown a pair of vertical magnets, which, by means of their armature and the pawl at its end, raise the shaft one step each time they are energized. The double dog is merely a ratchet intended to hold the shaft in an operated position. At RM is shown a pair of rotary magnets, which, by means of their armature and the pawl at its end, rotate the shaft one step each time they are energized. The double dog also acts as a ratchet for the rotary movement, hence the name, "Double Dog."

Side Switch, Spider Arm and Private Magnet.

We now come to what is perhaps the most interesting feature of the entire subject of automatic telephony. Reference is had to the relay composed of the side switch at the left, the spider arm in front and the private magnet at the right. The side switch in this case is made up of two wipers; they are mounted on one block and swing on two pivots, so that both move together. The side-switch has three positions, each wiper having, therefore, three contacts. Attached to the side switch block is the spider arm by which the movements of the side switch are controlled. The spider arm has a tendency to move the side switch from position 1 to position 3. This is resisted by the escapement which is mounted on the private magnet lever. See Fig. 7 (a). This escapement

FIG. 6.


SHAFT
V.M.
SIDE SWITCH WIPERS.
DOUBLE DOG
R.M.
SPIDER ARM
PRIVATE MAGNET
ESCAPEMENT SPRINGS.
PRIVATE BANK
LINE BANK.
HERSHEY

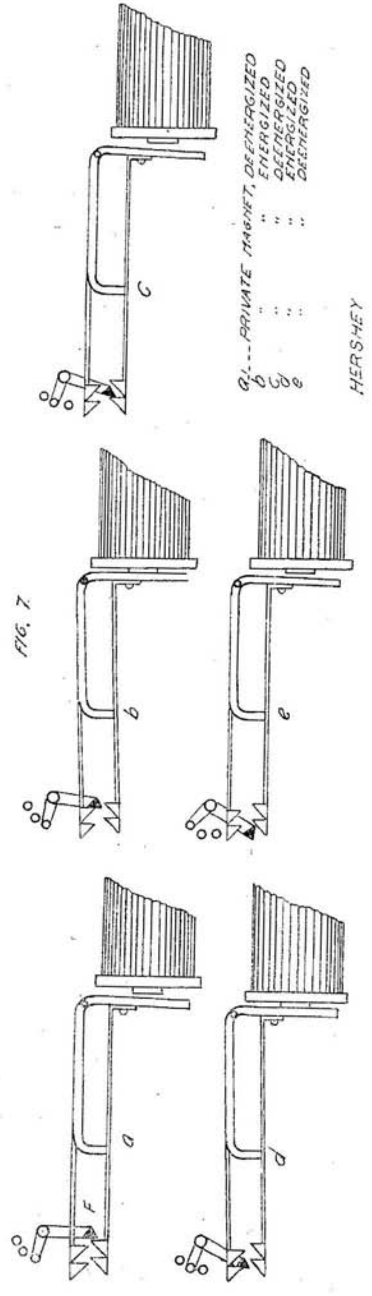

F
a
b
c
d
e
a.....PRIVATE MAGNET, DEENERGIZED
b " " ENERGIZED
c " " DEENERGIZED
d " " ENERGIZED
e " " DEENERGIZED
HERSHEY

FIG. 7

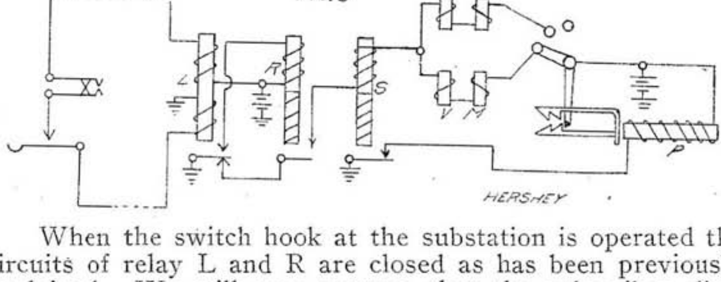
is composed of four teeth, two on the upper spring and two on the lower spring.

The triangular piece marked F is the end of the spider arm, and owing to the force of the spider arm spring, it tries to move to the left. When the private magnet is energized, the springs on its lever move downward, allowing the finger F to slip forward a little and to rest against the first upper tooth. See Fig. 7 (b). Although this allows the side switch wiper to move a little, the motion is so slight that it does not change the electrical conditions. When, however, the private magnet is de-energized, the spider arm finger F is unable to catch on the first lower tooth, but slips to the left and is caught by the second lower tooth. This allows the side-switch to move from position 1 to position 2. See Fig. 7 (c). A repetition of the energizing and de-energizing of the private magnet will result in moving the side-switch from position 2 to position 3. See Fig. 7 (d and e).

Circuit of Vertical and Rotary Magnets.

We are now ready to study the circuit by means of which the vertical and rotary motion is produced. Referring to Fig. 8 we have at the left a representation of the switch hook and impulse springs of a subscriber's station. Relay L is the line relay, the resistance of each winding is usually 200 or 250 ohms. Relay R is the release relay, the resistance of which is now 800 ohms. A few years ago it was common practice to make this relay 1,300 ohms. Relay S is termed the series relay, and is low in resistance so that the rotary and vertical magnets may operate through it. The resistance of this relay may be from one-half to four ohms. The rotary and vertical magnets usually have 26 ohms in each coil. The private magnet P is normally wound to 350 ohms.

FIG. 8



When the switch hook at the substation is operated the circuits of relay L and R are closed as has been previously explained. We will now assume that the subscriber dials the figure 6. As the dial returns to normal, the circuit of line relay L is momentarily opened 6 times. Each time the armature of relay L falls back it opens the circuit of relay R. Relay

R does not de-energize, however, on account of its being a slow acting relay. Each time the armature of relay L falls back a circuit may be traced from ground, through break springs relay L, make springs relay R, series relay S, vertical magnets, side switch wiper in first position, to negative battery. The current flowing in this circuit will cause the vertical magnets to energize six times and thereby lift the shaft step by step to the sixth level.

The first flow of current through the relay S will cause it to become energized, and since it is a slow acting relay it will maintain its armature in an operated position until a fraction of a second after the last impulse has passed through it. When relay S energizes, a circuit is closed through the private magnet P. The private magnet energizes, and, as has been previously explained, no change in the side-switch wiper takes place at this time. Shortly after the last impulse of current has passed through the relay S it will de-energize, which will open the circuit of the private magnet. The private magnet upon de-energizing, will cause the side switch wiper to pass to second position, as has already been explained.

All is now in readiness for the subscriber to call the second figure. Assume that the subscriber calls 5, the line circuit will be momentarily opened five times. And as before, the line relay L will operate to send a corresponding number of impulses through relay S. This time, however, the circuit through relay S is completed by way of the rotary magnets and side-switch wiper in second position.

The current flowing in this circuit will cause the rotary magnets to energize five times and thereby rotate the shaft and wipers step by step till the wipers rest on the contacts associated with telephone 65. At the first rotary impulse relay S will energize as before, and close a circuit through the private magnet. The private magnet will energize, but without changing the electrical condition at the side-switch. Shortly after the last impulse of current has passed through relay S, it will de-energize, which will open the circuit of the private magnet. The private magnet, upon de-energizing, will cause the side-switch wiper to pass to third position, in the manner already explained. The wipers of the connector switch are now standing on the bank contacts associated with the called line.

Questions.

A. Why are the rotary and vertical magnets made in pairs instead of utilizing single magnets?

B. In your opinion which movement would be the most difficult to produce, the vertical or rotary?

C. What would be the result if the coiled spring at the top of the shaft were too stiff?

D. What would be the result if the teeth on the upper and lower escapement springs were directly opposite each other?

E. What would be the result if the spider arm had a slight bind in the bearings?

F. What would be the result if the subscriber's line had a dead ground on the negative side? On the positive side?

G. What effect would be produced if the slug on relay R were cracked? If the slug on relay S were cracked?

H. If the private magnet were slow acting, what would be the result?

I. If in calling the number 22 the private magnet failed to operate, what would be the result?

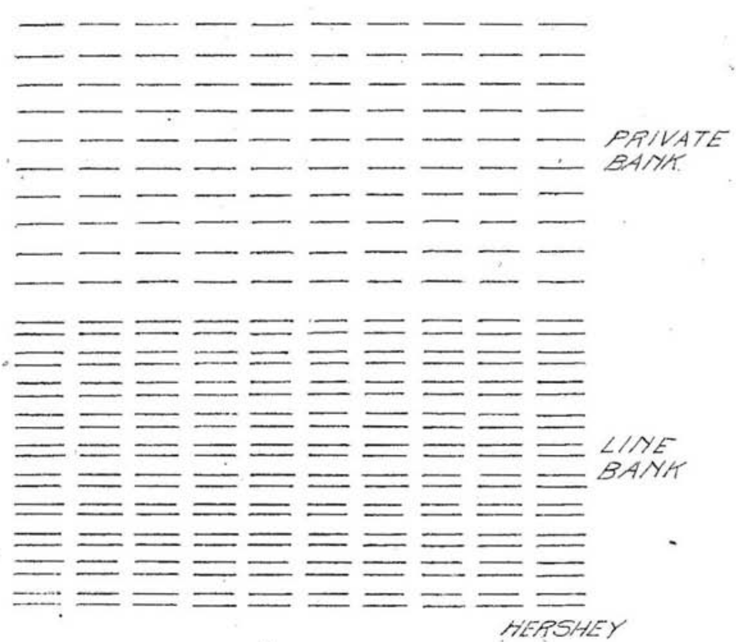
J. If one winding of relay L were reversed would the relay operate?

K. If the winding of relay S were reversed would it still retain its slow acting feature?

Chapter IV

Explanation of the Private Bank.

In the preceding chapter mention was made of the private bank. This bank (See Fig. 9) consists of one hundred single contacts, ten contacts in each level and ten levels high. The object of the private bank is to supply means by which a line may be protected against intrusion, when that particular tele-

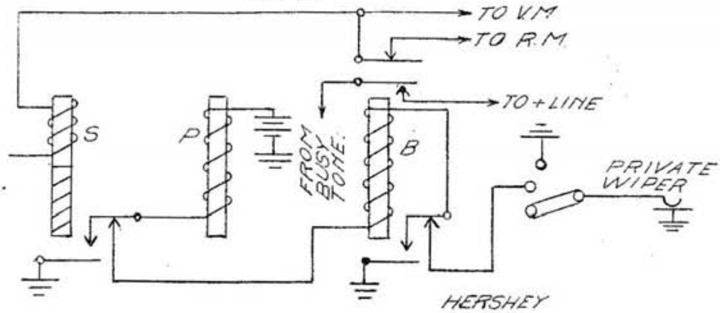


phone is in use. We have found that each telephone is connected to a certain pair of contacts in the line bank, the corresponding contact in the private bank is also associated with this line. For our present purpose it is sufficient to remember that whenever a telephone is in use the corresponding private bank contact is grounded.

Testing the Called Line for Busy.

Referring to Fig. 10 we find the series relay S and the private magnet P, which are familiar to us from the preceding chapter. The busy relay B is a low resistance relay, so that the private magnet may operate through it. The resistance is usually 30 ohms. The spring assembly on relays S and B illustrates what is called make before break springs. When the relay energizes the make spring strikes the movable spring, and causes it to break contact with the stationary spring.

FIG. 10



In the preceding chapter the wipers of the connector were advanced to the contacts associated with the telephone 65. We will assume that this telephone is in use, and that its private bank contact is grounded. When the series relay S de-energizes, following the secession of the rotary impulses, there will be an instant when all three springs on relay S are engaged. At this time a circuit may be traced from ground at the private bank contact, through private wiper, side-switch in second position, break springs relay B, relay B, break springs relay S, and private magnet P to negative battery. The current flowing in this circuit will cause the private magnet to remain energized and thereby lock the side-switch wiper in second position. Relay B will also energize, and will form a locking circuit for itself independent of the ground from the private bank contact. The circuit extends from ground through the make springs of relay B, relay B, break springs relay S, through private magnet to battery. In addition relay B closes a pair of contacts which place the busy tone on the positive line, as an indication to the calling subscriber that the called line is busy.

Locking on Busy.

The fact that the side-switch is locked in second position prevents interference with the subscribers who are using the busy line. When relay B is once energized it is independent of the ground on the private bank contact; this means that the calling subscriber will continue to receive the busy tone even though the called line should become idle. As shown in Fig. 10 there is no way to release the busy relay; this feature will be explained in a later chapter.

Prevention of Further Rotation.

It will also be noticed that the circuit to the rotary magnets is taken through a pair of break springs on relay B. If it were not for this, a subscriber while receiving the busy tone might again operate his dial, which would cause a further rotation of the connector and would result in a wrong number.

Guarding the Called Line Against Intrusion.

Let us now assume that the called line is idle, there will be no ground on the private bank contact and the side-switch will pass to third position following the de-energization of the series relay. When the side-switch passes to third position a ground is placed on the private bank contact, which will cause anyone calling this number to receive the busy tone, and thus the called line is guarded against intrusion.

Questions.

A. What would result if the lower make springs on relay B failed to make?

B. If the upper break springs of relay B were open how would it affect the operation of the switch?

C. If you called a line which was busy and did not get the busy tone where would you look for the trouble?

D. If relay B were made 1,300 ohms what result would you expect?

E. If the private wiper failed to make contact with the private bank, would you cut in on a busy line?

F. If you made a call and got both the called subscriber and the busy tone, where would the trouble probably be?

Chapter V

Connectors Using Both a Ringing and a Ring Cut Off Relay.

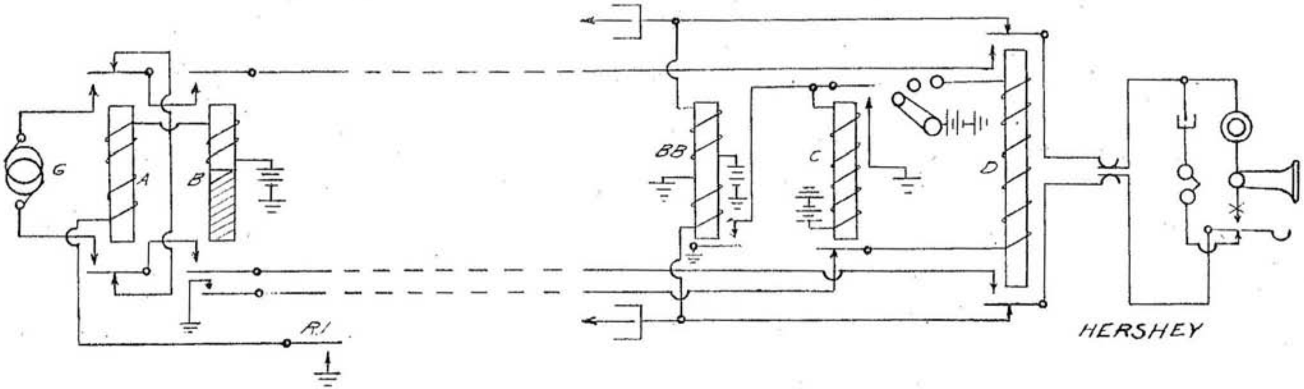
In the previous chapter we discussed the testing of the called line to determine whether or not it was busy. We will now consider the means by which the connector switch is enabled to automatically ring the called subscriber.

With reference to Fig. 11, the generator G may be considered as representing any source of alternating current which can be utilized to operate the ordinary telephone ringer. The relays A and B are termed the group ringing relays, and in practice there is usually one set provided for each group of a thousand lines. Each relay is wound to 500 ohms resistance. At RI is shown the ring interrupter, which for the present may be considered merely as a pair of springs which are continually making and breaking contact. At the right, in Fig. 11, a portion of a connector circuit is shown. The relay BB is termed the back bridge relay; each winding being of 200 ohms resistance. Relay C is the ring cut off relay, and is wound to 1300 ohms. Relay D is the ringing relay and is usually 500 ohms in resistance.

Each time the ring interrupter springs make contact a circuit is closed through relays A and B in series. The energization of relay A and B causes the generator to be thrown out on the generator leads, which are multipled to each connector in the group. In addition relay B, upon energizing, places ground on the ring interrupter lead, which is also multipled to each connector in the group.

We will now assume that we have called telephone number 65 and that we have found the line to be idle. The side switch has passed to third position in the manner already explained, and the next time relay B is energized a circuit will be closed from ground, through springs of relay B, springs relay C, ringing relay D and side switch wiper in third position to negative battery. Relay D will energize and impress ringing current upon the called line; the circuit may be traced from one side of generator G, make springs relay A, make springs relay B, make springs relay D, through the condenser and ringer at the sub-station, make springs relay D, make springs relay B and make springs relay A, to other side of generator G. The current flowing in this circuit will cause the ringer at the sub-station to operate and signal the called subscriber. It will be seen that the ringing will continue intermittently, being controlled by the group ringing relays, which in turn are controlled by the ring interrupter. Since relay B is a slow acting relay it will not release its armature

FIG. 11



as quickly as relay A. Therefore, each time the circuit through relay A and B is opened, relay A will fall away first, and will place a short across the generator leads until such time as relay B releases its armature. The object of this momentary shorting of the generator leads is to take up the discharge from the condenser at the sub-station. If this discharge were not taken up it would be likely to cause the operation of the back bridge relay BB following the de-energization of the ringing relay.

We will assume that the called party answers during a silent period. Relay D is at this time de-energized, and as soon as the receiver is removed a circuit may be traced from ground, lower winding of relay BB, break contact relay D, receiver and transmitter at the sub-station, break contact relay D, and upper winding of relay BB to negative battery. Relay BB will now operate and in so doing will close a circuit through the ring cut off relay C. Relay C, upon energizing, will form a locking circuit for itself independent of the circuit controlled by relay BB. In addition relay C will open the circuit of the ringing relay D, so that relay D will no longer operate in response to the ground impulses on the ring interrupter lead. As shown in Fig. 11 there is no provision made for the releasing of relay C; this feature will be discussed in a later chapter.

Connectors Using Only a Ring Cut Off Relay.

A more recent circuit employs a scheme by which the ringing relay is eliminated. Referring to Fig. 12 we find the familiar generator G. The ring interrupter here takes a little different form but the principal is the same. At the right we have the back bridge relay BB,. and the ring cut off relay C, the latter being a slow acting relay. The construction of this relay differs from that of the ordinary slow acting relay in that the copper slug is much thinner and extends the full length of the core under the windings. Relay C carries two windings, the first a low resistance winding of 200 ohms and the second a holding winding of 1,300 ohms.

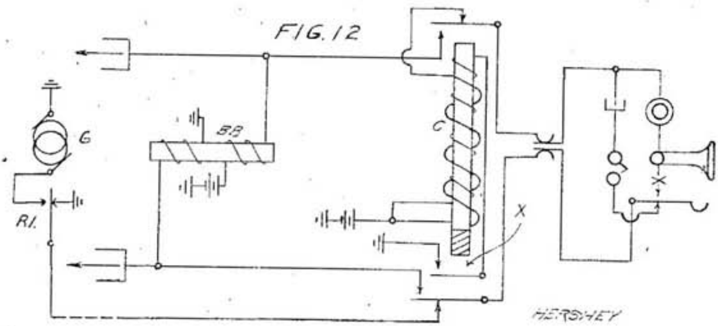
An interesting feature of a slow acting coil is that it refuses to respond to alternating current. If alternating current is passed through the low winding of relay C the armature will remain at normal, precisely as though no current were passing through the relay.

Let us assume that the wipers of this connector switch have been brought to rest upon the contacts of an idle line. A circuit may now be traced from ground through the generator G, ring interrupter, break springs relay C, lower contact of switch hook, ringer and condenser, break springs relay

C, and low winding relay C to negative battery and ground. The condenser will prohibit the flow of battery current in this circuit, but the alternating current will flow and operate the ringer at the called sub-station. The alternating current passing through the low winding of relay C does not cause it to energize, as has been previously explained. The bell will continue to ring intermittently as the ring interrupter operates back and forth.

Let us consider that the subscriber removes his receiver during the time that the generator is in the circuit. As soon as the transmitter and receiver are bridged across the line there will be a flow of direct current over above traced circuit in addition to the alternating current already flowing. This flow of direct current will cause relay C to attract its armature. The springs of relay C are so arranged that springs X make contact before the other springs are operated. As

FIG. 12



soon as the springs X engage a circuit is closed through the holding winding of relay C, which causes the complete energization of this relay. As a result generator is removed from one side of the line and the low resistance winding of relay C from the other, and at the same time the line is connected through to the back bridge relay BB.

If the subscriber had answered during a silent period the relay C would have operated as before. This time, however, there would have been no alternating current superimposed upon the direct. As shown in Fig. 12 there is no provision made for the releasing of relay C; this feature will be discussed in a later chapter.

Questions.

A. With reference to Fig. 11, why is it essential that relay C must have a locking circuit independent of that supplied by relay BB?

B. What would be the result if the discharge from the condenser at the sub-station did succeed in operating relay BB?

C. Referring to the circuit as shown in Fig. 11, what explanation could you give of the following subscriber's complaint: "The bell rings and when I answer there is no one there"?

D. If the ringing interrupter lead becomes permanently grounded, what will be the result in Fig. 11?

Chapter VI

Manual Practice as Contrasted With Automatic.

The called subscriber having answered, it is now necessary for us to provide means for feeding talking battery to both the calling and called subscribers. As it is beyond the scope of this lecture to go into the theory of the transmission of speech, it will suffice to say that the transmitters at the substations are of the common battery type. The receivers are direct current receivers, i. e., they have no permanent magnet, but use an electro-magnet and are connected in series with the line and transmitter during the conversation. The X mark seen between the switch hook and the receiver is the conventional method of indicating the dial mechanism in a schematic drawing.

In Fig. 13 is shown the Hayes method of supplying talking battery, which has come into very extended use in manual operation. At the central office, KK are two repeating coils, each having two windings. The two windings of the coil K are connected together at the point A, which is connected to negative battery. The other ends of these two windings are connected with the lines as shown. In a similar manner

FIG. 13

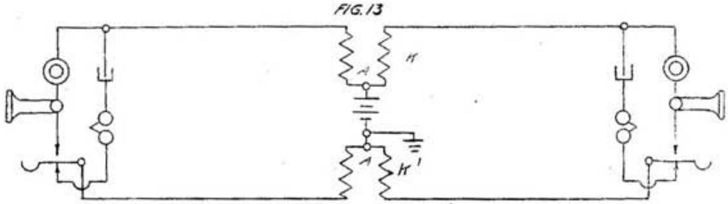
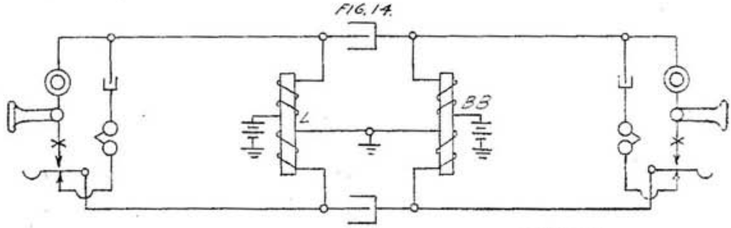


FIG. 14



HERSHEY

the two windings of repeating coil K' are connected together at the point A', which is connected to positive battery. The other ends of these two windings are connected with the lines as shown. Any changes in the current in either circuit, produced by one of the transmitters, will act inductively through the repeating coils upon the other circuit, causing corresponding fluctuations in current to flow through that circuit and actuate its receiver.

In Fig. 14 is shown the method of supplying talking battery used in Automatic Connectors. It will be seen that each line draws its current through a separate impedance coil. In this plan, instead of depending upon the electro-magnetic induction between two sides of a repeating coil, as in the Hayes system, the electro-static induction afforded between the plates of two condensers is depended upon for transmitting the fluctuations in current from one line to the other.

Reverse Battery Supervision.

Referring to Fig. 14 we find the well known line relay L, which is here used as battery feed. The relay BB is termed the back bridge relay and feeds battery to the called subscriber. If a call originates at a toll board, for instance, it is essential that the operator be notified when the called party answers. Therefore we may say that supervision is the re-

FIG. 15

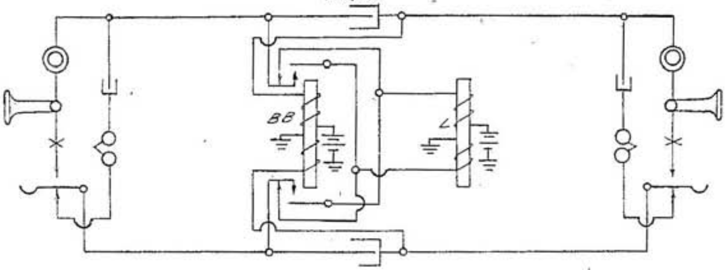
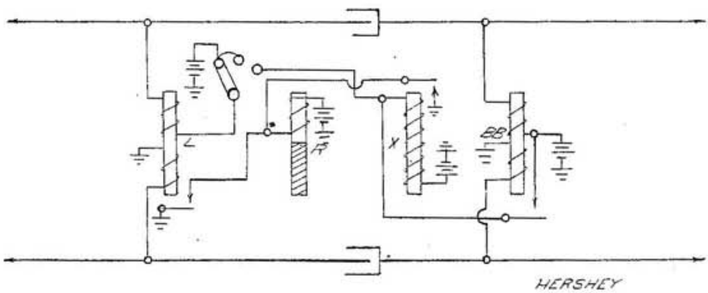


FIG. 16



sult obtained when the conditions are so arranged that the answering of the called subscriber produces a change in the calling line such as can be utilized to give a visual indication of the fact that the called party has answered. Reverse battery supervision is the scheme usually used in Automatic

Practice. Referring to Fig. 15, it will be seen that the line relay L is connected to the calling line through the springs of the back bridge BB, in such a manner that should the latter be energized the polarity of the calling line will be reversed. This reversal of the battery on the calling line may be used to give supervision at a manual board.

High Resistance Supervision.

In some of the older automatic installations high resistance supervision will be found, which is of sufficient interest to warrant our discussion. In Fig. 16 we find the line relay L, back bridge relay BB and release relay R. In addition there is represented the high resistance relay X. The resistance of this relay is usually 3,000 ohms. It will be seen that during the vertical and rotary motion direct negative battery is placed on one winding of relay L by means of the side switch wiper. When the side switch passes to third position relay X is cut in series with relay L, this greatly reduces the current flow in the calling line. When the called party answers relay BB energizes and shunts out relay X, whereupon the current in the calling line is increased to normal. This variation of the current in the calling line may be used to give supervision at a manual board. When relay X energizes it closes a holding circuit through relay R. This is a safeguard, for it might happen that the reduction of the current in the calling line would cause the de-energization of relay L. And if it were not for the circuit controlled by relay X a premature release would occur.

Questions.

A. If the outside terminals of each repeating coil in Fig. 13 were shorted what effect would it have on transmission if a long line were connected to a short one? What is the Stone system of battery feed?

B. In Fig. 14 would the transmission be effected if both condensers were short circuited, assuming lines of equal resistance?

C. In Fig. 15 what would be the result if relay BB pulled "half way up," i. e., energized sufficiently to close the make contacts but not enough to open the break contacts?

D. If one side of the line tested open to a reverse battery connector where would you look for your trouble?

E. In Fig. 16 what would be the result if relay X became partially short circuited?

F. With reference to Fig. 16 what would be the result if relay X "froze up"?

Chapter VII

The Release of the Connector Switch.

In Chapter III we discussed the mechanism of the connector switch and, among other things, mentioned that the double dog (See Fig. 6) was utilized to hold the shaft in an operated position. After the completion of the conversation it is necessary that means be provided whereby the double dog may be removed, thus allowing the shaft to return to normal. It is also necessary that the side switch wipers be returned to first position; both of these actions are accomplished mechanically by the use of what is termed a release magnet. Referring to Fig. 17, we have the familiar line relay L, release relay R and series relay S, and in addition the release magnet Y. This magnet must be quite powerful, in order to accomplish its mechanical functions, and is usually wound to 46 ohms.

To the left of the release magnet is represented what is termed a pair of off normal springs. When the shaft is at normal a projecting edge rests on a bushing of the off normal spring assembly and holds the springs apart. When the shaft is raised one or more steps the off normal springs make contact, and continue in contact until such time as the shaft again returns to normal. It will be remembered that the release relay R energizes as soon as the receiver is removed, and that it remains energized throughout the dialing period and during the conversation. Therefore the circuit of the release magnet Y remains open at the springs of relay R, even though the off normal springs are closed at the first vertical step.

After the conversation is completed and the receiver is returned to the switch hook at the calling sub-station the line relay releases. A fraction of a second later the release relay de-energizes and closes a circuit which may be traced from ground, back contact relay L, back contact relay R, off normal springs, and release magnet Y to negative battery. The release magnet will energize over this circuit and operate to remove the double dog and force the spider arm back to first position, following which its own circuit will be opened at the off normal springs as soon as the shaft reaches normal.

The Release from Busy Connector.

This is a subject which logically would come under Chapter IV, but at that time we were not sufficiently advanced to appreciate the beauties of this circuit. It will be remembered that the ordinary connector, when used to call a busy line will lock on the same, holding the connector wipers on the bank contacts until such time as the calling party hangs up his receiver. In some Private Automatic Exchanges you will find what are termed "Release from Busy" connectors. These connectors, upon striking a busy line, will release and give the calling subscriber the busy tone after the connector shaft reaches normal.

In Fig. 18 is represented the familiar line relay L, release relay R, release magnet Y, private magnet P, series relay S, a new kind of busy relay B and an added relay X. The busy relay B carries two windings, the upper a holding winding of 1,300 ohms, and the lower a low resistance winding of two and one-half ohms. This winding is made low in resistance so that the release magnet may pull up through it. The relay

FIG. 17

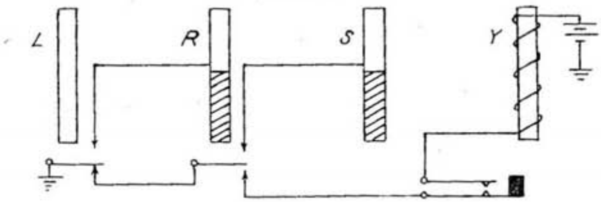
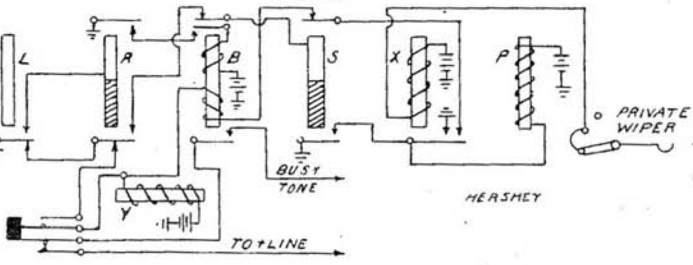


FIG. 18



X is usually 1,300 ohms. If a busy line is called when using this connector, a circuit may be traced from ground at the private bank contact, side switch wiper in second position and relay X to negative battery. Relay X upon energizing, closes a circuit through the private magnet which holds the same energized. Relay X also closes a circuit which may be traced from ground, make springs relay X, break springs relay S, low resistance winding of relay B, through release magnet Y, to negative battery. Relay B will energize over this circuit and lock itself up through the contacts of relay R. The release magnet will energize and cause the release of the connector in the usual manner. As soon as the shaft reaches normal the busy tone is given to the calling subscriber through the make springs of relay B and the lower set of off normal springs. When the calling subscriber restores his receiver to the switch hook the line and release relays de-energize, and as a result relay B is unlocked. It will be seen that relay X must carry stiff spring tension, otherwise it is likely to pull up as the private wiper passes over busy contacts in the level.

Your attention is called to the fact that the B relay, when operated, serves to open the circuit to the vertical magnets, thus no movement of the switch will result if the subscriber should operate his dial while he is receiving the busy tone.

Questions.

A. What result would you expect if the off normal springs failed to break?

B. In Fig. 18 what would be the result if the upper make springs on relay R failed to make?

C. What result would you expect if the break springs of relay S had dust in its contact?

D. If relay X should pull up while the switch is rotating would it cause a release?

Chapter VIII

Circuit Reading of the Complete Connector.

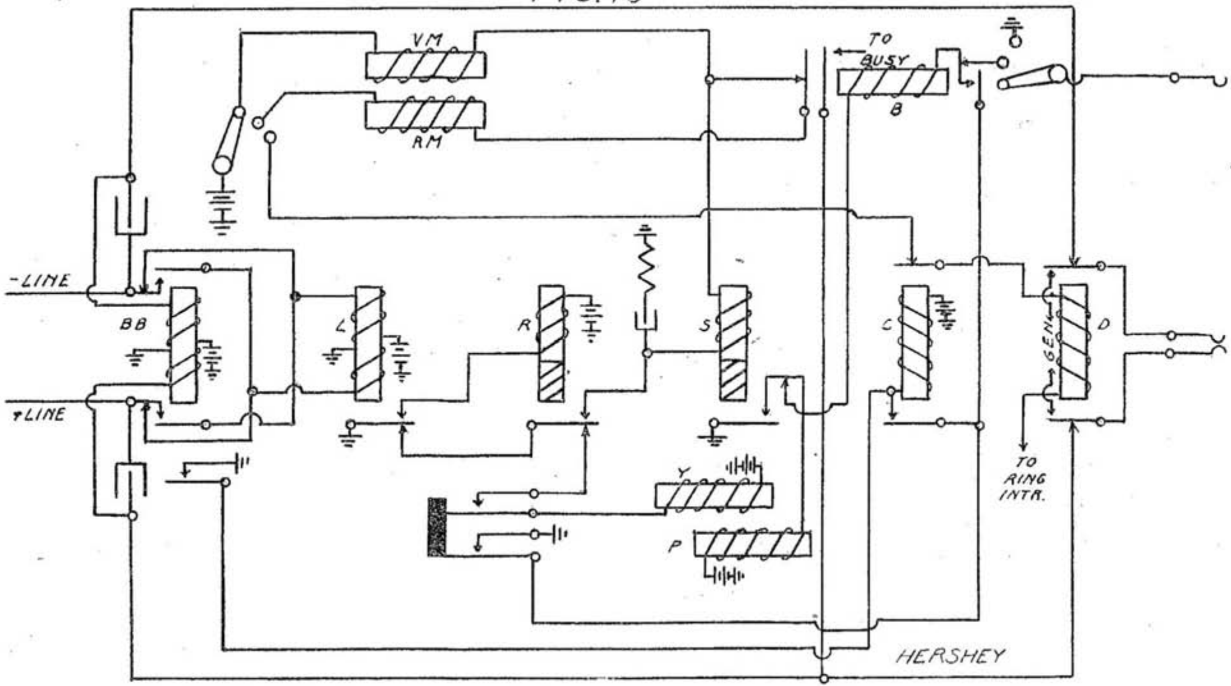
In Fig. 19 is shown a complete circuit embodying all the functions that we have previously discussed in detail. In the figure is shown the familiar line relay L, release relay R, series relay S, back bridge relay BB, ring cut-off relay C, ringing relay D, busy relay B, vertical magnet V M, rotary magnet R M, release magnet Y, and private magnet P.

When the receiver of the telephone associated with this connector is removed the line and release relays will become energized and will operate to prepare the circuit of the vertical magnets. When the dial is operated for the first figure a series of impulses will be delivered to the line relay. The line relay will de-energize in response to these impulses and will cause a similar number of impulses to be sent through the series relay and the vertical magnets. The vertical magnets will respond to these impulses and will operate to raise the shaft and wipers to a position opposite the desired bank level. The series relay will energize at the first impulse of current through it and will cause the circuit of the private magnet to be closed. The private magnet will now energize, but no movement of the side switch will take place at this time. After the secession of the impulses the series relay will de-energize and open the circuit of the private magnet, which will now de-energize and allow the side switch to pass to second position.

When the dial is operated for the second figure the line relay will respond as before, but this time the impulses will be repeated through the series relay to the rotary magnets. The rotary magnets will respond to these impulses and will operate to rotate the shaft and wipers into engagement with the bank contacts associated with the called line. The series relay will energize at the first impulse of current through it and will cause the circuit of the private magnet to be closed. The private magnet will again energize, but, as before, no movement of the side switch wipers will take place at this time. After the secession of the impulses the series relay will de-energize and open the circuit of the private magnet, which will now de-energize and allow the side switch to pass to third position.

Upon the side switch reaching third position the ringing relay D will respond to the impulses on the ring interrupter lead and will operate to impress ringing current out on the called line. When the called party answers, the back bridge relay will energize and close the circuit of the ring cut-off relay. The ring cut-off relay will then energize and open

FIG. 19



the circuit of the ringing relay, so that the latter can no longer respond to the impulses on the ring interrupter lead. Upon energizing the back bridge relay also operates to reverse the polarity of the calling line, so as to give supervision should the call have originated at a toll board. The ring cut-off relay, upon energizing, will form a locking circuit for itself independent of the springs on the back bridge relay. If it were not for this lock-up feature the ringing would again start should the called party be the first to hang up his receiver.

When the conversation is completed the restoration of the receiver to the switch hook at the calling sub-station will cause the release of the line relay, following which the release relay will de-energize and close the circuit of the release magnet. The release magnet will energize and operate to move the double dog and to force the side switch wipers back to first position, its own circuit being opened at the off normal springs as soon as the shaft reaches normal.

If the called line had been engaged, the busy relay would have energized and locked itself up in series with the private magnet, thus holding the private magnet energized and causing the side switch wipers to be locked in second position. The busy relay also operates to give the calling subscriber the busy tone, and in addition opens the circuit to the rotary magnets so that a further rotation of the switch is impossible. When the calling subscriber restores his receiver the release will take place in the usual manner.

It will be noticed that in this circuit the busy relay and the ring cut-off relay lock themselves up to off normal ground; as a result the locking circuit of these relays will be opened when the shaft reaches normal.

Functions of the Connector Relays.

A. **The Line Relay.** Receives the dial impulses and repeats the same to the vertical and rotary magnets, and also serves to feed talking battery to the calling subscriber.

B. **The Release Relay.** Operates to prepare the circuit of the rotary and vertical magnets, and in addition maintains the circuit of the release magnet open until such time as the conversation is completed.

C. **The Series Relay.** Operates in series with the vertical and rotary magnets to control the circuit of the private magnet.

D. **The Busy Relay.** When a busy line is encountered this relay energizes and locks itself up in series with the private magnet, thus holding the private magnet energized and causing the side switch wipers to be locked in second position.

The busy relay also gives the calling subscriber the busy tone, and in addition opens the circuit to the rotary magnets so that a further rotation of the switch is impossible.

E. **The Ringing Relay.** When the side switch wipers reach third position this relay energizes in response to the ground impulses on the ringing interrupter lead and operates to impress ringing current upon the called line.

F. **The Back Bridge Relay.** This relay feeds talking battery to the called subscriber. It also operates to reverse the polarity of the calling line, and in addition closes the circuit of the ring cut-off relay.

G. **The Ring Cut-Off Relay.** This relay opens the circuit of the ringing relay, and also forms a locking circuit for itself so that the ring will not again start should the called subscriber hang up first.

H. **Vertical Magnets.** Operate to raise the shaft and wipers to a position opposite the desired level of bank contacts.

I. **Rotary Magnets.** Operate to rotate the shaft and wipers into engagement with the desired bank contact.

J. **Release Magnet.** Operates to remove the double dog and to restore the side switch wipers to first position.

K. **Private Magnet.** Operates to control the movement of the side switch wipers.

A Resistance in Series With the Spark Condenser.

In Fig. 19 it will be seen that a resistance has been cut in series with the condenser which bridges the break contact of the impulse springs. A spark condenser is ample protection for the ordinary break contact, but the springs are likely to weld if a condenser only is used around a contact which is rapidly making and breaking. The theory seems to be that the condenser will be charged at the break of the contact as usual, following which the contact will again be made before the charge in the condenser has had time to dissipate. As a result, when the springs come together for the second time the condenser will discharge a heavy current across the minute air gap and will thereby cause the springs to weld. The resistance coil is inserted so that an impedance will be offered to the discharge of the condenser, thus lowering the current below the point which will cause the welding of the springs. It would not do, of course, to have too great a resistance, or the capacity of the condenser would be neutralized. In practice 10 to 15 ohms are cut in series with a one-half M. F. condenser.

Questions.

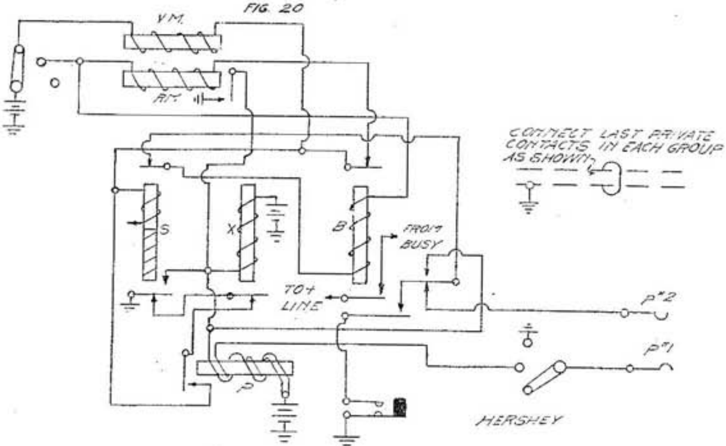
A. Why is the circuit in Fig. 19 inoperative?

Chapter IX

Theory of the Rotary Connector.

It often occurs that a subscriber to telephone service desires a number of trunk lines leading to his place of business, and usually he requires that a single number be listed in the directory under his name. We will now have to provide a connector which will automatically pick an idle trunk in the group which may be called. In assigning the numbers it is preferable to place the first trunk on the first contact of the level; contact 21 for instance. This is the number that will appear in the directory; the additional trunks will be placed on the contacts immediately following, 22, 23, 24, etc. The

FIG. 20



last private contact in the group will be wired as shown in Fig. 20. The first subscriber to call 21 will be connected through on that trunk. A second subscriber calling 21 will not receive the busy tone, but the rotary connector will automatically advance the wipers one step, and the subscriber will be connected through on the second trunk. A third subscriber will automatically be given the next trunk, and so on until all the trunks are in use. Should another subscriber call 21, at this time, the rotary connector would pass to the last contact in the group, and finding this busy, would give the calling subscriber the busy tone.

Circuit Reading of the Rotary Connector.

Referring to Fig. 20 it will be seen that there is an upper and lower private bank contact, instead of the single private bank contact as usually found. Rotary connectors always have a double private bank, that is, both the line and private bank are the same in construction. In the above figure is shown the familiar series relay S, private magnet P, vertical magnet VM, rotary magnet RM, and an added relay X. The private magnet as here indicated is a double wound relay, each winding usually being 175 ohms in resistance. Relay X is wound to 1,300 ohms. The busy relay B, must in this case be a 1,300 ohm relay, as it no longer operates in series with the private magnet.

Let us assume that the first trunk in the group of three is busy, when the second party calls this number (21), and after the series relay S de-energizes following the last rotary impulse, a circuit may be traced from ground at the lower private bank contact, private wiper No. 1, side switch wiper in second position and private magnet P to negative battery. This circuit will cause the private magnet to remain energized and hold the side switch wipers in second position. When the back contact of relay S is made, a circuit can be traced from ground, break springs relay S, break springs relay X, make springs private magnet, break springs relay B, rotary magnet and side switch wiper in second position to negative battery. The rotary magnet will energize over this circuit and operate to advance the wipers one step.

When the rotary magnet energizes it closes a circuit through relay X and through the private magnet. Relay X, upon energizing, opens the circuit of the rotary magnet, which de-energizes and in turn opens the circuit of relay X. If the second trunk is idle private wiper No. 1 will find no ground, and the private magnet will release, allowing the side switch to pass to third position. If the second trunk is also busy private wiper No. 1 will again pick up ground and maintain the private magnet energized. The rotary magnet and relay X will operate, as before, to advance the wipers one step. This operation will continue until an idle trunk is reached or the wipers are advanced to the last trunk of the group. The object of having the rotary magnet close a circuit through the private magnet, is to make the private magnet independent of the ground at the private bank contacts during the instant that the wiper is passing from one contact to another.

Let us suppose that all three trunks are busy, a fourth party dials this number and his connector starts rotating to find an idle trunk. When the private wipers reach the third private bank contact a circuit may be traced from ground at the lower bank contact (given it by the connector standing on this trunk), through the loop to the upper private bank contact, private wiper No. 2, break springs of busy relay B, break springs relay S, relay B and side switch in second position to negative battery. Relay B will energize over this circuit and lock both itself and the private magnet to off normal ground. The busy signal will be given the subscriber in the usual manner.

Night Connections.

When a business house has a number of trunks leading to its Private Branch Exchange it is customary for them to put up a night connection on each trunk. Just before their operator leaves for the day she will insert the plug associated with the first trunk into the local jack leading to the Garage, for instance. The second trunk will be connected to the Engine Room, etc., until the trunks are exhausted.

The directory listing for this business house will appear as follows:

Dayton Company, The............................36361

Private Branch Exchange.

After business hours call the following night numbers:

Garage 36361
Engine Room 36362
Watchman 36363

Thus these special telephones will have both incoming and outgoing service throughout the night.

The scheme, as above presented, is not satisfactory for the following reason: If the Engine Room is busy, and a second party calls that night number the rotary connector will "kick over" to the next contact, and as a result the calling party will be connected with the Watchman instead of with the Engine Room.

In order to overcome this difficulty the lines and private No. 1, of trunk 36361, are multipled with the lines and private No. 1, of some other line, for instance 36301. The line switch is now removed from position 36301, and the privates No. 1 and No. 2 associated with this line are shorted in the usual manner. It must be borne in mind that this shorting of the privates on line 36301 **does not** short the privates associated with trunk 36361. If a subscriber should now call 36301 he will, of course, be connected with the Garage, since 36301 is multipled with 36361. If a second party should call 36301 at this time his connector will lock on busy, due to the fact that the private contacts associated with 36301 are shorted. Thus the calling subscriber will be notified of the fact that the Garage is busy.

The other trunks used for night connections will each be multipled with a night number, in the same manner as explained for trunk 36361. These night numbers need not be consecutive, but may be scattered throughout the board, or anywhere in the exchange for that matter.

The directory listing for this business house will now appear as follows:

Dayton Company, The............................36361

Private Branch Exchange.

After business hours call the following night numbers:

Garage 36301
Engine Room 36390
Watchman 36827

This multipling will not interfere with the ordinary day service, and it is quite possible to gain access to the P. B. X. by calling a night number during the day, but naturally the advantage of the automatic rotary will be lost.

If the night number is assigned in some other board, other than a rotary board, there will be only a single private, and it is this private which will be multipled with private No. 1 of the trunk.

Questions.

A. What effect would an open in the lower break contact of relay B have upon the operation of the rotary connector?

B. Given that one group of trunks are on contacts 21, 22 and 23, and another group of trunks are on contacts 24 and 25, and that the loop over the last private contact of the first group is missing, what complaint would you expect from the subscriber on the latter group of trunks?

C. Assume that the first trunk is busy, and that the second is idle, if the rotary magnet failed to close the circuit through the private magnet what might result?

D. If the lower private wiper failed to make contact with the bank, what would result? If the upper private wiper failed to make contact?

E. Why do the standard adjustments specify that the lower springs on relay S must break before the upper set of springs?

Chapter X

Removal of the Line Wipers During Rotation.

You will recall that in Chapter VIII the question was brought up as to why the circuit in Fig. 19 is inoperative. The reason is that there has been no provision made to remove the line wipers from the back bridge during rotation. As a result, if this connector were used to call telephone number 26 while line 25 happened to be in use, the subscribers on the busy line would hear a crash in their receivers as the wiper of our connector passed over contact 25.

The first scheme employed to obviate this difficulty is shown in Fig. 21. Here we have two additional side switch wipers which are so arranged that the line wipers are not cut through to the back bridge until the side switch passes to third position.

In Fig. 24 is shown what is called the Newforth scheme for keeping the wipers clear during rotation. This consists of a low resistance slow acting relay X cut in series with the private magnet. The relay X will remain energized during the rotary period and thus keep the line wipers clear.

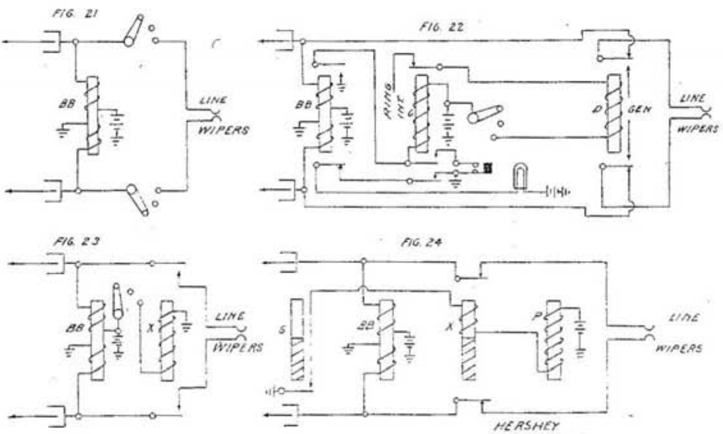
Fig. 23 shows the device employed in the later type of connector to keep the line wipers clear. This consists simply of relay X, which is not cut into circuit until the side switch passes to third position.

Called Party Supervision.

The statement has sometimes been made that in an Automatic System a subscriber can call a certain number, then by leaving his own receiver off the hook can tie up the line of the called party indefinitely. In Fig. 22 is shown what is termed a supervisory lamp; the circuit of this lamp is normally closed at the springs of relay BB, and normally open at the springs of ring cut off relay C. When a call is made on this connector the response of the called party causes relay BB and relay C to energize; the circuit of the supervisory lamp is now open at relay BB and closed at relay C. If the called party should hang up first, relay BB will de-energize and close the circuit of the supervisory lamp. In ordinary service the calling and called parties hang up at so nearly the same time that the supervisory lamp will do no more than flash. But if an attempt should be made to tie up a line the supervisory lamp will light, and continue to burn, indicating to the man in charge of the central office just what has occurred.

Ringing the Same Party a Second Time.

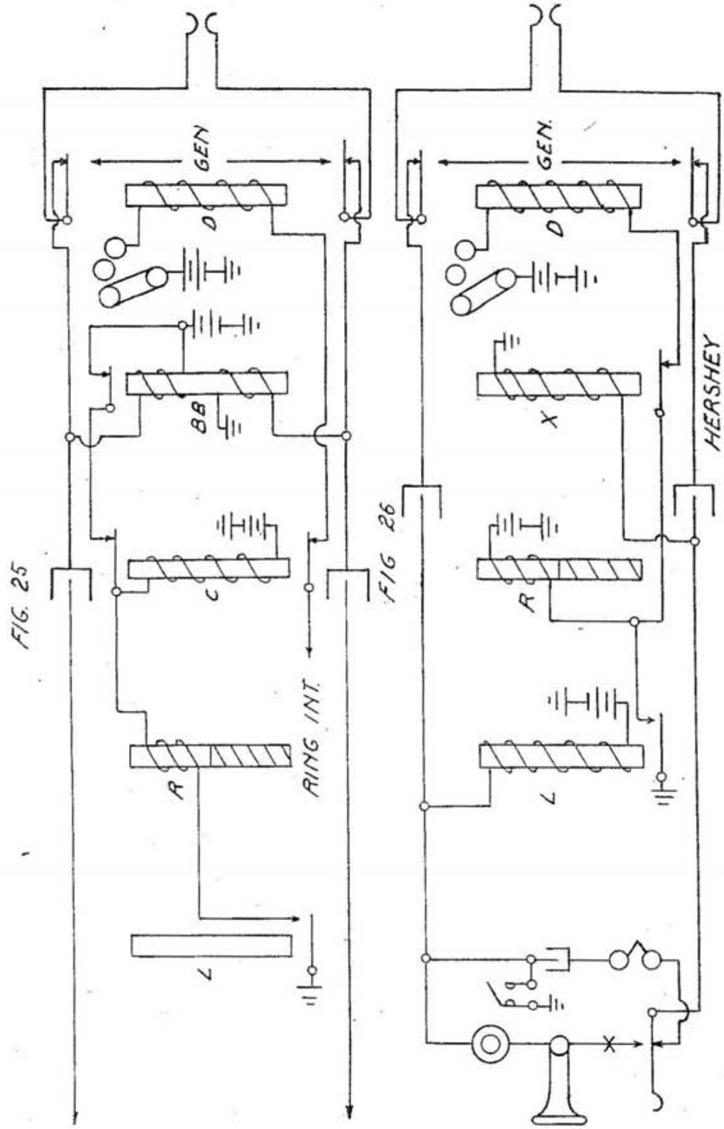
It is a rule in automatic telephony that the automatic ring must stop when the called party answers, and that it must be impossible to again ring this party without first releasing the connection and building it up a second time. Like all rules it has its exception, the author recalls at least one automatic plant in which the novel scheme illustrated in Fig. 25 is in use. Here it will be seen that the ring cut off relay C is normally shunted through a pair of springs on the back bridge relay BB, and that this shunt is the battery feed for release relay R. When the called party answers relay BB is energized, thus removing the shunt from around relay C. Relay C thereupon energizes in series with relay R. Assuming that the called party hangs up, and that the calling party decides that he wishes to call him back; the calling party then operates his dial from the figure one. This causes a momentary break in the line circuit, relay L falls back and



momentarily opens the circuit of relay R and relay C. Relay C, being a quick acting relay, will de-energize and be again shunted out by the springs of relay BB. The ringing will now proceed in the same manner as though this were a new call.

Push Button Ringing.

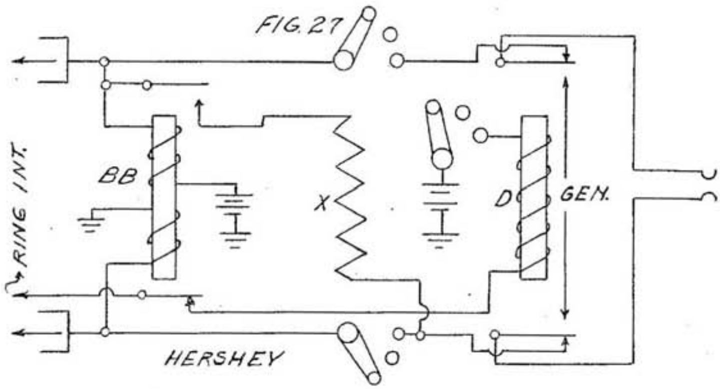
Sometimes it is an advantage, particularly in a P. A. X., to be able to ring the called party at will. This is ordinarily termed push button ringing and is illustrated in Fig. 26. In this figure we have the usual subscriber's instrument and in addition a push button is provided. This push button is so connected that it grounds the negative side of the line when operated. The ordinary double wound line relay is replaced by the single wound line relay L. Ground is fed to the posi-



tive side of the line through relay X. After the completion of the dialing the calling subscriber operates the push button to signal the called party. Each time the push button is depressed it grounds the negative side of the line, thus maintaining a circuit through relay L, but shunting out relay X. With relay L energized, and relay X at normal, a circuit is closed through the ringing relay D, which energizes and impresses ringing current out upon the called line. This same operation is sometimes effected by having the push button at the substation cut a high resistance in the line, instead of grounding the negative side.

Connector with No Ring Cut Off Relay.

In the connector circuits that we have been discussing there will be found both a ringing relay and a ring cut off relay. In an attempt to eliminate the ring cut off relay the



circuit shown in Fig. 27 was developed. In this circuit the back bridge relay BB, upon energizing, locks itself up through the impedance coil X, and at the same time opens the circuit of relay D. If the called party should hang up first, the ringing will not start again, for the reason that relay BB is locked up through impedence coil X and is independent of the loop at the called substation.

Questions.

A. With reference to Fig. 24 what would be the result if the break springs of relay X failed to make contact?

B. With reference to Fig. 22 why does the supervisory lamp fail to light when a busy line is called?

C. With reference to Fig. 25 what is the function of the upper break springs on relay C?

D. If the break spring of relay BB, Fig. 25, were open how would it affect the operation of the connector?

E. If the push button, Fig. 26, was stuck in an operated position what trouble would result?

F. In Fig. 26 will the relay X operate as the dial returns to normal?

G. With reference to Fig. 27 why is one terminal of the impedence coil X placed between the side switch wiper and the line wiper?

Chapter XI

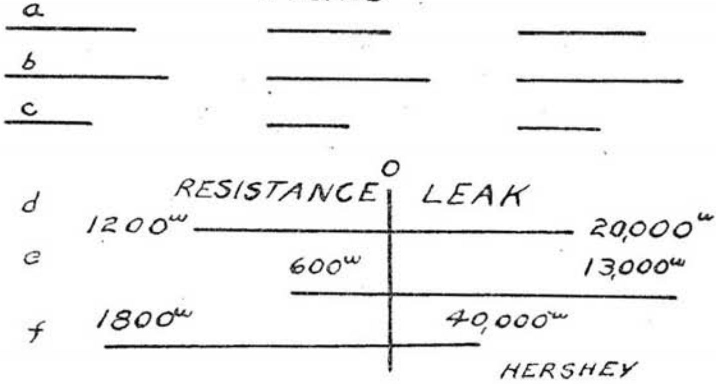
Light and Heavy Impulses.

If the switch is operating properly the impulses through the vertical magnets will be of sufficient duration to cause the vertical armature to be drawn snugly up against the vertical magnets. As the vertical armature operates it raises the shaft one step, and when the armature is fully operated the shaft is lightly wedged between the vertical pawl and the frame of the switch. Under the same conditions the interval between the impulses will be of sufficient length to allow the vertical armature to be fully restored to normal. This standard operation is graphically shown in Fig. 28 (a) in which the solid lines indicate the duration of the impulse and the spaces represent the length of the period between impulses. It will be seen that the lines and the spaces are equal in length, thus indicating that the standard impulse is equal to the space between impulses. During the space between impulses the circuit of the release relay is closed, and with standard operation this closing is of sufficient duration to maintain the release relay in an operated position throughout the dialing period.

If the impulse should be longer than standard the vertical magnets will remain energized longer, and as a result the vertical armature will strike a "heavy" blow against the vertical magnets. Should a switch be operated by this kind of an impulse a peculiar sound would result, which a switchman would describe as "heavy." This kind of an impulse is graphically indicated in Fig. 28 (b). It will be seen that the cycle in b is equal to the cycle in a, i. e., the length of time from the start of the first impulse to the start of the second impulse is the same. Since the cycle remains the same and the length of the impulse has been increased it must follow that the space between the impulses has been decreased. A "heavy" impulse will therefore result in the release relay not receiving sufficient current to maintain it energized, and as a result it will de-energize between impulses and cause the release of the switch.

If the impulses were shorter than standard the vertical armature would not be raised high enough to wedge the shaft between the vertical pawl and the frame of the switch. As a result the momentum of the shaft might cause it to rise two or three steps for each operation of the vertical armature. When operating in this manner a switch is said to be "light," since the vertical armature strikes only a light blow against the vertical teeth of the shaft. The short impulses to the vertical magnets may not be of sufficient duration to maintain the series relay energized, and as a result the series relay will de-energize and allow the switch to "cut out" to second position. A "light" impulse is graphically indicated in Fig 28 (c). As before the cycle is of standard duration, but the impulse has been shortened and the space between impulses lengthened.

FIG. 28



The proper operation of a switch depends upon the following factors:

Shape of the impulse cam.
Tension and adjustment of the impulse springs.
Speed of the calling device.
Line relay, release relay, and series relay adjustment.
Vertical magnet adjustment.
Line conditions.

The shape of the impulse cam is standardized at 90°, and as the cam makes one-half revolution for each unit called, it follows that the duration of an impulse will equal the duration of the space between two impulses.

The tension and adjustment of the impulse springs permits of quite close standardization and no change is likely to take place in service.

The speed of the calling device is controlled by the governor and is normally 10 impulses per second. So long as the dial runs evenly the speed can vary from 6 to 15 impulses per second without causing the central office apparatus to fail.

The adjustment of the line, release, and series relay can be very closely standardized, as this adjustment depends upon the make and break of the springs, the set of the residual screws, and the tension of the springs. In adjusting springs it is customary to specify that certain springs shall make and break with so many thousandths of an inch between the armature and the core; thus the adjustment of the springs can be kept quite uniform. For any given relay the set of the residual screw is specified as extending a certain number of thousandths of an inch below the face of the armature. The standard spring tension of a relay can be obtained by adjusting the relay to operate on a certain flow of current, but not to operate on another specified current flow.

The vertical magnet adjustment may also be standardized by the use of the thickness gauge and the milli-ammeter.

Thus we find that the only variable factor is the condition of the line. If this line be of high resistance, the line relay will be quicker to de-energize and slower to energize, on account of the reduction in the lines of force, and as a result a "heavy" impulse will be delivered to the vertical magnets. If the line has a leak across it the line relay will be slower to de-energize and quicker to energize, on account of the lines of force constantly produced by the leak, and as a result a "light" impulse will be delivered to the vertical magnets.

The terms "light" and "heavy" refer to the operation of the switches in the central office and are generally used by switchmen. To the outside man adjusting dials the terms "light" and "heavy" have no particular meaning, so he prefers to use the terms "long" and "short." A "long" impulse is caused by the impulse springs remaining broken for too long a time, and as a result delivering a "heavy" impulse to the switches. A "short" impulse is caused by the impulse springs being opened for too short a period, thereby delivering a "light" impulse to the switches.

In order to take care of the variation in line conditions it is customary to adjust the switches to operate through as wide a range as possible. In practice the switches are adjusted to operate properly from a standard impulse over an artificial line of 1,200 ohms resistance, and also over the same line with the resistance removed and a 20,000 ohm coil bridged across the line. This adjusting of a switch to operate at the two extremes is termed "varying."

The range through which an automatic switch will work is, we will say, a constant as represented by the line in Fig. 28 (d). As ordinarily adjusted this extends from 1,200 ohms series resistance to 20,000 ohms leak. If the line is moved to the right as shown in Fig. 28 (e) the range remains the same, but it now extends from 600 ohms series resistance to 13,000 ohms leak. If the line is moved to the left as shown in Fig. 28 (f) the range remains the same, but it now extends from 1,800 ohms series resistance to 40,000 ohms leak. In practice it has been found that the adjustment shown in Fig. 28 (d) will best meet the usual line conditions. In actual practice the switches do not maintain a constant ratio between series resistance and leak, such as was assumed to be the case in the illustration.

Questions.

A. Let us assume that a switch will operate satisfactorily over a line having a 20,000 ohm leak. When testing with 46 volts and a 100,000 ohm voltmeter how many "volts short" will it be safe to pass up? When testing with a 10,000 ohm voltmeter?

Chapter XII

Theory of the Non-Numerical Switch.

In our previous discussions we have confined ourselves to a one hundred line system in which each line has an individual connector. With each connector of the hundred is associated a line and private bank. The contacts of these banks are multipled, i. e., no matter what connector is used, if it is stepped one up and one in it will ring telephone number 11.

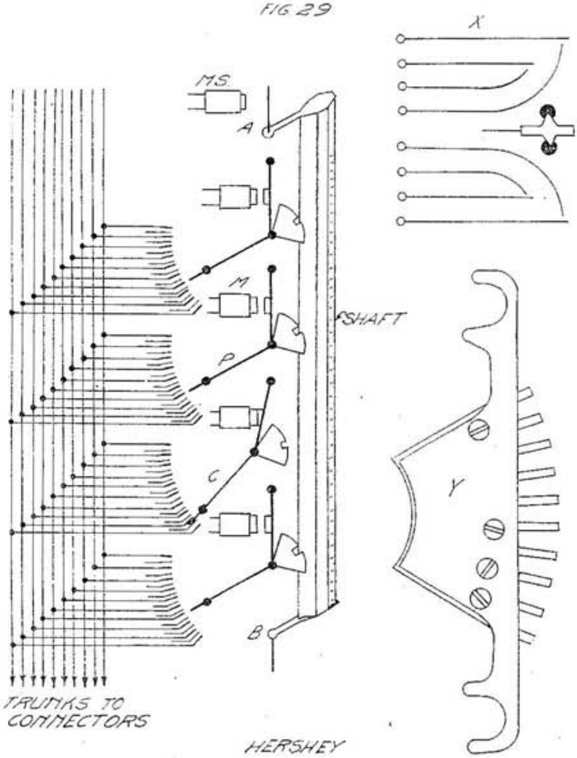
A connector is a more or less complicated machine and as the saying is, "it costs money," the fact is that it costs so much money that a system such as we have been discussing could not be commercially operated, due to the excessive cost of equipping each line with one of these complicated connectors. Fortunately each line is not in use all the time, therefore we can arrange a scheme of this kind: We will provide but ten connectors, the banks of which will be multipled so that each connector has access to each and every line in the hundred. Each line will now terminate on what is termed a non-numerical switch. Whenever a subscriber removes his receiver this non-numerical switch causes his line to be extended to an idle connector in the group of ten, after which the connection is completed in the manner with which we are already familiar.

The Keith Line Switch.

The Keith Line Switch is the most successful form of non-numerical switch. The economy incident to the use of the Keith Line Switch was probably the determining factor which made Automatic Telephony a commercial possibility.

Referring to Fig. 29 we find that the trunks to the ten connectors have been arranged in the arc of a circle. The Keith line switch consists of a magnet M and a plunger P, the head or wing of this plunger is slotted so that it may engage a projecting edge of the shaft. The shaft is pivoted at the points A and B and is capable of an oscillatory motion through about 40 degrees, under the control of the master switch M. S. This motion of the shaft causes the plungers of the various line switches to swing back and forth in front of the terminals of the trunks to the connectors. The master switch so controls the shaft that it will only come to rest opposite an idle trunk. Let us assume that the shaft is holding all the plungers opposite the second trunk, if a subscriber removes his receiver the corresponding line switch will "plunge in" and extend the connection to the connector associated with trunk number two. The line switch which "plunged in" is now free of the shaft, as may be seen at C. The master switch immediately, by means of the shaft, moves the remaining line switches opposite an idle trunk, thus we have what is termed the "pre-selection of trunks." When the subscriber, who plunged in on trunk number two, restores his receiver to the switch-hook his line switch will "come out" of the bank, but the slot in the wing of the plunger will not engage the shaft at this time. Therefore, this particular line switch will remain opposite trunk number two until such

FIG. 29



time as the shaft again swings in front of this trunk and "picks it up." It is essential that a line switch must not "plunge in" during the time that the master switch is seeking an idle trunk, for if it did, the calling party would get in on a busy line. This is taken care of by what is termed the "open main" battery feed.

Each line switch is provided with a line switch bank into which it "plunges." This bank consists of a set of springs for each trunk, as shown at X. As the standard bank is made up of ten trunks, it will therefore contain 80 springs. A sketch showing the complete bank will be found at Y. With reference to X, it may be said that the straight springs are really not springs at all, but pieces of stiff brass; the curved springs are made of a special spring bronze and are of about the thickness and width of the reeds in the ordinary mouth harp. When a plunger enters the bank it causes the curved springs to first move over against the heavy springs, and then to partially straighten out, thus producing a rubbing effect which results in a more reliable contact than is obtained by using the ordinary platinum points. Each curved spring is multipled with the corresponding spring in each trunk; the fact is the ten corresponding springs are all formed from the same piece of bronze.

Questions.

A. Why is a line switch termed a non-numerical switch?

B. Given that connectors cost $25.00 each and that line switches cost $6.00 each, what saving is made by using line switches in a one hundred line system employing ten per cent trunking?

C. How would you express the relative seriousness of the following cases of trouble? Line switch out of service. Connector out of service. Master switch out of service.

D. What would be the condition of the master switch immediately following the removal of the tenth receiver, assuming that none of the preceding nine had been restored to the switch hook?

E. If in ten per cent trunking, ten subscribers were already calling out, what would happen if an eleventh party attempted to call?

Chapter XIII

Mechanics of the Two Coil Line Switch.

The two coil line switch is the form of Keith switch most commonly met with. As shown in Fig. 30, it consists primarily of a double wound relay. This relay carries two armatures as shown, the smaller or bridge cut off armature operates to shift a spring assembly. The larger or plunger arm carries upon its extremity the line switch plunger, which, when forced in the line switch bank causes the movable springs to make contact with the stationary springs. An interesting feature of the line switch is the relative pulling power of the two windings. If the pull down winding be energized it will cause the operation of the B. C. O. armature, and will also cause the plunger arm to force the plunger into the line switch bank. Should the B. C. O. winding be energized it will cause the operation of the B. C. O. armature, but will not be strong enough to operate the plunger arm. If, however, the two armatures are already in an operated position the B. C. O. winding will have strength to maintain both armatures even though the P. D. circuit be opened. The resistance of the P. D. winding is usually 46 ohms, and that of the B. C. O. winding 1,250 ohms. The line relay X is a slow acting relay of 500 ohms.

Circuit Reading of the Two Coil Line Switch.

As shown in Fig. 30, the two conductors from the telephone enter the office and branch to three different points. One branch goes to the connector banks, through which it is multipled in order that this telephone may receive incoming calls. The second branch of the line goes to the B. C. O. springs, and the third to the line switch bank, where it is multipled through ten sets of springs. When the subscriber removes his receiver a circuit may be traced from ground, B. C. O. springs, through the instrument, B. C. O. springs, line relay X, to negative battery. The line relay X energizes and closes a circuit from ground through the pull down winding to open main, which at this time can be considered as ordinary negative battery. The P. D. winding will energize and cause the B. C. O. armature and the plunger arm to operate. When the B. C. O. armature operates the line relay X will be cut off, but it will not release its armature immediately on account of its being a slow acting relay.

When the plunger enters the bank a circuit may be traced from ground, lower winding line relay L, bank contacts,, through the instrument, bank contacts, upper winding relay L, to negative battery. Relay L will energize and close the circuit of release relay R. Relay R, upon energizing will close a circuit which may be traced from ground, springs of relay

R, bank contacts, B. C. O. winding to negative battery. The B. C. O. winding will energize and hold both the B. C. O. armature and the plunger arm in an operated position, even after the de-energization of the P. D. winding, which will

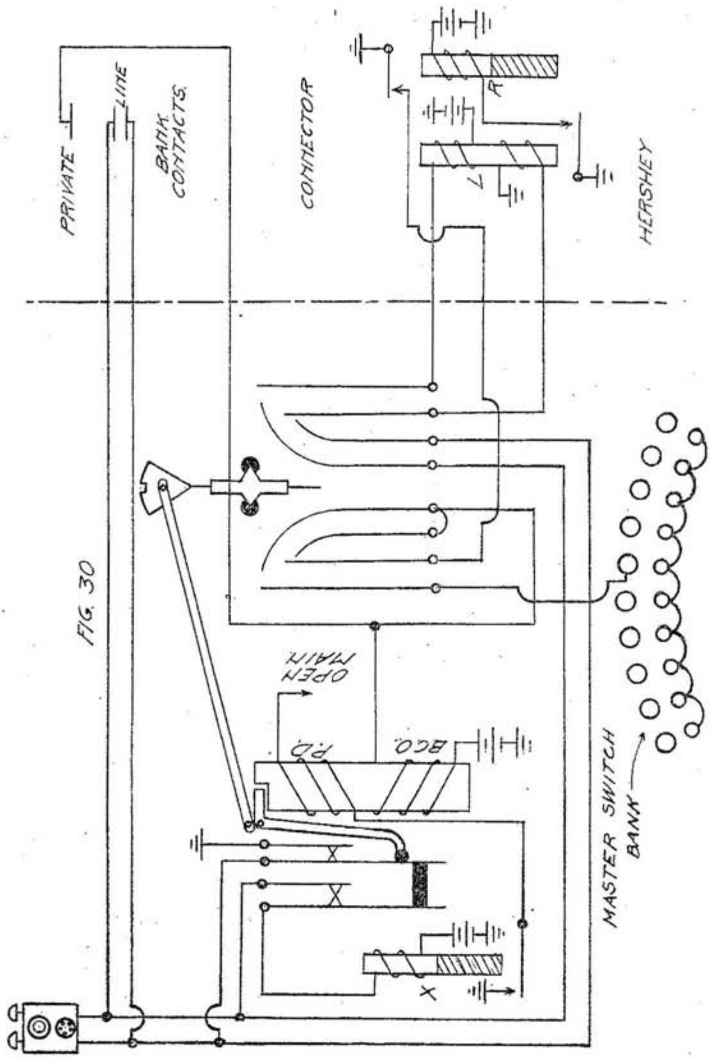


FIG. 30

occur as soon as the line relay X releases its armature. It will be seen that the slow acting effect of relay X must be great enough to keep the P. D. circuit closed until such time as the release relay of the connector sends back ground on the release trunk to energize the B. C. O. winding. A branch of the above circuit extends the release trunk ground to the private bank contact, thus as soon as the line switch plunges in there will be ground placed on the corresponding private bank contact to protect the calling line from intrusion. Release trunk ground also passes through a pair of bank contacts to the master switch bank. It is this ground which causes the master switch to operate and move the remaining line switches opposite an idle trunk.

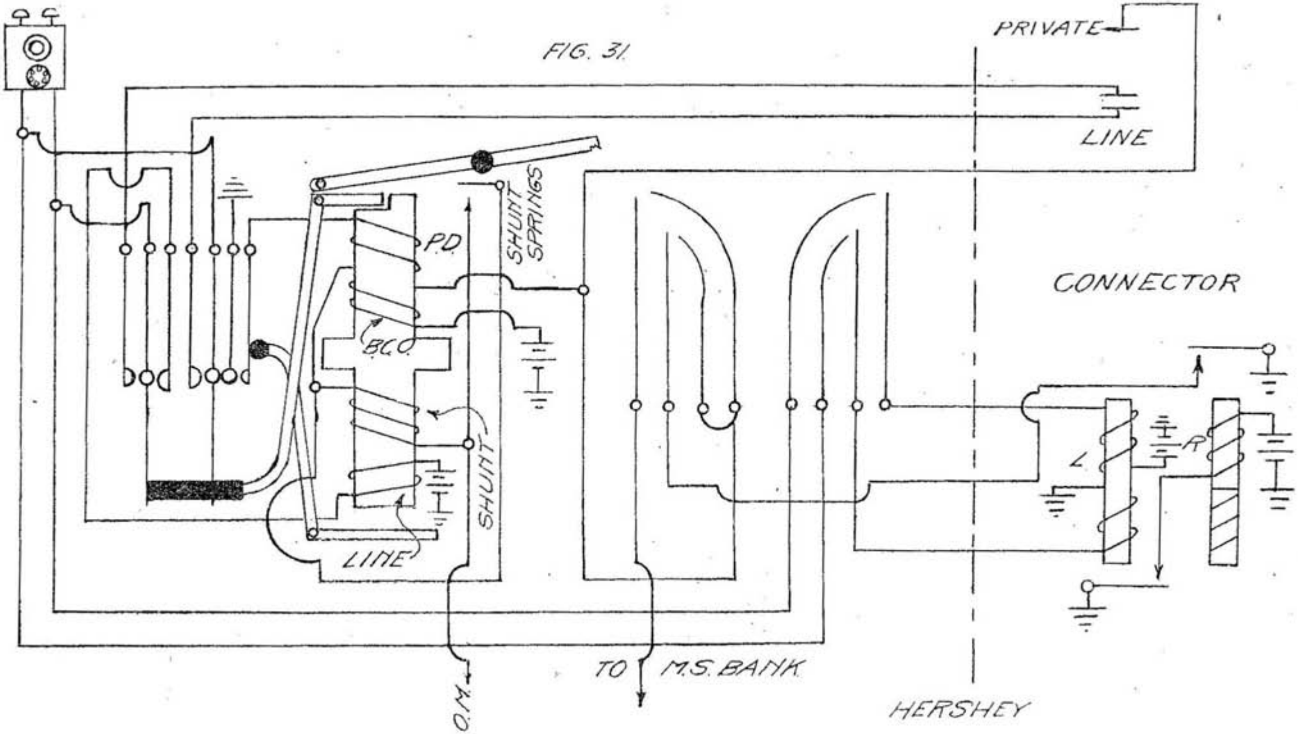
After the conversation is completed the restoration of the receiver at the calling substation causes relays L and R to de-energize. Relay R, upon de-energizing, removes the release trunk ground, the B. C. O. winding will then de-energize and allow the line switch to return to normal. At the same time the protecting ground is removed from the corresponding private bank contact, and from the contact of the master switch bank. As a result the master switch may again stop before this particular trunk, as it is now idle.

In a previous chapter the statement was made that a slow acting relay attracted its armature approximately as quickly as an ordinary relay. It is this minute lag in the pulling up of a slow acting relay that makes it possible for the two coil line switch to operate as it does. If the armature of the line relay X were on the coil end, instead of on the slug end, the line switch would fail to operate. The result of changing the position of the armature on relay X may be explained in this way; the first increment of current that passes through the winding will produce lines of force, the majority of which cut the slug, thus a current will be induced in the slug which will oppose the further up-building of the lines of force. If the armature is on the slug end it will not be attracted until such time as the core is fully saturated, as a result the slow acting relay will maintain its armature in an operated position for some time after the B. C. O. armature opens its circuit. A few of the first lines of force produced will leak out at the sides of the coil without cutting the slug. If the armature is on the coil end of relay X these lines of force will cause the armature to operate, but since the core of the relay X is not fully saturated it will have practically no slow acting effect, and will release its armature as soon as the B. C. O. armature opens its circuit.

The Single Coil Line Switch.

The study of this switch is of particular interest on account of the complicated magnetic circuits which it introduces. In Fig. 31 may be seen a peculiarly shaped relay core; it is in reality two relays mounted end to end. The supposition is

FIG. 31.


PRIVATE
LINE
SHUNT SPRINGS
P.D.
B.C.O.
SHUNT
LINE
CONNECTOR
L
R
O.M.
TO M.S. BANK
HERSHEY

that the extended flange in the middle will keep the upper and lower magnetic circuits separate. The upper relay consists of the P. D. and B. C. O. windings with which we are already familiar. The lower relay consists of a shunt winding of 6 ohms, and a line winding of 94 ohms. The energization of either the line or shunt winding will cause the operation of the line armature, which will cause the first two springs in the B. C. O. spring assembly to make contact. As shown in the figure the bank contacts are not directly attached to the line, but are brought to make springs in the B. C. O. spring assembly. Therefore the bank contacts are open from the line except when the associated B. C. O. armature is energized; this is what we term "open normals."

When the subscriber at the substation removes his receiver a circuit may be traced from ground, through B. C. O. springs, through instrument, B. C. O. springs, line winding to negative battery. The energization of the line winding will cause the operation of the line armature, which will close a circuit from ground, first two springs of B. C. O. assembly, P. D. winding, shunt winding, to open main. The P. D. winding will energize and cause the operation of both the B. C. O. armature and of the plunger arm. As soon as the B. C. O. springs break, the circuit of the line winding will be opened, but the line armature will remain operated on account of the current through the shunt winding. Just as the plunger arm reaches the end of its stroke it forces the shunt springs together, as a result the shunt winding is short circuited. This short circuiting of the shunt winding causes a slow acting effect which maintains the line armature in an operated position for a fraction of a second, thus allowing sufficient time for the connector to return release trunk ground to the B. C. O. winding. The remaining operations are the same as have been explained in connection with two coil line switch.

Questions.

A. If the B. C. O. winding became reversed what effect would it have on the operation of the line switch?

B. If the release trunk ground was not led to the private bank contact what complications would arise?

C. If the first two springs in the B. C. O. assembly (Fig. 31) stuck together, what would be the result?

D. What would be the operation of the line switch if the positive, negative, or release trunk were open to the connector.

F. If a line switch indicates an open trunk, could you step to the connector, and by merely a visual inspection decide as to whether or not the trouble was due to an open release trunk?

Chapter XIV

Mechanics of the Solenoid Master Switch.

The solenoid master switch is a recent design, and differs from the older types in that it feeds only one way, that is, when seeking trunks this master switch moves from right to left, but when moving from left to right the motion is a continuous one under the control of a solenoid. In Fig. 32 will be seen the locking segment L, which carries the shaft S, by which the alignment of the idle line switches is controlled. This shaft is moved from right to left under the influence of a spring as shown, and from left to right by means of the solenoid SL. One arm of the locking segment L is so formed as to force the springs Y into engagement when the master switch is standing opposite the first trunk. The trip relay T has a mechanical lockup feature, which, after it is once energized, will hold the springs in an operated position until mechanically released. A second arm of the locking segment is so formed as to release the springs of the trip relay T when the master switch comes opposite the tenth trunk.

The master switch bank consists of ten sets of double contacts, the lower contacts being multipled together. Each contact in the upper row is associated with one of the line switch trunks. The master switch wiper is so constructed that it will short the upper and lower bank contact associated with the trunk upon which it happens to be standing. The locking magnet LM is so constructed that upon energizing it not only forces its springs together, but also draws the retaining arm RA out of engagement with the locking plate L. Furthermore if the retaining arm is resting against the locking plate L, but has not yet fallen into a slot, the retaining arm will hold the springs of relay LM in engagement. The trip relay is 500 ohms in resistance and the locking magnet 70 ohms. The solenoid is between 50 and 80 ohms, and the busy relay O and relay X, 1,000 ohms each. Both windings of the starting relay SR are 1,300 ohms in resistance.

Circuit Reading of the Solenoid Master Switch.

We will assume that the master switch is standing opposite trunk number eight, and that a line switch plunges in on this trunk. As explained in the last chapter the release trunk ground from the connector will be extended to the master switch bank contact associated with this trunk. A circuit can now be traced from release trunk ground, through master switch wiper and starting relay SR to negative battery. Relay SR will energize and close a circuit from ground through springs of relay SR, locking magnet LM to negative battery. The locking magnet will energize and withdraw the retaining arm from the locking plate.

The locking plate, now being free to move under the influence of the spring, will cause the master switch wiper and

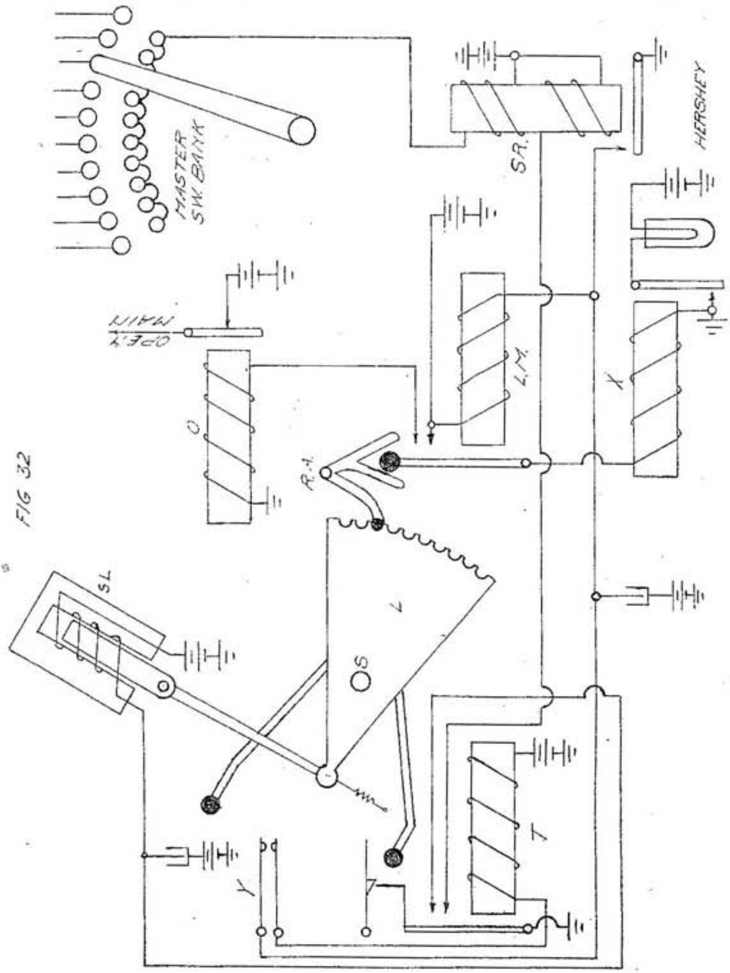


FIG 32

the idle line switches to swing in front of trunk number seven. If trunk number seven is idle there will be no ground on the associated bank contact, therefore relay SR will de-energize and open the circuit of the locking magnet. The locking magnet will de-energize and allow the retaining arm to drop into the seventh slot in the locking plate. This will arrest the movement of the locking plate and will hold the master switch wiper and the idle line switches opposite the seventh trunk until such time as that trunk becomes busy. If the seventh trunk had been busy the circuit of relay SR would not have been opened, and the rotation would have continued until such time as an idle trunk was found.

For our next discussion let us assume that the master switch is standing opposite trunk number one. When a line switch plunges in the circuit of relay SR will be closed as before. Relay SR, upon energizing, will close the same circuit through locking magnet LM; and a new circuit will be closed from ground, through springs of relay SR, springs Y and trip relay T, to negative battery. Trip relay T will energize and mechanically lock itself up, at the same time a circuit will be closed through the solenoid SL and a holding circuit will be provided through the second winding of the starting relay SR. The solenoid will now operate to move the master switch wiper and idle line switches opposite trunk number ten. When trunk ten has been reached one of the arms on the locking segment will release the springs of the trip relay L. The circuit of the solenoid and the holding winding of relay SR will thus be opened.

If trunk number ten is idle relay SR will de-energize and open the circuit of the locking magnet LM. The magnet LM will de-energize and allow the locking arm to enter the tenth slot in the locking segment. If the tenth trunk had been busy, relay SR would have remained energized on account of the ground from the master switch bank contact, and the master switch would have moved to the left in its search for an idle trunk. It will be seen that so long as the springs of the locking magnet LM are in an operated position the circuit of the open main relay O will be closed. The open main relay carries a pair of break springs through which "open main" battery is fed to the group of line switches. As you will recall the open main conductor is connected to one side of the pull down winding of the line switches. Therefore a line switch cannot plunge in while the master switch is moving, for at this time 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. This is to insure that a master switch cannot "get stuck" without giving an alarm.

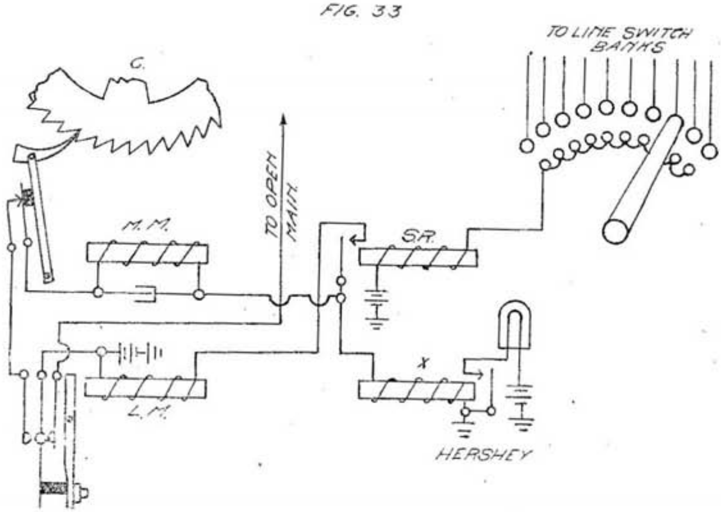
Mechanics of the Buzzer and Cam Master Switch.

This is an older form of master switch and selects idle trunks in either direction. The power is obtained by means of the motor magnet MM, the armature of which operates to rotate the cam C. The cam C is arranged so that its rotary motion causes the master switch wiper and idle line switches to swing back and forth in front of the trunks. The locking magnet LM is in principle the same as has already been explained, the mechanical structure, however, is slightly different. The supervisory relay X is a low resistance relay (one-half ohm) so that magnets LM and MM may operate through it. The resistance of magnets MM and LM is 70 ohms each. The resistance of relay SR is 1,300 ohms.

Circuit Reading of the Buzzer and Cam Master Switch.

When the master switch wiper picks up ground from the bank contact a circuit is closed through the starting relay SR. Relay SR, upon energizing, closes a circuit through the locking magnet LM. The locking magnet, upon energizing, removes the retaining arm from its hole in the locking plate

FIG. 33



(not shown) and closes the circuit of the motor magnet MM. The motor magnet now operates as a buzzer, and causes the rotation of the cam C. When the master switch wiper reaches an idle contact relay SR will de-energize and open the circuit of magnet LM. Magnet LM, upon de-energizing, will open the circuit of the motor magnet and will also allow the retaining arm to drop into the hole in the locking segment associated with this particular trunk. When the master switch wiper reaches trunk number one a further rotation of the cam C will cause it to move back over the contacts to the right. The retaining arm will hold the springs of magnet LM in an operated position until such time as it has fully dropped into one of the holes in the locking segment. In this switch the open main is controlled by means of a pair of break springs on the locking magnet.

Questions.

A. Why is it necessary to retain the locking magnet energized while the solenoid is swinging the master switch from trunk 1 to 10?

B. Should the starting relay have a weak or stiff spring tension?

C. If the locking circuit from the trip magnet springs went direct to the locking magnet, instead of to the second winding of relay SR, what difficulty would be encountered?

D. What trouble would develop if the Y springs failed to make?

E. What would be the result if the springs of the trip relay were not unlocked when the master switch reached the tenth trunk?

Chapter XV

Clearing the Called Line of Attachments.

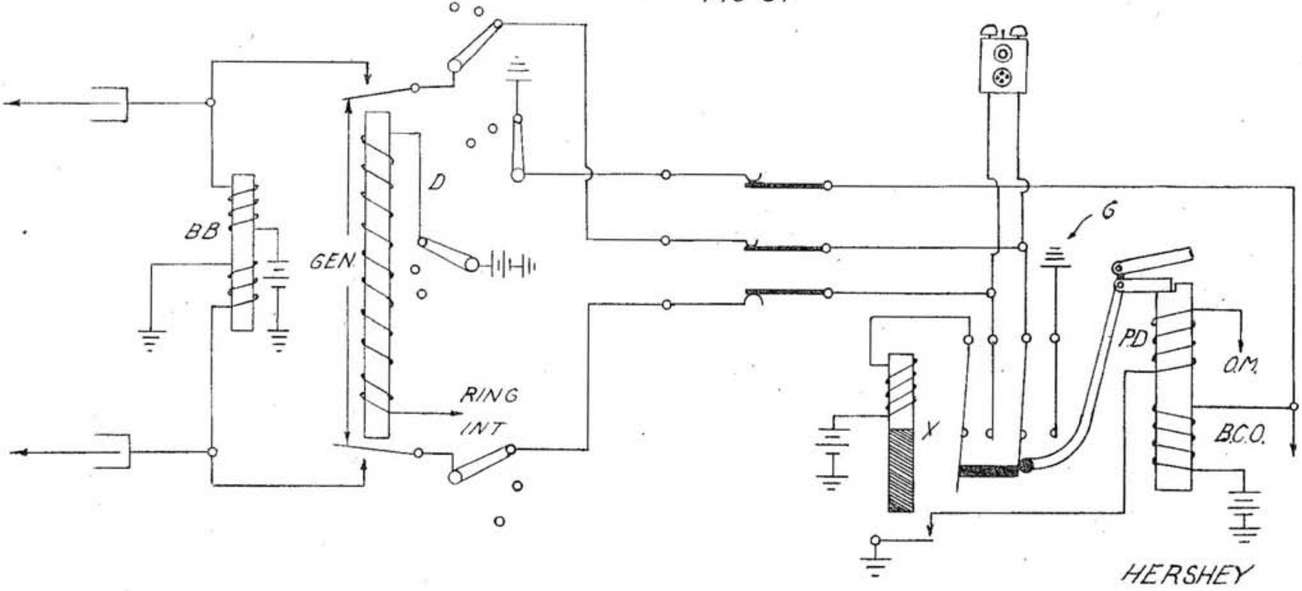
In our Automatic System as it now stands, each line terminates on a line switch. When the line switch is at normal one side of the line is connected to the line relay, and the other side of the line goes to ground direct. When a telephone is called it is necessary that the line be cleared from this battery and ground feed, this is what is termed "clearing the called line of attachments," and was listed as Function D in Chapter I.

In Fig. 34 is shown a portion of a connector switch circuit. It is assumed that a certain number was called, the line was found to be idle, and the connector passed to third position. At the right is shown a part of the line switch circuit associated with the called line. When the connector passed to third position a circuit was closed from ground, side switch wiper in third position, private wiper, bank contact, B. C. O. winding of called line switch, to negative battery. The B. C. O. winding energized over this circuit and caused the B. C. O. armature to remove the line relay X, and ground G, from the negative and positive sides of the line, respectively.

The circuit as shown in Fig. 34 is unsatisfactory for the following reason. Let us assume that the ringing interrupter is in such a position that ringing relay D will energize as soon as the side switch passes to third position. The passing of the side switch to third position also closes the circuit of the B. C. O. winding, but suppose relay D energizes before the B. C. O. has had time to operate. Under these conditions we will have a circuit from ground. B. C. O. springs, make springs relay D, generator G (see Fig. 11) or the short at relay A (depending upon the position of the ringing interrupter), make springs relay D, B. C. O. springs, line relay X, to negative battery. The line relay X will energize over this circuit and cause the P. D. winding to force the plunger of the line switch into the bank. This is what is usually termed "ringing down the first selector." When it is desired to use a connector as shown in Fig. 34, it would be advisable to use a line switch employing "open normals" as shown in Fig. 31. With this type of line switch there is no harm done if the ringing relay does energize before the B. C. O. armature, for the line bank contacts are not connected with the line until after the B. C. O. armature has operated.

When Mr. Newforth designed the circuit shown in Fig. 24 it enabled him to use a line switch with "closed normals." For the reason that relay X, being a slow acting relay, will

FIG 34



not cut the line wipers through for a fraction of a second after the connector has passed to third position. This fraction of a second is ample time for the operation of the B. C. O. armature.

The scheme shown in Fig. 23 may be used with a line switch employing closed normals, for the reason that the relay X is made "slow to pull up." This result is accomplished by purposely making a very poor magnetic circuit. The armature of the relay carries a brass "residual" screw, which extends through perhaps 25 thousandths of an inch, the stroke is then made rather long and the spring tension heavy. As a result the relay is quite slow to energize, thus giving plenty of time for the operation of the B. C. O. armature. You will always hear this relay spoken of as the "wiper cut off relay," which is a misnomer, as in reality it cuts the wipers through to the back bridge.

Questions.

A. What advantages have "closed normals" over "open normals"?

B. The open normals are shown on a single coil line switch. Could they be used with a two coil line switch?

Chapter XVI

Theory of the One Thousand Line System.

In our discussion up to this time we have been considering only a connector system, which limits the size of our exchange to one hundred lines. We will now take up the discussion of a thousand line system. Imagine, if you will, one thousand lines divided up into ten groups of one hundred lines each. In each group there will be ten connectors, the banks of the ten connectors for any given group will be multipled, and each connector will have access to all lines in its own group. If we wish to call telephone number 563, it is first necessary that we obtain access to one of the connectors in the 500 group, after which we will dial 63 and obtain the connection in the manner with which we are already familiar. It makes no difference to us which one of the ten connectors we use, as all of them have access to line number 63.

In order to obtain access to one of these connectors we must supply a new piece of apparatus, which is called a Selector. For the present let us assume that each line terminates on one of these selectors. If we dial 6 this selector will pick out an idle connector in the 600 group, by means of which we can complete a connection to any telephone in that group. If we had dialed 3, this accommodating selector would have picked out an idle connector in the 300 group, etc.

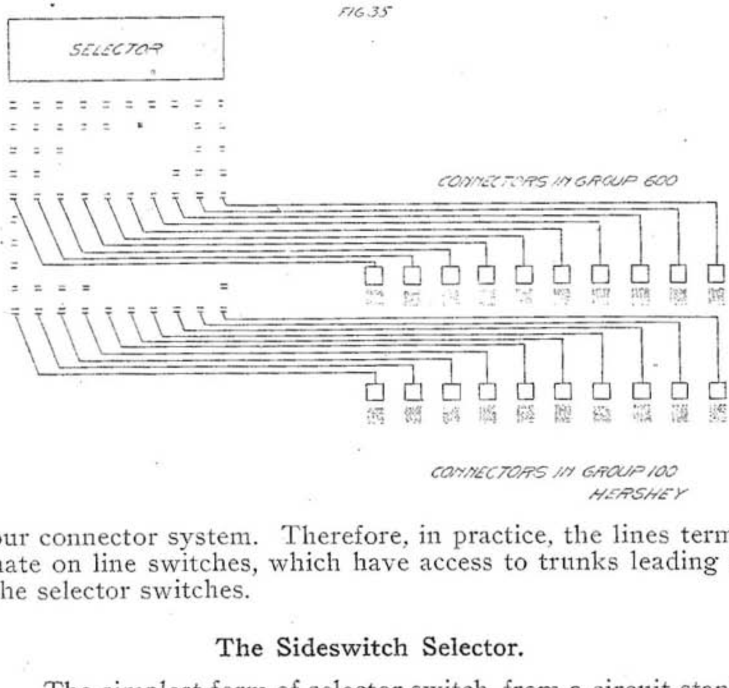
In Fig. 35 a selector is indicated by means of a rectangle. The mechanical structure of a selector switch is similar to that of a connector, i. e., it can impart a vertical and rotary motion to a shaft and wipers. Just below the selector is shown a line bank (in practice a selector carries both a line bank and a private bank, but for the sake of clearness the private bank is not shown).

At the right of the figure is shown a group of connectors that have access to all the lines in the 600 group; just below them is shown a group of connectors that have access to all the lines in the 100 group. It will be seen that the contact 6 up and 1 in of the selector bank leads to the first connector in the 600 group, and that the contact 6 up and 2 in leads to the second connector, etc. These trunks are represented by one line, but in reality they consist of positive and negative line, and release trunk. Although two levels only have been shown, it is to be understood that each contact in the selector bank leads to a corresponding connector in a group associated with the particular level of which the bank contact is a part.

It only remains for us to provide a circuit, by means of which the selector shaft can be raised to the desired level in response to the dial impulses, and following which the selector will automatically rotate the shaft until an idle trunk is found, after which it must extend the connection to the selected connector switch.

If we provide each line with an individual selector, the cost of the system will be excessive, as it was found to be in

FIG. 35



our connector system. Therefore, in practice, the lines terminate on line switches, which have access to trunks leading to the selector switches.

The Sideswitch Selector.

The simplest form of selector switch, from a circuit standpoint, is that which is termed the sideswitch selector. This selector is mechanically an exact duplicate of the connector switch, the only difference being in the circuit arrangement. With reference to Fig. 36 we find the familiar line relay L, release relay R, series relay S, release magnet Y, private magnet P, vertical magnet VM and rotary magnet RM. In addition there is the slow acting interrupter relay X, which is a low resistance relay wound to two and one-half ohms. This relay is made low in resistance so that the rotary magnet will operate through it. The relay E is termed the switching relay, and is of 1,300 ohms resistance.

Let us assume that a subscriber removes his receiver, and that the line switch associated with his line plunges in and extends the connection to the selected shown in Fig. 36. A circuit may now be traced from the ground, lower winding of line relay L, break springs relay E, through the line switch and instrument, back through break springs relay E, upper winding of line relay L, to negative battery. The line relay L will energize and operate to close the circuit of release relay R. Release relay R, upon energizing, will place ground upon the release trunk, which will be utilized at the line switch, first to energize the B. C. O. winding, second to move the master switch away from this particular trunk, and third to busy the private bank contact associated with this line.

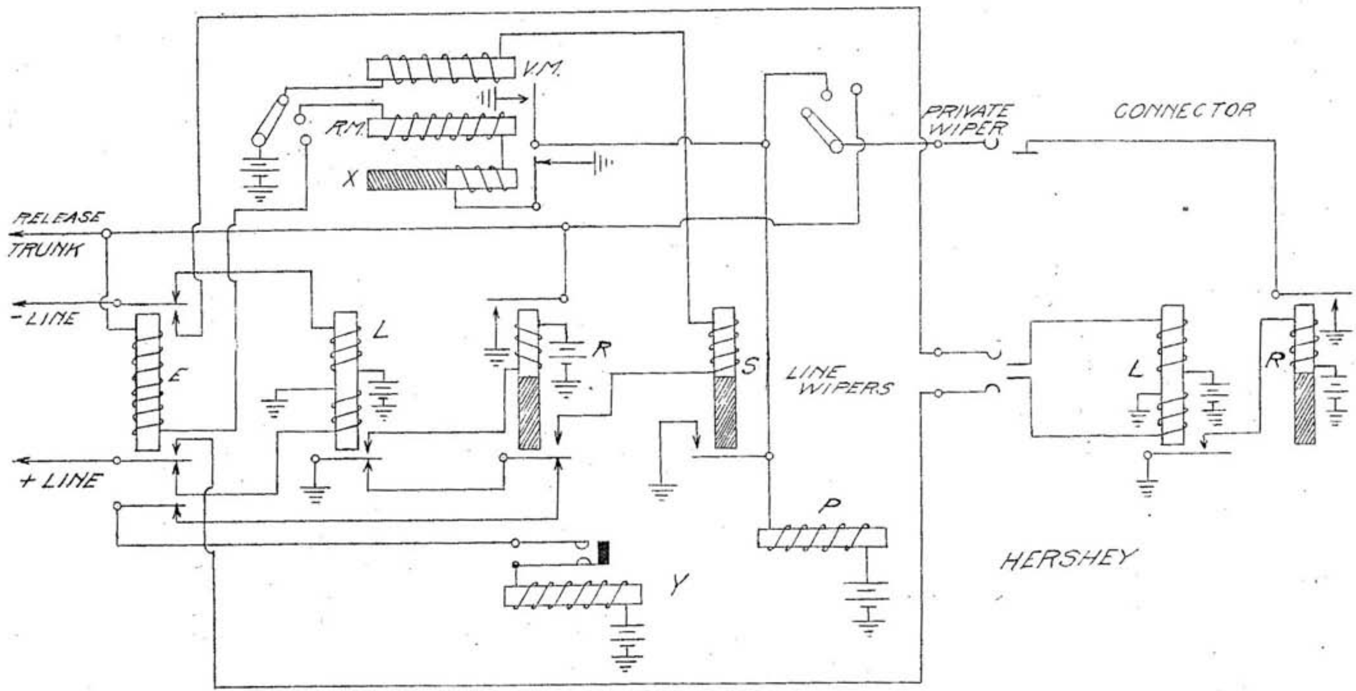
We will assume that the calling subscriber desires to call telephone number of 634. He will first operate his dial from the figure 6. This will cause the line circuit to be opened six times, at each break of the line circuit the relay L will momentarily de-energize. Each time relay L de-energizes a circuit is closed from the ground, break springs relay L, make springs relay R, series relay S, vertical magnet VM, sideswitch wiper in first position, to negative battery. The vertical magnet will energize over this circuit and operate to raise the shaft and wipers, step by step, to the sixth level of bank contacts.

At the first impulse of current to the vertical magnet the series relay will energize and close a circuit through the private magnet P. Relay S, being a slow acting relay, will maintain its armature in an operated position until a fraction of a second after the last impulse of current passes through it. Following the secession of the vertical impulses the relay S will de-energize and open the circuit of the private magnet. The private magnet, upon de-energizing, will allow the side switch to pass to second position. As soon as the side switch passes to second position a circuit is closed from ground, through springs of interrupter relay X, relay X, rotary magnet, side switch wiper in second position, to negative battery.

The rotary magnet will energize over this circuit and operate to advance the shaft and wipers one step, thus bringing them into engagement with the first set of contacts in the sixth level. The rotary magnet also closes a circuit through the private magnet, which causes the same to energize. In addition the relay X will energize over the above traced circuit and operate to break the circuit through itself and the rotary magnet. The rotary magnet will now de-energize and open the circuit of the private magnet, which (assuming that the first contact is idle) will de-energize.

When the private magnet de-energizes it allows the side switch to pass to third position. As soon as the side switch reaches third position a circuit may be traced from ground, through springs relay R, switching relay E, side switch wiper in third position, to negative battery. The switching relay will energize over this circuit and will extend the connection

FIG. 36


V.M.
R.M.
X
PRIVATE
WIPER
CONNECTOR
RELEASE
TRUNK
-LINE
E
L
R
S
LINE
WIPERS
L
R
+LINE
P
Y
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to the connector associated with the first contact of the sixth level. When the connection is extended to the connector a circuit may be traced from ground, lower winding line relay L (of the connector), line wiper, make springs relay E, through the line switch and instrument, back through make springs relay E, line wiper, upper winding line relay L (of the connector), to negative battery.

The line relay L (of the connector) will energize over this circuit and close the circuit of release relay R (of the connector), which in turn will energize and close a circuit that may be traced from ground, make springs relay R (of the connector), private wiper, side switch wiper in third position relay E, to negative battery. A branch of this circuit also extends back to the line switch as has already been explained. When the switching relay E energizes it opens the circuit of relay L, which in turn will de-energize and open the circuit of relay R. Relay R, being a slow acting relay, will not immediately de-energize, but will maintain the ground on the release trunk until sufficient time has elapsed for the release relay of the connector to return a new holding ground on the release trunk. The connection is now completed by means of the connector, in a manner with which we are already familiar.

Should the first trunk be busy the private magnet P will not de-energize following the first de-energization of the rotary magnet, for the reason that a holding circuit is now formed from the grounded private bank contact, side switch wiper in second position, through the private magnet, to negative battery. It can be seen that the circuit of the private magnet will be closed so long as the private wiper engages grounded contacts. As a result the side switch is locked in second position, and the interrupter relay X operates as a buzzer and causes the rotary magnet to advance the shaft and wiper, step by step, until an idle trunk is reached.

When the relays L and R de-energize the circuit of the release magnet Y will not be closed, on account of the open at the break springs carried by relay E. After the completion of the conversation the restoration of the receiver to the switch hook at the calling sub-station will cause the de-energization of the line and release relays of the connector switch. The release relay, upon de-energizing, will remove ground from the release trunk, thereby causing the release of the switching relay E. When relay E de-energizes the circuit of the release magnet Y will be closed. Release magnet Y will energize and operate to remove the double dog and force the side switch back to first position, following which its own circuit will be opened at the off normal springs as soon as the shaft reaches normal.

In some selectors a "Rotary arm finger" is carried by the rotary magnet armature in such a manner that it mechanically operates the armature of the private magnet, thus accomplishing the same results as the pair of rotary magnet springs shown in Fig. 36.

Questions.

A. What would be the result of an "open" in the break springs of relay E?

B. Primarily what is the function of the springs on the rotary magnet?

C. Are the rotary magnet springs needed after the first rotary step is accomplished?

D. Why is relay X made slow acting?

Chapter XVII

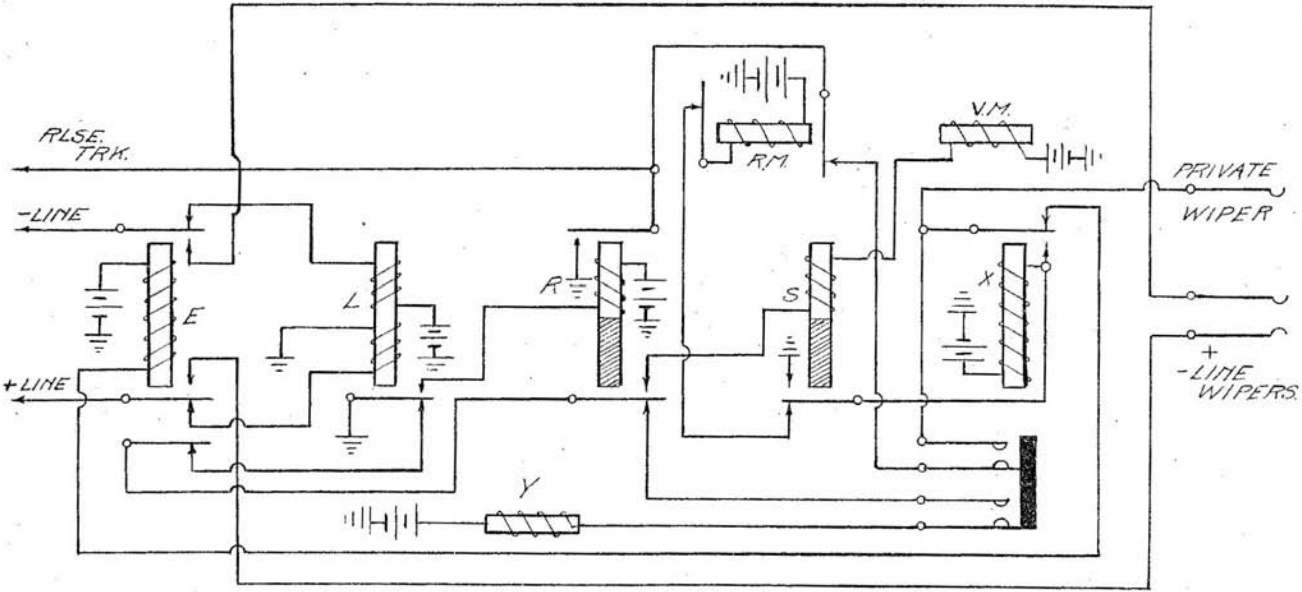
Circuit Reading of the Sideswitchless Selector.

In an attempt to reduce the mechanical complexity of the Sideswitch Selector a new selector was brought out; this selector is mechanically the same as a connector switch, except that it has no private magnet, spider arm, or sideswitch wipers. This Sideswitchless Selector, as it is called, is mechanically less complicated than the older type, but from a circuit viewpoint it is more complex. With reference to Fig. 37 we have the familiar line relay L, release relay R, series relay S, switching relay E, release magnet Y, rotary magnet RM, vertical magnet VM, and the private control relay X. The relay X is 350 ohms in resistance, and is made with a very small core, in order that the relay shall be quick to de-energize.

We will assume that the connection has been extended to the selector shown in Fig. 37, and that the calling subscriber now dials the Fig. 6. The line relay, release relay and series relay will operate in the usual manner and cause six impulses of current to be sent through the vertical magnets. When the series relay energizes (at the first vertical impulse), a circuit is closed from ground, make springs relay S, private control relay X, to negative battery. Relay X will energize and form a locking circuit for itself which may be traced from ground, through make springs relay R, break springs rotary magnet, off normal springs (which are now closed since the shaft has been raised one step), make springs relay X, relay X, to negative battery. When the series relay de-energizes (a fraction of a scond after the last vertical impulse passes through it), a circuit may be traced from ground, make springs relay R, break springs rotary magnet, off normal springs, make springs relay X, break springs relay S, break springs rotary magnet, rotary magnet, to negative battery. The rotary magnet will energize over this circuit and operate to rotate the shaft and wipers into engagement with the first set of contacts in the sixth level of the bank.

When the rotary magnet energizes it will also open its own circuit and the circuit of the private control relay X. Let us assume that the first private contact is idle; the private control relay will now release and close a circuit from ground, make springs relay R, break springs rotary magnet (after the same has de-energized), off normal springs, break springs relay X, switching relay E, to negative battery. The switching relay will energize over this circuit and operate to extend the connection to the connector switch in the same manner as was explained in the last lesson.

FIG. 37



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If the first private bank contact is busy the private control relay will not de-energize following the first energization of the rotary magnet, for the reason that a holding circuit will be formed from ground at the private bank contact, make springs of relay X, relay X, to negative battery. Thus it will be seen that the private control relay will remain energized so long as the private wiper engages busy private bank contacts. The rotary magnet will continue to operate as a buzzer and will cause the shaft and wipers to be rotated step by step until such time as an idle trunk is reached.

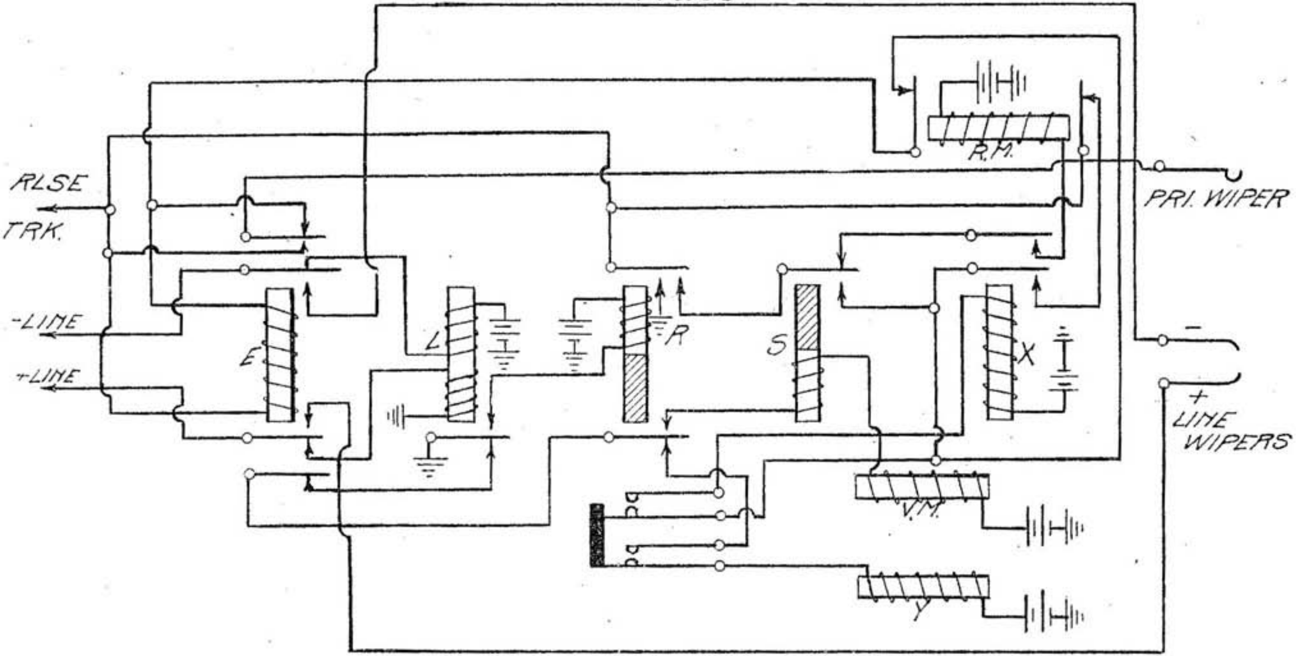
After the conversation is completed the release of this connection takes place in the same manner as explained in the discussion of the Sideswitch Selector.

Circuit Reading of the Powell Selector.

In both the Sideswitch and the Sideswitchless Selector the stopping on an idle trunk is dependent upon the de-energization of a relay. As a result the operation of the selector is marginal, for if the relay springs are too stiff the selector may stop on a busy trunk, and if the relay springs are too weak the selector will pass over an idle trunk. In some P. A. X. circuits the private bank contacts are normally connected through a low resistance relay to negative battery. If the first four contacts are busy, and the fifth goes to battery through a fairly low resistance, it is difficult to adjust the selector shown in Fig. 37 so that it will stop on the fifth contact. The reason is that relay X is shunted and made slow acting, at least sufficiently slow acting so as to fail to de-energize quickly enough to allow the selector to "cut out" on the first idle contact. In an endeavor to devise a selector which would be independent of the time element in the release of a relay Mr. Powell produced the circuit shown in Fig. 38. We have here the familiar line relay L, release relay R, series relay S, switching relay E, release magnet Y, vertical magnet VM, rotary magnet RM, and private control relay X. The private control relay as used in this circuit is of 210 ohms resistance, and is purposely made very inefficient, so that it will not operate when in series with the switching relay E.

We will assume that the connection has been extended to the selector shown in Fig. 38, and that the calling subscriber now dials the figure 6. The line relay, release relay, and series relay will operate in the usual manner and cause six impulses of current to be sent through the vertical magnets. When the series relay energizes (at the first vertical impulse), a circuit is closed from ground, make springs relay R. make springs relay S, off normal springs (which are now closed since the shaft has been raised one step), private control relay X, to

FIG. 38



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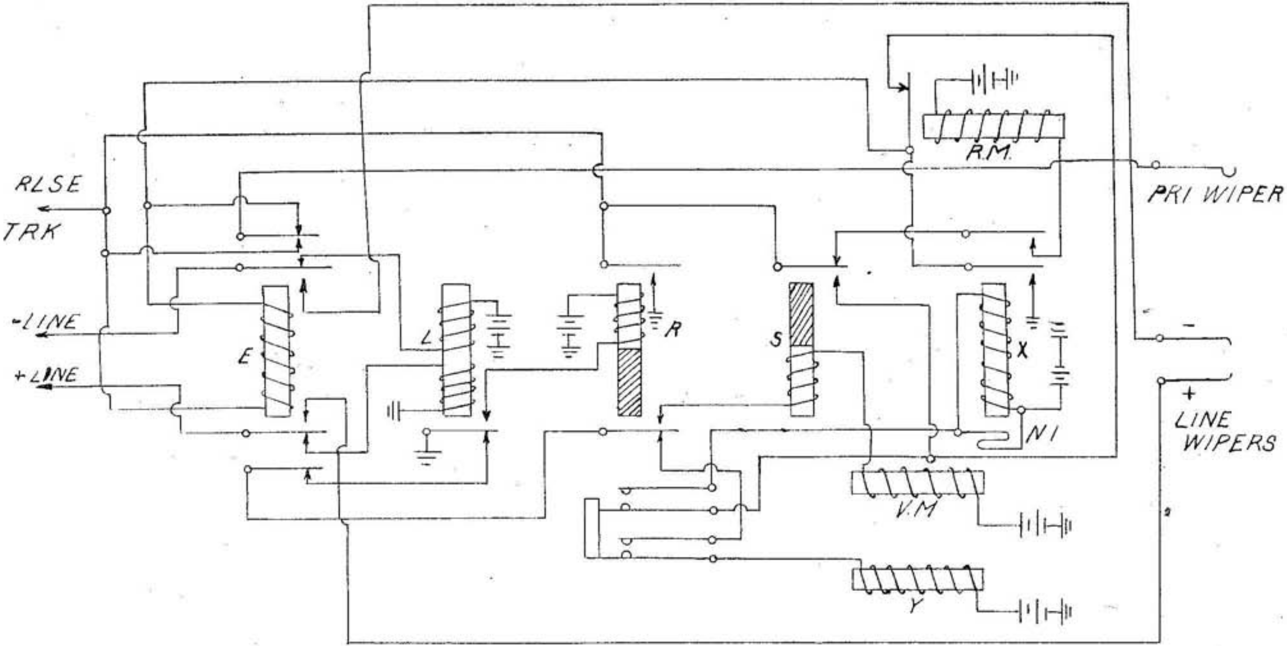
negative battery. The private control relay will energize and form a locking circuit for itself which may be traced from ground, make springs relay R, break springs rotary magnet, make springs relay X, off normal springs, relay X, to negative battery. When the series relay de-energizes (a fraction of a second after the last vertical impulse passes through it), a circuit may be traced from ground, make springs relay R, break springs relay S, make springs relay X, rotary magnet, to negative battery. The rotary magnet will energize over this circuit and operate to rotate the shaft and wipers into engagement with the first set of contacts in the sixth level of the bank. In addition the rotary magnet opens the locking circuit of relay X, which in turn will de-energize and open the circuit of the rotary magnet. Let us assume that the first private bank contact is idle. As soon as the rotary magnet de-energizes a circuit can be traced from ground, springs relay R, relay E, break springs rotary magnet, off normal springs, relay X, to negative battery. The relay X, due to its construction, will not energize in series with the switching relay E. Relay E will, however, energize over the above traced circuit and operate to extend the connection to the connector switch in the manner with which we are familiar. Your attention is called to the fact that when the switching relay is at normal the private wiper is attached to its upper terminal, but when the switching relay is energized the private wiper is shifted to its lower terminal. The reason for this change will be explained in the following paragraph.

If the first private bank contact is busy the switching relay will be shunted out, and, following the de-energization of the rotary magnet, a circuit may be traced from ground at the private bank contact, break springs relay E, break springs rotary magnet, off normal springs, relay X, to negative battery. The private control relay will energize and close the circuit of the rotary magnet; the rotary magnet, in turn, will energize and advance the shaft and wipers one step, at the same time opening the circuit of relay X. Thus it will be seen that the switching relay will remain shunted out so long as the private wiper engages busy private bank contacts. The rotary magnet and the relay X will continue to operate alternately, and as a result the shaft and wipers will be advanced step by step until such time as an idle trunk is reached. After the call has been extended to the connector the release trunk ground must not again shunt out relay E, therefore the private wiper is shifted from one terminal of relay E to the other.

In this selector it will be seen that the switching relay is shunted out by the ground on the busy private bank contacts and that the stopping on an idle trunk is dependent upon the

FIG. 38A



HERSHEY

pulling up of the switching relay. As a result there is no marginal adjustment, and the placing of negative battery on the private bank contacts introduces no complications. The author has called this rotary movement an "electrical escapement," its action being so similar to the escapement in a watch or clock.

Your attention is called to the fact that the pair of break springs on the E relay is wired between the springs of relay R and the off normal springs in Fig. 36, while in Figures 37 and 38 these springs are wired between the springs of relay L and the springs of relay R.

If the release circuit in Fig. 37 or 38 were to be wired the same as shown in Fig. 36 the following difficulty would arise. When the switching relay becomes operated the line relay is cut off and will immediately de-energize, the release relay, however, being a slow acting relay, will remain energized for a short length of time, and as a result a circuit will be closed through the vertical magnets until such time as the release relay de-energizes. For this reason it is necessary that the break springs on the E relay be wired between the springs of the L and R relay.

The above difficulty will not occur in Fig. 36, for at the time the switching relay operates the circuit to the vertical magnets will be open at the side switch.

The Improved Powell Selector.

In Fig. 38-A is shown a recent improvement which Mr. Powell has made in his selector. The various relays are the same as in Fig. 38, the only change being the elimination of the floating spring on relay R, and a saving of one set of break springs on the rotary magnet. A 1,300 ohm non-inductive winding is placed around the X relay in order to take up the spark at the springs of the rotary magnet.

We will assume that the connection has been extended to the selector shown in Fig. 38-A, and that the calling subscriber now dials the figure 6. The line relay, release relay, and series relay will operate in the usual manner and cause six impulses of current to be sent through the vertical magnets. When the series relay energizes (at the first vertical impulse), a circuit is closed from ground, make springs relay R, make springs relay S, off normal springs (which are now closed since the shaft has been raised one step), private control relay X, to negative battery. The private control relay will energize and form a locking circuit for itself which may be traced from ground, make springs relay X, break springs rotary magnet, off normal springs, relay X, to negative battery. When the series relay de-energizes (a fraction of a second after the last vertical impulse passes through it), a circuit may be traced from ground, make springs relay R, break springs relay S, make springs relay X, rotary magnet, to negative battery. The rotary magnet will energize over this circuit and operate to rotate the shaft and wipers into engagement with the first set of contacts in the sixth level of the bank. In addition the rotary magnet opens the locking circuit of relay X, which in turn will de-energize and open the circuit of the rotary magnet. Let us assume that the first private bank contact is idle. As soon as the rotary magnet de-energizes a circuit can be traced from ground, make springs relay R, relay E, break springs rotary magnet, off normal springs, relay X, to negative battery. The relay X, due to its construction, will not energize in series with the switching relay E. Relay E will, however, energize over the above traced circuit and operate to extend the connection to the connector switch in the manner with which we are familiar. Your attention is called to the fact that when the switching relay is at normal the private wiper is attached to its upper terminal, but when the switching relay is energized the private wiper is shifted to its lower terminal. The reason for this change will be explained in the following paragraph.

If the first private bank contact is busy the switching relay will be shunted out, and, following the de-energization of the rotary magnet, a circuit may be traced from ground at the private bank contact, break springs relay E, break springs rotary magnet, off normal springs, relay X, to negative battery. The private control relay will energize and close the circuit of the rotary magnet; the rotary magnet, in turn, will energize and advance the shaft and wipers one step, at the same time opening the circuit of relay X. Thus it will be seen that the switching relay will remain shunted out so long as the private wiper engages busy private bank contacts. The rotary magnet and the relay X will continue to operate alternately, and as a result the shaft and wipers will be advanced step by step until such time as an idle trunk is reached. After the call has been extended to the connector the release trunk ground must not again shunt out the relay E, therefore the private wiper is shifted from one terminal of relay E to the other.

Questions.

A. How would the speed of the rotary motion of the two selectors compare?

B. What would happen if relay X energized in series with relay E?

C. If, in Fig. 38, there were a short between the upper pair of make springs on relay E what would result?

Chapter XVIII

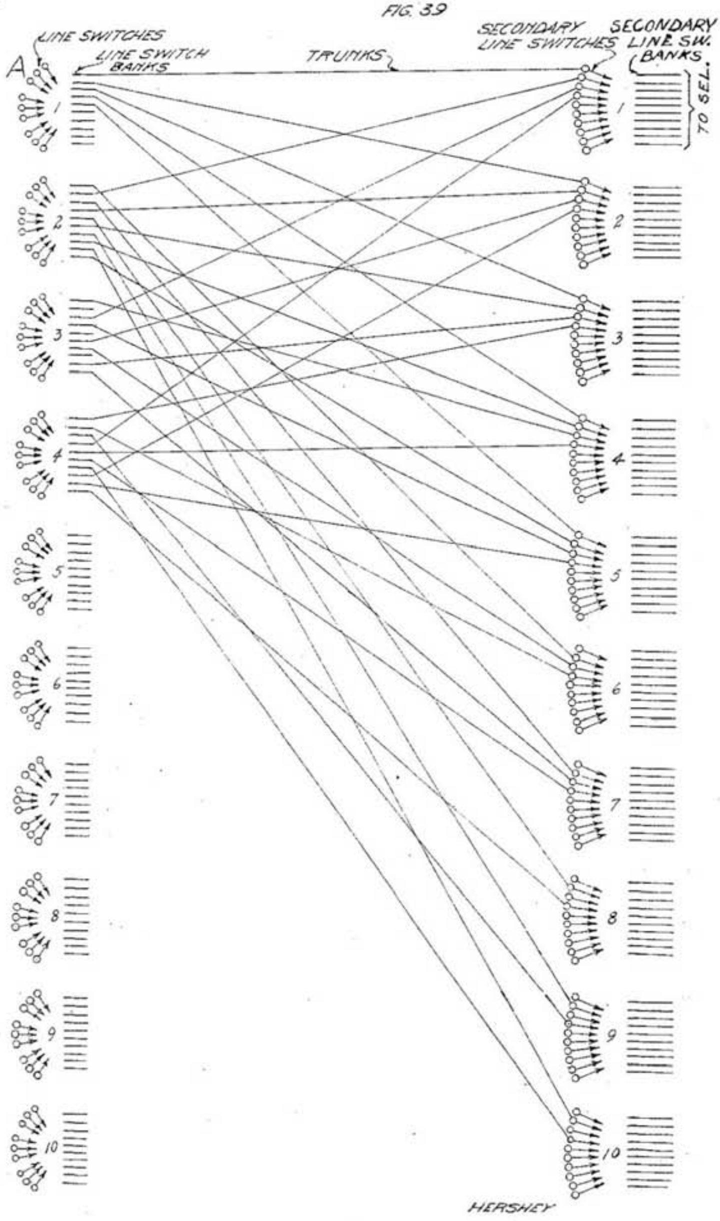
Theory of the Secondary Line Switch.

In the Automatic System that we have developed each line terminates on a line switch, there are one hundred line switches in a group, and ten outgoing trunks from each group which lead to selectors. This is what is termed ten per cent trunking, but nothing can be told of the value of ten per cent trunking unless we know the size of the group. If, for instance, there were ten lines in a group supplied with one outgoing trunk, it would still be ten per cent trunking, but the service would be very poor. If the group consists of one hundred lines supplied with ten outgoing trunks the service is much better, and if the group consists of one thousand lines supplied with one hundred outgoing trunks the service would be very good indeed; the fact is the one hundred trunks would not be needed. In order to profit by the economies incident to the use of larger groups the secondary line switch was developed.

When secondary line switches are employed the lines terminate on primary line switches, which have access to a group of trunks terminating in secondary line switches, the secondary line switches, in turn, have access to a group of trunks leading to selector switches. The general principle of trunking between primary and secondary line switches is shown in Fig. 39. On the assumption that three indicates ten, the three groups of three circles each at A indicates a group of one hundred line switches to which the subscribers' lines are attached. The trunks from the banks of the primary line switches run to the secondary line switches as shown. The trunks from the banks of the secondary line switches lead to first selectors, of which there are ten or less for each group of secondaries, depending upon the traffic.

It will be observed that not more than one trunk from a primary group goes to a given secondary group. The first trunk from the first primary group runs to the first secondary in the first secondary group, the second trunk goes to the first secondary in the second secondary group, etc. This is the basic principle of the scheme, and upon it depends the effectiveness of the trunking. By giving each primary group a trunk into each of the ten secondary groups, all of the selectors are made available to all the subscribers. If all of the outgoing trunks from a given secondary group become busy it renders useless not more than one trunk from each primary group.

FIG. 39



LINE SWITCHES
LINE SWITCH BANKS
A
TRUNKS
SECONDARY LINE SWITCHES
SECONDARY LINE SW. BANKS
TO SEL.
1
2
3
4
5
6
7
8
9
10
HERSHEY

Circuit Reading of the Secondary Line Switch.

In its mechanical structure the secondary line switch is very similar to the primary line switch, the only difference is that a projection at the rear of the plunger arm is utilized to operate a set of springs. By referring to Fig. 40 it will be seen that the secondary line switch consists of a double wound magnet. The pull down winding is 85 ohms in resistance, and is capable of operating the plunger arm. The holding winding is capable of retaining the plunger arm in an operated position and is usually wound to 1,200 ohms. The slow acting relay O is termed the open main relay and is of 10 ohms resistance.

Let us assume that a subscriber removes his receiver, and that his line switch plunges into the bank springs shown at the left of Fig. 40. A circuit may now be traced from ground, bank springs, holding trunk, pull down winding, break springs, open main relay O, to open main (negative battery). The relay O will energize over this circuit and short the holding and release trunks; the object of this is to place ground on the release trunk so that the B. C. O. winding of the primary line switch will be energized. The pull down winding will also energize over the above traced circuit and will cause the plunger arm to enter the bank. Just as the plunger arm completes its stroke the springs will be shifted, and the holding winding will be cut in series with the pull down winding. When the plunger enters the bank the connection will be extended to the selector. The line and release relay of the selector will operate and ground will be returned on the relase trunk to maintain the primary and secondary line switches in an operated position. The relay O, being a slow acting relay, will not release its armature immediately following the operation of the plunger arm, but will retain the short between the holding and release trunks until sufficient time has elapsed for the selector to return a ground on the release trunk. After the completion of the conversation the removal of the ground from the release trunk will cause the primary and secondary line switches to release.

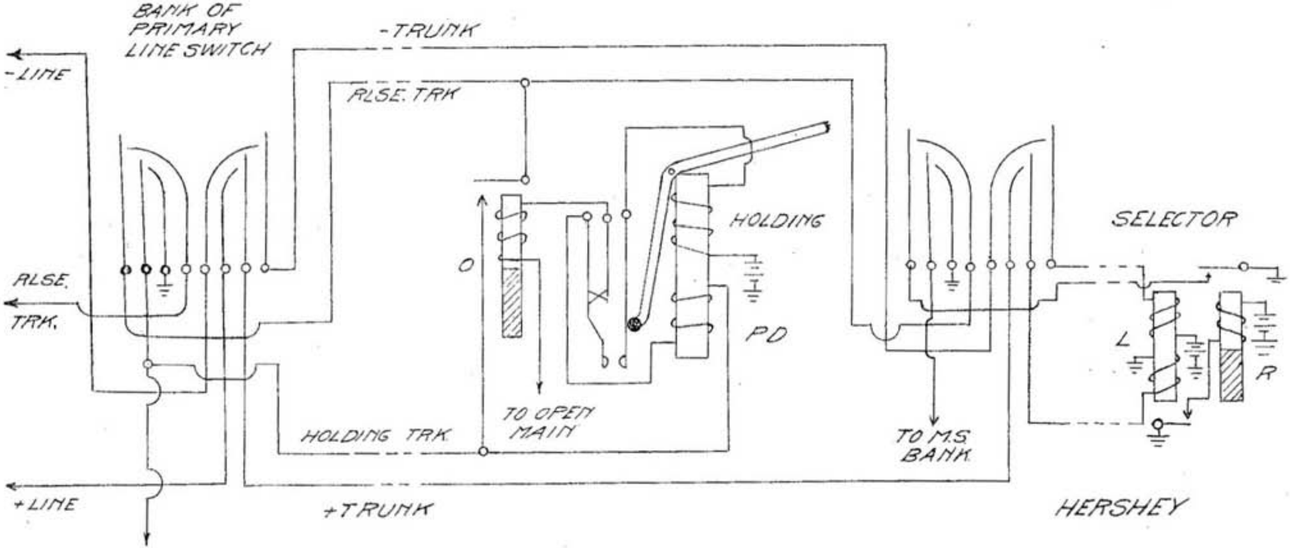
Questions.

A. Why is a holding winding provided?

B. If relay O became quick acting what would result?

C. If the springs of relay O failed to break what effect would it have upon the primary line switch?

FIG 40.


BANK OF
PRIMARY
LINE SWITCH
-TRUNK
-LINE
RLSE. TRK
RLSE.
TRK.
O
HOLDING
PD
TO OPEN
MAIN
HOLDING TRK
+LINE
+TRUNK
SELECTOR
L
R
TO M.S.
BANK
HERSHEY

Chapter XIX

Circuit Reading of Primary and Secondary Line Switch.

In Fig. 41 is shown a primary line switch H, secondary line switch I, primary master switch J, secondary master switch K, secondary relay equipment L and chain relays M.

The primary line switch H is the same line switch as is shown in Fig. 30.

The secondary line switch I is identical with the secondary line switch shown in Fig. 40.

The primary master switch J is similar to the master switch shown in Fig. 32. In this master switch the open main relay O is a slow acting relay, and as a result the holding circuit from the springs of the trip relay T goes direct to the locking magnet L M, thus the starting relay S R can be a single wound relay. At P is shown a slow acting "kick off" relay, which is usually 1,100 ohms in resistance. The supervisory relay X is here shown as a double wound relay, the right hand winding of which is low in resistance (fifteen one-hundredths of an ohm), so that the locking magnet may operate in series with it.

The secondary master switch K is mechanically the same as the master switch shown in Fig. 32. The familiar trip relay is shown at T, the open main relay at O, the locking magnet at L M, and the solenoid at S L.

In the secondary relay group L the function of the starting relay A is the same as that of relay SR in Fig. 32, the resistance of this relay is 1,300 ohms. The function of the stop relay B is to remove battery from the secondary master switch K when all the outgoing trunks from the secondary group are busy. Upon energizing it also closes the circuit of the kick off relay P, in each primary master switch associated with this group of secondaries. The resistance of this relay is 1,300 ohms. The supervisory relay C is similar to the supervisory relay X of the primary master switch J, the low resistance winding is, however, on the left hand end. The relay D is in series with the open main feed to the secondary line switches, the left hand winding is 3,400 ohms and the right hand winding 18 ohms in resistance. The trunk busying relay E is a slow acting relay of 3,410 ohms resistance; this relay is normally energized and only drops back when the starting relay A operates.

The chain relays M are ten in number, one being associated with each outgoing trunk from the secondary group.

Let us assume that a subscriber removes his receiver and that the primary line switch H plunges in. A circuit may now be traced from ground, bank contacts line switch H, low winding of the secondary line switch I, break springs secondary line switch, open main relay O of the secondary line switch, make contacts relay E, relay D, break springs open main relay O of the secondary master switch K, break springs stop relay B, low resistance winding of supervisory relay C to negative battery. Neither the secondary line switch nor the open main relay O will energize at this time, due to the resistance of relay D. The relay D will energize and the 3,400 ohm winding will be shunted, following which the secondary line switch I and the open main relay O will operate and the connection will be extended to the first selector. When the primary line switch H plunged in on this trunk, a ground was placed on the associated master switch bank contact, which caused the primary master switch J to seek an idle trunk.

When the secondary line switch plunges in a circuit may be traced from ground, bank contacts secondary line switch, master switch bank contact, starting relay A, to negative battery. The starting relay A will energize and cause the secondary master switch to seek an idle trunk. In addition the starting relay will open the circuit of the trunk busying relay E. The relay E, upon de-energizing, will remove open main from the open main lead to the secondary line switches, and will place ground thereon. This ground will feed back thru the various secondary line switches to the master switch bank contacts associated with the trunks to this particular group of secondaries. If any primary master switch happens to be standing opposite one of these trunks it will be moved off, this is to insure that no primary line switch will plunge in on a trunk to a secondary while the master switch associated with that particular secondary is operating. The relay E is made slow acting so that its speed of de-energizing can be controlled. In some offices it is adjusted not to release unless the secondary master switch swings over at least three trunks. This saves considerable wear on the primary master switches, but makes it possible for a primary to plunge in on a secondary while the associated master switch is operating.

When the release relay L of the selector returns ground on the release trunk the circuit of the corresponding chain relay is closed. The chain relay energizes and closes its portion of the chain, and also places ground on the associated master switch bank contact. This arrangements is advantageous in that an outgoing trunk may be made busy by simply grounding the release trunk at the selector. Following which the attendant should step to the secondaries and operate the master switch, to insure that no secondary line switches are left standing opposite the trunk which has been made busy.

If all the outgoing trunks from the secondary group become busy a circuit may be traced from ground, thru the make springs of each chain relay, stop relay B, to negative battery. The stop relay B, upon energizing, will open the battery feed to the secondary master switch K, thus causing the secondary master switch to cease hunting an idle trunk. No matter where the secondary switch comes to rest it will find the master switch bank contact grounded, and as a result the starting relay A will be held energized. As before, the trunk busying relay E will de-energize and ground all the trunks leading into this group of secondaries. This busy condition is likely to last quite a while, so it is not sufficient to merely ground the contacts in the primary master switch banks which are associated with the trunks to this group of secondaries. For the reason that a primary may have plunged in on one of these trunks, and then released; but has not yet been picked up by its master switch. If this subscriber again removed his receiver he would plunge in on a trunk leading to a secondary line switch in the group whose outgoing trunks were all in use. Therefore when a secondary group becomes busy it is necessary that all the primary master switches in the thousand be operated so as to pick up any line switch that happens to be standing opposite a trunk to the secondary group whose outgoing trunks are all in use.

When the stop relay B energizes, and before relay E de-energizes, a circuit may be traced from ground, make springs relay B, make springs relay E, to each primary master switch in the group. Continuing the circuit at primary master switch J, we find that it passes thru the break springs of kick off relay P, relay P, to negative battery. The current flowing in the above traced circuit is of short duration, for the trunk busying relay E soon de-energizes after the start relay A opens its circuit. This impulse of current will, however, be sufficient to operate the various kick off relays, which, when once energized, form a locking circuit for themselves. In the case of master switch J this circuit may be traced from ground, supervisory relay X, break springs trip relay T, make springs relay P, relay P to negative battery. When the kick-off relay energizes it closes a circuit thru the locking magnet L M which, upon energizing, removes the retaining arm thus allowing the master switch to swing in front of trunk number one. When trunk number one is reached the springs Y are operated and a circuit is closed thru the trip relay T, which operates in a manner with which we are familiar, and causes the master switch to swing in front of trunk number ten.

When the trip relay energized the circuit of the kick-off relay was opened, the kick-off relay does not again energize when the trip relay is released, for its circuit is now open at the springs of trunk busying relay E. From the foregoing it will be seen that all the master switches in the thousand have made at least one sweep over the trunks, and thus all the idle line switches have been picked up.

When an outgoing secondary trunk becomes idle the associated chain relay will de-energize and open the circuit of the stop relay. The stop relay will de-energize and again place battery on the master switch K, which will immediately take up a position opposite the idle trunk. The starting relay will now de-energize and close the circuit of the trunk busying relay, which will energize and remove the busying ground from the various trunks, and at the same time place open main on the secondary line switches.

If open main battery were normally placed directly upon the secondary line switches the starting relay S R in the primary master switches would be partially short circuited, and as a result it would be difficult to adjust it to de-energize upon the first idle trunk. This is the same theory as was explained in detail in Chapter XVII. In order to assure the proper operation of the starting relays the open main battery is controlled by the relay D, which maintains 3,400 ohms in the open main circuit until such time as a primary line switch plunges in.

Questions.

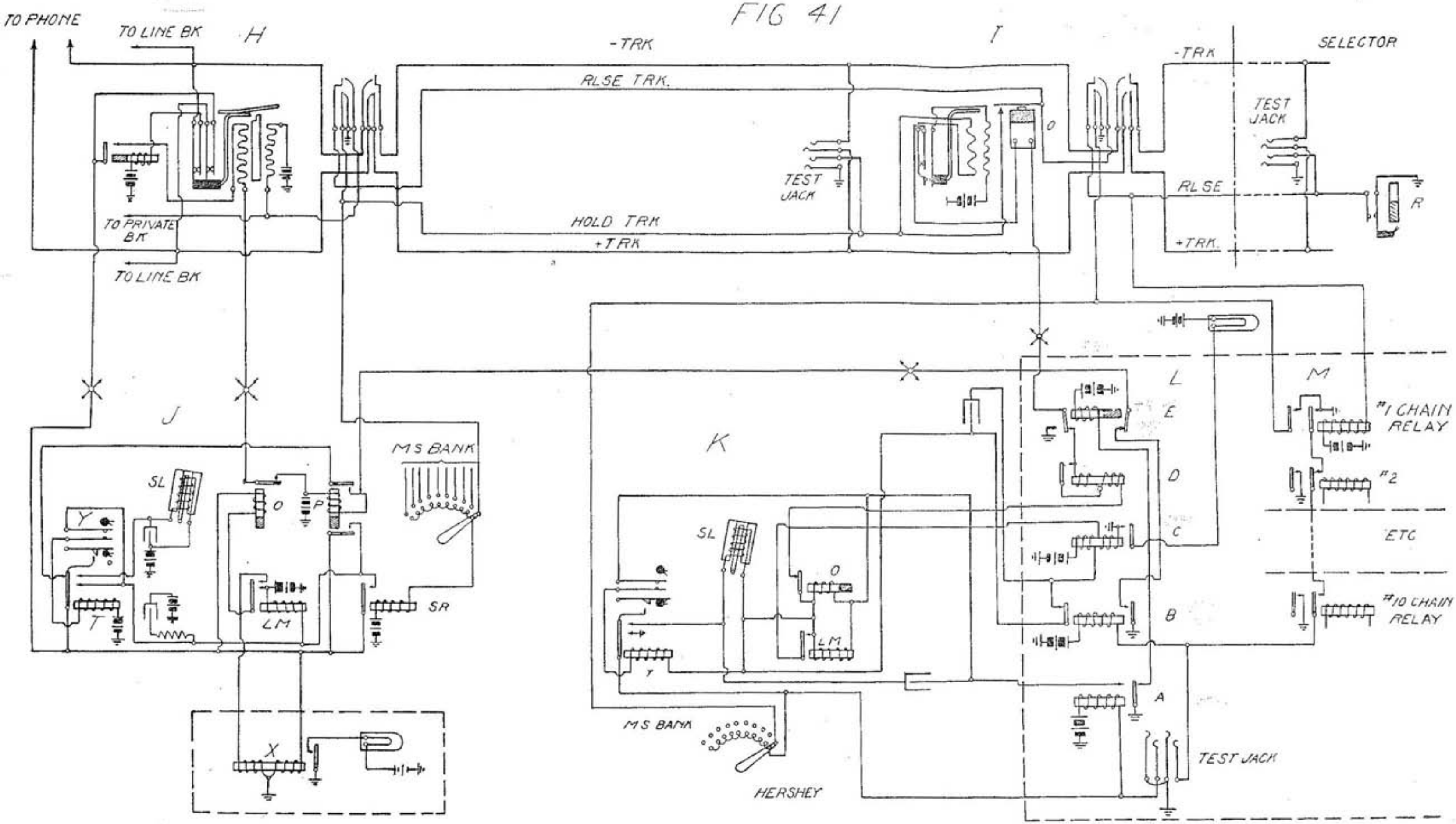
A. What would be the result if one of the chain relays failed to energize?

B. What would happen to the primary line switch if the relay D failed to energize promptly?

C. If the power board fuse for all secondary groups should blow what effect would it have on the primary master switches?

D. In view of the fact that the E relay controls the open main feed to the secondary line switches, why is it necessary to have an open main relay on the secondary master switch?

FIG 41


TO PHONE
TO LINE BK
H
-TRK
RLSE TRK.
I
-TRK
SELECTOR
TEST JACK
O
TEST JACK
RLSE
R
HOLD TRK
+TRK
+TRK.
TO PRIVATE BK
TO LINE BK
L
M
E
#1 CHAIN RELAY
D
#2
J
K
MS BANK
SL
Y
O
P
C
ETC
SL
O
T
LM
SR
LM
Y
B
#10 CHAIN RELAY
A
X
MS BANK
TEST JACK
HERSHEY

Chapter XX

The Party Line Board.

In all automatic plants harmonic ringing is employed for party line signalling. This system of ringing depends upon the fact that a pendulum has a set period of vibration. If a pendulum is given even a slight impulse at exactly the right interval it soon picks up and vibrates widely. But if the impulses occur at the wrong interval, or frequently, the pendulum will not pick up. A harmonic ringer is one whose clapper is mounted on a tuned reed, or pendulum. In four-party service one reed is tuned to approximately 16 cycles per second, the second to 33 cycles, the third to 50 cycles and the fourth to 66 cycles. If 16 cycle ringing current is impressed upon the line the 16 cycle reed, or pendulum, will be the only one that will pick up and sound the gongs. In the same way the other frequencies will cause only the corresponding ringer to operate.

If there are one hundred four-party lines in the board it will be necessary to have four groups of connectors, the banks of all of the connectors will be multipled so that line number 11 will be 1 up and 1 in on any connector bank. Each group of connectors will be supplied with ringing current of a different frequency. If it is desired to call the first party on line number 11, a connector in the first group will be used; for this group of connectors is supplied with 16 cycle generator, and it is 16 cycle generator which operates the ringer at the first station. The second group of connectors is supplied with 33 cycle generator and can signal only the second party on the line. The third group of connectors is supplied with 50 cycle generator and can signal only the third party on the line. The fourth group of connectors is supplied with 66 cycle generator and can signal only the fourth party on the line.

In order to operate an Automatic Party Line System it is neecssary that we provide means which will insure that a connector supplied with the right frequency will be used when calling a given number. To do this the trunks to the connectors in the first group are brought from the first level of a selector bank. The second level of the selector bank will lead to the second group of connectors, the third level to the third group, and the fourth level to the fourth group. Thus if we wish to call the first party on line 64 we will dial 164, the connector that we seize will ring out on line 64 with 16 cycle generator. If we wish the second party we call 264, if we wish the third party we call 364, and if we wish the fourth party we call 464. From the foregoing it will be seen that the third figure from the last is the one which picks the particular party on a party line. See Fig. 41A.

In nearly all automatic plants it will be found that the party line numbers contain one more figure than do the straight line numbers in the same plant.

The Reverting Call.

When party lines are used it is necessary to provide means by which one subscriber on a line can call another subscriber on the same line. In some automatic plants the subscribers are instructed to call a manual operator when desiring a party on their own line. The operator then rings out with the proper frequency to signal the desired subscriber. In a plant utilizing branch offices the operator cannot ring back directly, and it is necessary for her to dial the number of the called party in order to ring them. This is unsatisfactory because the calling subscriber oftentimes removes his receiver too quickly, and the operator finds the line in a busy condition.

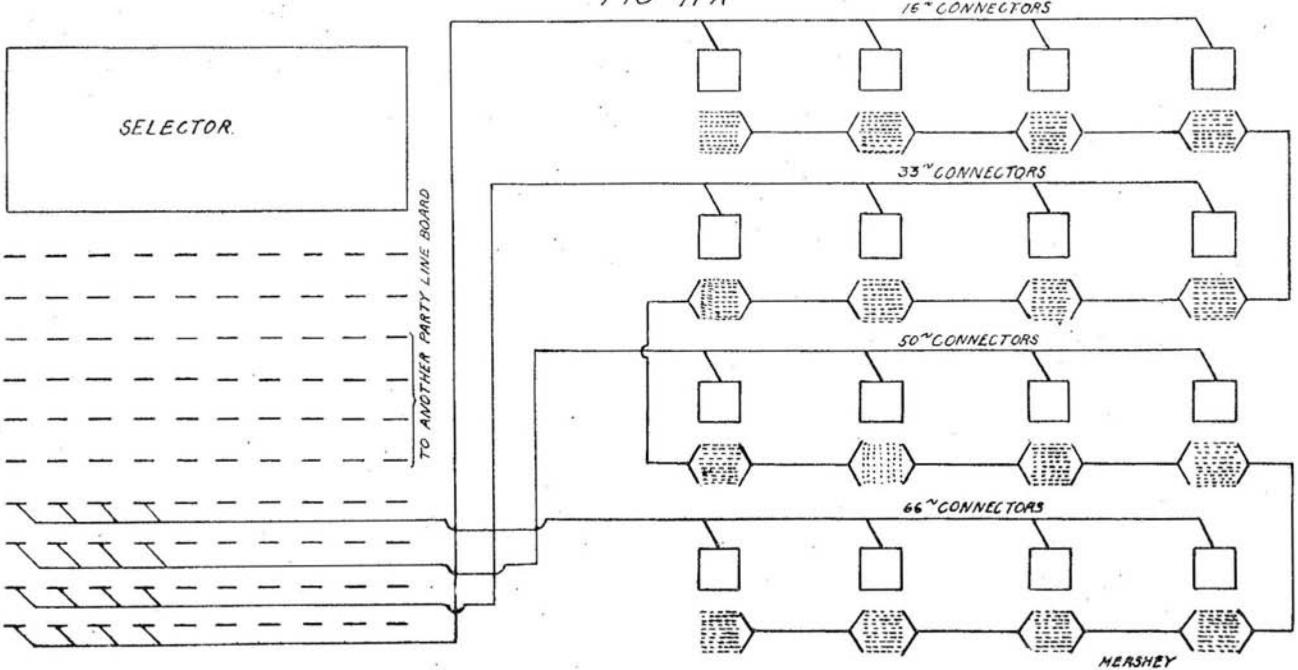
To overcome the difficulties incident to the use of a manual operator, in completing reverting calls, a reverting call switch has been devised. When this scheme is used the following information is placed on the transmitter of each party line telephone:

For Directory No. 536284 call No. 181
For Directory No. 536384 call No. 182
For Directory No. 536484 call No. 183

These telephones are on your line. To call the numbers listed above follow the instructions given in your directory, paragraph 3, page 2.

From the numbers given it is evident that this telephone is the 16 cycle, or first station. If the subscriber at the first station desires to call the second station he will remove his receiver and dial 181, after which he will return his receiver to the switch hook. His bell will now ring alternately with that of the second station. When the called party answers the ringing will cease, and this will serve as an indication to the calling subscriber that the called party has answered. The calling subscriber will now remove his receiver and converse

FIG 41-A


16~ CONNECTORS
SELECTOR
33~ CONNECTORS
50~ CONNECTORS
66~ CONNECTORS
TO ANOTHER PARTY LINE BOARD
MERSHEY

with the called party. After the completion of the conversation the restoration of both receivers to the switch hook will bring about the release of the apparatus. If the ringing continues several times it is an indication that "there is no one there," and the calling subscriber then removes his receiver for an instant in order to stop the ring, after which he hangs up his receiver and the release of the mechanism takes place.

The call numbers for the various combinations are shown in the following table:

Call Numbers for Reverting Calls.

First party (16 cycle) calling Second party (33 cycle) Call No. 181.

First party (16 cycle) calling Third party (50 cycle) Call No. 182.

First party (16 cycle) calling Fourth party (66 cycle) Call No. 183.

Second party (33 cycle) calling Third party (50 cycle) Call No. 184.

Second party (33 cycle) calling Fourth party (66 cycle) Call No. 185.

Third party (50 cycle) calling Fourth party (66 cycle) Call No. 186.

The straight 16 cycle frequency is usually placed on 187, the 33 on 188, the 50 on 189 and the 66 on 180. This is for the convenience of repair men who can ring themselves by this means when adjusting ringers. The 33 cycle ringback is also used by straight line subscribers when calling an extension telephone.

From the table given above it will be seen that the information on each party line transmitter will be different. The directory numbers will change in accordance with the line number, and the call numbers will vary according to the frequency of the particular telephone.

Chapter XXI

Circuit Reading of the Reverting Call Switch.

In its mechanical construction this switch is similar to the connector, the only difference being that the Reverting Call Switch has no vertical magnets, therefore its shaft is capable of only a rotary motion. In Fig. 42 is shown the familiar line relay L, release relay R, series relay S, rotary magnet R M, release magnet Y, and private magnet P. The switching relay E is wound to 200 ohms resistance so that the series relay may energize in series with it. The ring cut off relay C is similar to the ring cut off relay C shown in Fig. 12, except that no high resistance winding is provided. The off normal springs shown in the figure are rotary off normal springs and break at the first rotary step. At the right of Fig. 42 is shown a pair of ringing relays, these relays energize alternately in response to grounded impulses from the ringing interrupter. As each relay energizes it removes ground from the sixth bank contact and impresses ringing current of a particular frequency upon it. Only one set of ringing relays is shown in the figure, but it is to be understood that there is one set for each of the first six contacts in the bank. A single ringing relay is provided for each of the last four bank contacts.

We will assume that the reverting call switch has been seized by calling the number 18; the line and release relays will operate as usual and a holding ground will be returned on the release trunk. If the subscriber now dials the figure 6 the line relay will de-energize six times and operate to send six impulses of current through the rotary magnet R M. The rotary magnet will operate to advance the shaft and wipers into engagement with the sixth bank contact. The series relay S will energize at the first rotary impulse and will close a circuit through the private magnet P. After the secession of the rotary impulses the series relay will de-energize and open the circuit of the private magnet, following the de-energization of which the side switch will pass to second position. The calling subscriber now hangs up his receiver and awaits the ringing. The opening of the line circuit will cause the release of relay L, following which a circuit may be traced from ground, break springs relay L, make springs relay R, series relay S, break springs relay C, switching relay E, side switch wiper in second position, to negative battery. Relay S will energize in series with the switching relay and will close the circuit of the private magnet. The switching relay, upon energizing,

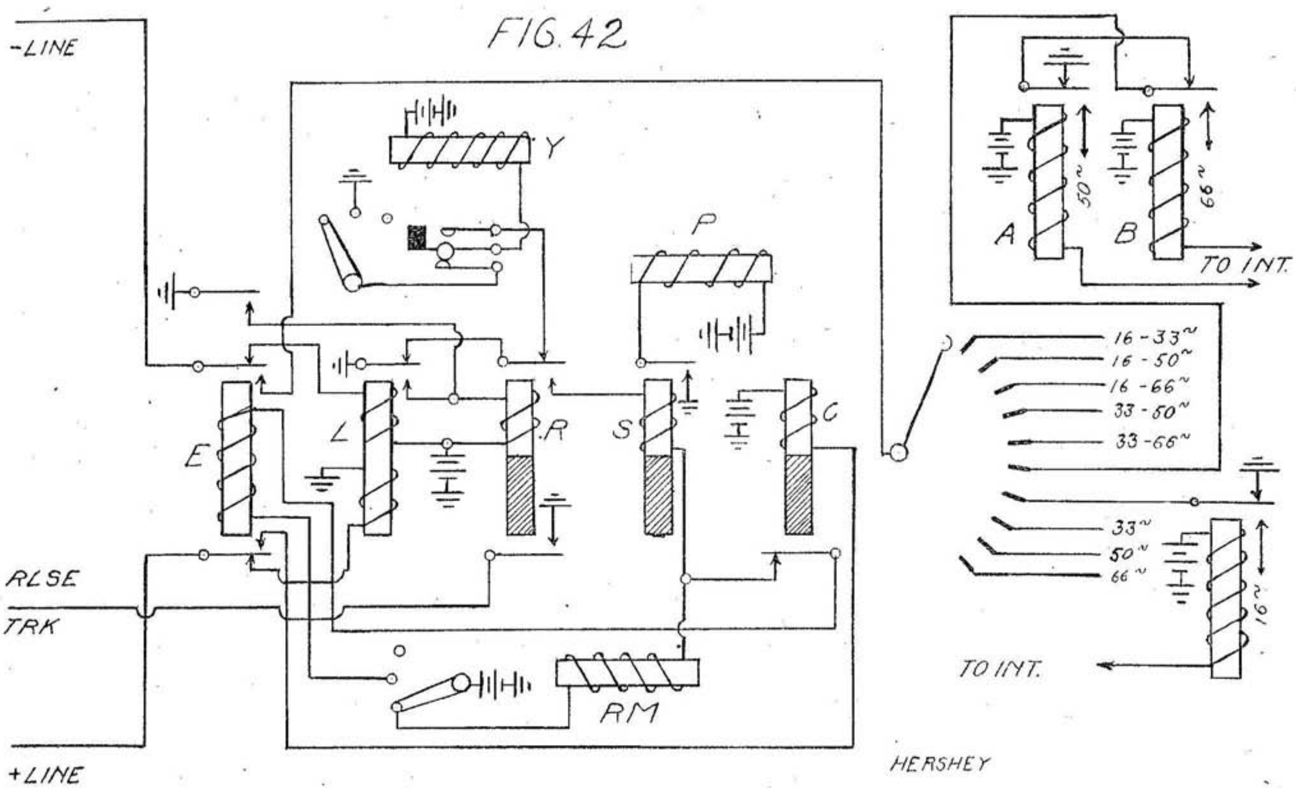

-LINE
Y
P
A
B
50~
66~
TO INT.
E
L
R
S
C
16-33~
16-50~
16-66~
33-50~
33-66~
33~
50~
66~
16~
RLSE
TRK
RM
TO INT.
+LINE
HERSHEY

FIG. 42

will form a holding circuit for relay R, and in addition a circuit may be traced from ground, break springs relay A, break springs relay B, bank contact number 6, make springs relay E, through the various switches to the calling line, thence through the ringer and condenser at each station to the opposite side of the line, back through the various switches, make spring relay E, ring cut off relay C, to negative battery. Due to the condensers at the sub-stations no battery current can flow over this circuit, but when relay A energizes 50 cycle ringing current will be impressed on the above traced circuit, and as a result the 50 cycle ringer will operate. A few seconds after the de-energization of relay A, the relay B will operate and impress 66 cycle ringing current upon the calling line. The alternating current flowing through the ring cut off relay C will have no effect upon its armature, but when the called party answers a path for direct current will be provided, and this flow of direct current will cause relay C to operate. When relay C energizes it opens the circuit of the switching relay E, which will then de-energize and again extend the connection to the line relay L. The energization of relay C also opens the circuit of the series relay S, which will de-energize and open the circuit of the private magnet. The private magnet, upon de-energizing, allows the sde switch to pass to third position.

FIG. 43

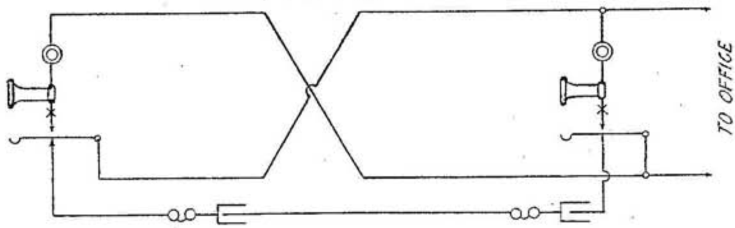
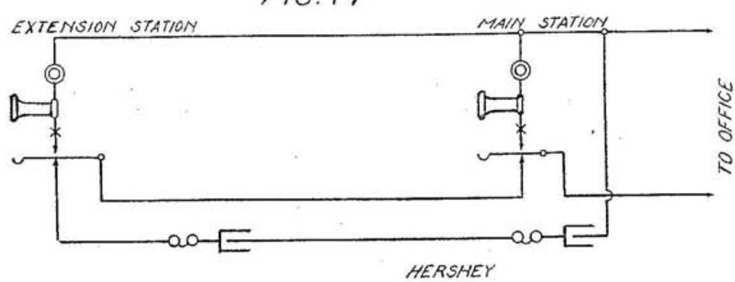


FIG. 44



When the second party removes his receiver the conversation takes place, the talking battery being supplied through the relay L. After the conversation is completed the restoration of both receivers to the switch hook will cause the de-energization of line relay L, following which a circuit may be traced from ground, break springs relay L, break springs relay R, off normal springs, release magnet Y, to negative battery. The release magnet will energize and operate to remove the double dog and force the side switch to first position, following which its own circuit will be opened at the off normal springs as soon as the shaft reaches normal. The second side switch wiper is provided to insure that the side switch will be forced back to first position.

With a circuit as shown in Fig. 42 it is apparent that the reverting call switch will be tied up throughout the time of conversation. A very simple change in the circuit will cause the reverting call switch to release when the ring is cut off. When arranged in this manner the connection drops down and the subscribers receive their talking battery from a first selector. This leaves the reverting call switch in readiness to serve a second subscriber.

The Wiring of Extension Telephones.

On party lines the dialing causes no tinkle of bells, for the ringers are harmonic and will not pick up on the dial impulses. If, however, two straight line phones are bridged across a line each bell will tinkle as the dial at the other phone is operated. To overcome this annoyance it is necessary to remove both ringers when calling from either phone. To do this a third conductor is run and the phones connected as shown in Fig. 43.

If secrecy is desired it is necessary to arrange a circuit in which the removal of the receiver at the main station will serve to cut the extension station out of the circuit. This scheme is illustrated in Fig. 44. When it is impracticable to run the third conductor the ringers may be biased, or 33 cycle harmonic bells may be used.

Questions.

A. If the side switch in Fig. 42 failed to pass to third position what complications would arise?

B. What would be the result if relay E failed to provide a holding circuit for relay R?

C. Would it be possible, in Fig. 44, for the two parties to signal each other by means of the reverting call switch?

D. What objections may there be to the circuit shown in Fig. 42?

Chapter XXII

The Connector Test Box.

In the maintenance of their automatic switchboards the various operating companies are coming more and more to the adoption of standard adjustments and of routine inspections. This is merely another illustration of that great growth of the last few years which has resulted in the division of labor and the specialization of the employe.

While it is beyond the scope of this work to discuss the details of standard adjustments and routine inspections, still we will be well repaid to devote one lesson to what is perhaps the most important of the routine inspections. Reference is had to the testing of the connector switches. It would be well at this time to refer to the first chapter and review the seven functions of the Connector Switch.

Before routine inspections were adopted there was no set way of proceeding to test out a connector switch. Each switchman had his own idea as to how it should be done, and as a result some of the seven functions were likely to be overlooked. Mr. Roy Gould, while in charge of the plant at Lansing, Mich., first conceived the idea of developing a testing circuit which would standardize the operations in testing a connector.

By means of such a testing circuit, usually called a Connector Test Box, it is possible to make all the necessary tests by simply operating the various keys and the calling device in a routine manner. It is not necessary for the man making the tests to be an expert switchman, and usually when trouble is found, as indicated to him by the test box, he merely makes that switch busy and turns a trouble ticket over to a more experienced man.

In automatic practice each connector is equipped with a four-point test jack, the upper jack being the negative line, the second jack the positive line, the third jack the release trunk, and the fourth jack being direct ground. To facilitate the testing it is customary not to assign the OO line in each hundred. The positive and negative line and the private of the OO line are then brought out to a test jack conveniently located on each board.

At the left of Fig. 45 is shown a calling plug which may be inserted into the test jack of the connector under test. At the right of the figure is the answering plug, which is to be inserted into the test jack associated with the OO line in the particular board in which we are testing. The varying keys A and B are used when testing out the vertical and rotary motion. When operated key A will cut 1,200 ohms in series with the calling line, upon operating key B 20,000 ohms will be cut across the calling line. The busy test key is arranged to place release trunk ground upon the private of the OO line, so that the same is made busy in order to test out the busy test circuit. Release trunk ground is used so that this test may also verify the fact that the connector under test is throwing ground back on the release trunk. The release key carries a pair of break springs by means of which the calling line can be opened. The other springs of the release key are used in repeater testing, as are the lamps L and L′, and will not be discussed at this time. The calling device consists of the usual impulse and shunt springs. The double wound relay C is electro polarized and will not operate until such time as the connector reverses the polarity of the calling line. The relay D is provided to place a tone upon the called line, and operates by energizing and shorting itself out. The receiver, preferably a head band receiver, is placed in the calling line so that the switchman can hear the tone on the called line as a test of the talking condensers, and, of course, is also used when testing for busy.

When desiring to test a connector the tester will insert the calling and answering plugs in their respective jacks. A circuit may now be traced from ground, through the lower winding of the line relay of the connector under test, second jack of the calling plug, break springs key A, impulse springs, receiver, left hand winding of relay C, resistance E, break springs of the release key, upper jack of the plug, thru the upper winding of the line relay of the connector, to negative battery. The relay C will not energize at this time since current is flowing in only one winding. The tester will now depress the key A thereby cutting 1,200 ohms additional resistance in the calling line, following which the dial will then be operated from the O position. When the shunt springs make, a shunt is placed around the receiver, relay C and resistance E, consequently the only resistance in the circuit will be the 1,200 ohms at key A. The tester will note the operation of the switch and then will depress the release key thereby opening the circuit of the calling line and causing the release of the connector. The key A will now be restored and the key B depressed to cut 20,000 ohms across the calling line. The figure O will be again called on the dial and the tester will note the operation of the switch.

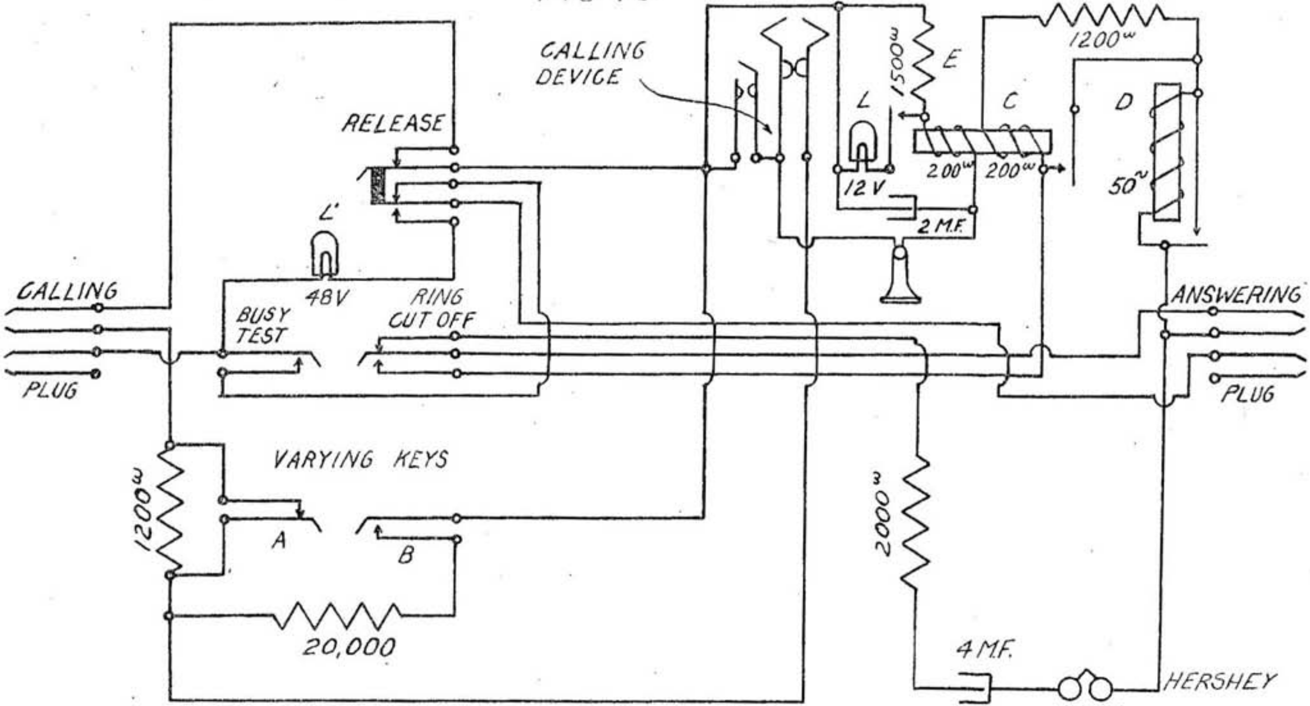
Some authorities maintain that the resistance at A and B should be made respectively higher and lower, and that the tester should O. K. the switch if the shaft reaches the top, even tho it is apparent that the impulse is not what it should be. The advocates of this scheme intend using low grade help on connector testing, whose judgment is not mature enough to pass upon the operation of the switch. Therefore the margins are made wider in order that a switch slightly out of adjustment will fail entirely, and thus bring itself to the attention of the tester.

If the switch "varies" the tester will then depress the busy key which places ground on the private of the OO line over the following circuit, from release trunk ground, third jack of the calling plug, make springs busy key, break springs release key, third jack of the answering plug, to the private of the OO line. The tester will now call OO, and the connector, finding the called number busy will place the busy tone on the calling line. It will be seen that the resistance E and the relay C are shunted by a condenser so that the busy tone may pass thru the receiver. The tester will again operate his dial to see that the busy relay has opened the circuit to the rotary magnets, following which the busy key will be restored to find if the busy relay has locked itself up independent of the ground on the private bank contact associated with the called telephone. If the connector operates satisfactorily on the busy test the tester will depress the release key and cause the release of the switch.

The tester again dials OO and the connector rings out on a circuit which may be traced from the second jack of the answering plug, ringer, condenser, 2,000 ohm resistance, break springs ring cut off key, to the upper jack of the answering plug. The ringer will operate as an indication to the tester that the connector is ringing and in addition the tester will be able to hear the ringing induction in his receiver.

The tester now operates the ring cut off key and a circuit may be traced from the second jack of the answering plug, relay D, 1,200 ohms resistance, right hand winding of relay C, make springs ring cut off key, to the upper jack of the answering plug. The current flowing in this circuit will cause the connector to cut off the ring. Relay C will not energize at this time because the current in the second winding is flowing in such a direction as to oppose the current in the other winding. Relay D will not receive sufficient current thru the 1,200 ohm resistance to enable it to operate. After the ring is cut off, the back bridge of the connector will energize over the above traced circuit and will operate to reverse the polarity of the calling line. The relay C will now energize and place a shunt around the 1,200 ohm coil and its own right hand wind-

FIG 45


CALLING DEVICE
1500ω
E
1200ω
C
D
L
RELEASE
200ω
200ω
12 V
50~
2 M.F.
L'
48V
CALLING
PLUG
BUSY TEST
RING CUT OFF
ANSWERING
PLUG
VARYING KEYS
1200ω
A
B
20,000
2000ω
4 M.F.
HERSHEY

ing. At the same time the resistance E will be shunted by the lamp L, and the relay C will remain operated due to the increased current flowing in its left hand winding. When the shunt is placed around the 1,200 ohm coil the relay D will energize and operate to shunt itself out. As a result the relay D will rapidly energize and de-energize producing a distinctive tone on the called line. The tester will hear this tone in his receiver and will know that the connector reversed the battery, and that the talking condensers are O. K. This completes the connector test and the tester will now release and pass on to the next switch.

Questions.

A. If the connector under test failed to place ground on its private wiper in third position what indication would you receive?

Chapter XXIII

Theory of Multi-office Systems.

In our discussions so far we have used only first selector switches ,and therefore the size of our exchange is limited to 1,000 lines. If second selectors are inserted between the banks of the first selectors and the connectors, the size of the exchange will be increased to a possible 10,000 lines. The following table gives the relationship between switchboard equipment and the ultimate size of the system.

Switchboard Equipment	Ultimate Size of System
Connectors	100 lines
First Selectors and Connectors	1,000 lines
First Selectors, Second Selectors and Connectors	10,000 lines
First Selectors, Second Selectors, Third Selectors and Connectors	100,000 lines
First Selectors, Second Selectors, Third Selectors, Fourth Selectors and Connectors	1,000,000 lines

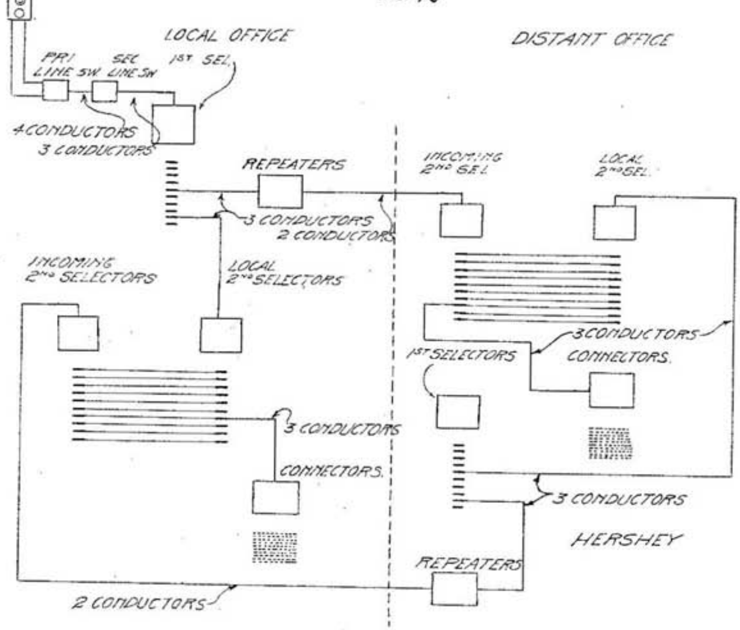
In construction and circuit arrangement these various selectors are all similar to the selector shown in Fig. 38. The term first, second, third and fourth relates only to the position of the selector in the system.

It will be recalled that there are three conductors in the trunk between a selector and a connector, and of course there must be a three conductor trunk between selector and selector. If the complete system is housed in one office the three conductor trunks are not overly expensive, but if it was necessary to run three conductor trunks to a distant office the expense would be burdensome.

In order to be able to use two conductor trunks between offices it is necessary to introduce a new piece of apparatus called a Repeater. This Repeater is not a voice repeater, such as a repeating coil, but the name is derived from the fact that it "repeats" the dial impulses to the switches in the distant office. There are no mechanical parts in the ordinary repeater, it consists merely of a group of relays.

In Fig. 46 a telephone is shown connected to a primary line switch which has access to a secondary line switch, which in turn has access to a first selector. The second level of the first selector banks lead to a group of local second selectors.

FIG. 46



The fourth level in the banks of the local second selectors go to a group of connectors in the originating office. The sixth level of the first selectors is carried to a group of repeaters, each repeater being associated with a two conductor trunk which terminates on an incoming second selector at the distant office. The third level of the incoming second selectors in the distant office is shown as leading to a group of connectors. In the originating office a group of incoming second selectors are shown whose banks are multipled with the banks of the local second selectors. The incoming second selectors in the originating office are the terminals of a set of repeaters which may be seized from the second level of the first selector banks in the distant office. The sixth level of the first selector in the distant office is led to a group of local second selectors the banks of which are multipled with those of the incoming second selectors.

If a party in the local office calls the number 2486, the first selector will step up 2, the local second selector will step up 4, and the connector will complete the connection. If 2486 is called from the distant office the first selector will step up 2, the incoming second selector (at the local office) will step up 4, and the connector will complete the connection. Should the number 6386 be called from the local office the first selector will step up 6, the incoming second selector (at the distant office) will step up 3, and the connector will complete the connection. Should the number 6386 be called from the distant office the first selector will step up 6, the local second selector will step up 3, and the connector will complete the connection.

From the foregoing it can be seen that the local office is the 2000 office, and the distant office is the 6000 office. While only one connector group is shown in each office it is to be understood that the ultimate capacity of each office is 1000 lines.

Aside from the saving made possible by the use of a two conductor trunk, the repeater is of value in that the calling subscriber is fed talking battery from the local office, even though the connection is extended to a distant office. This is of great importance where common battery transmitters are used.

Questions.

A. Why is it necessary to multiple the banks of the local and incoming second selectors?

B. Why is it necessary to have a four conductor trunk between the primary and secondary line switches?

Chapter XXIV

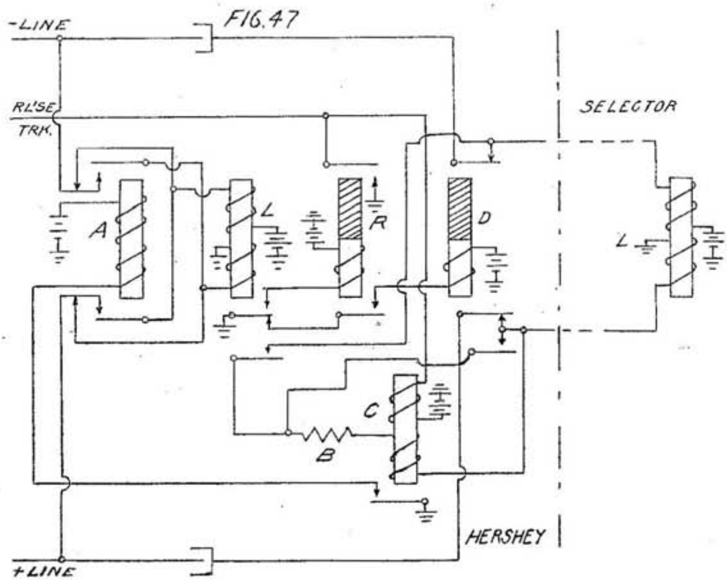
The Reverse Battery Repeater.

Referring to Fig. 47 we find the familiar line relay L and the release relay R. The reverse battery relay A is a 1,300 ohm relay, and operates to reverse the polarity of the calling line. The condenser cut-off relay D is a slow acting relay of 325 ohms resistance. The electro polarized relay C has an upper winding of 1,900 ohms and a lower winding of 60 ohms resistance. The impedance coil B is 500 ohms in resistance.

Let us assume that a connection has been extended to this repeater. The line relay L will energize and close the circuit of the release relay R, which in turn will energize and place ground on the release trunk. Upon the energization of relay L a circuit may be traced from ground, thru the lower winding of relay L of the selector at the distant office, lower winding of relay C, impedance coil B, make springs relay L, upper winding of the line relay L of the selector at the distant office, to negative battery. The line relay of the selector at the distant office will energize over this circuit and stand in readiness to receive the impulses which will be sent it by the repeater. When the release relay energized a circuit was closed from ground, make springs relay R, upper winding of relay C, to negative battery. The current flowing in the two windings of relay C will at this time oppose each other, and as a result the relay will not operate. It is furthermore to be understood that the upper winding of relay C is not strong enough to operate the relay when it alone is energized.

When the subscriber dials the next figure in the number, a 6 for example, the line relay L will momentarily release its armature six times. Each time the relay L de-energizes a circuit is closed from ground, break springs relay L, make springs relay R, condenser cut off relay D, to negative battery. The relay D will energize over this circuit, and, since it is a slow acting relay, will maintain its armature in an operated position so long as the line relay is responding to the dial impulses. When relay D energizes the talking condensers will be removed from the trunk, and at the same time the lower winding of relay C, and the impedance coil B, will be short circuited.

Each time the line relay L de-energizes it will open the circuit of the line relay L of the distant selector. In this way the dial impulses are repeated over the trunk to the switches in the distant exchange, which will respond to the repeated impulses and complete the connection in the same manner as tho the impulses had come direct from a dial.



When the called party answers the connector will reverse the battery on the trunk, this will cause the upper and lower windings of relay C to assist each other. As a result relay C will energize and close the circuit of the reverse battery relay A. Relay A will energize and cause a reversal of polarity on the calling line.

When the conversation is completed the restoration of the receiver to the switch hook at the calling sub-station will cause the circuit of line relay L to be opened. When the line relay L de-energizes it opens the circuit to the connector in the distant office, and the release of the appartus in that office follows immediately. The de-energization of relay L also opens the circuit of the release relay R, which, upon de-energizing, will remove the ground from the release trunk, following which the apparatus in the local office will immediately release.

The Series Repeater.

There have been various attempts made to produce a less complicated circuit which would still permit the use of two conductor trunks between exchanges. In order to do this it has been necessary to give up that feature of the ordinary repeater which supplies talking battery to the calling subscriber from his local exchange.

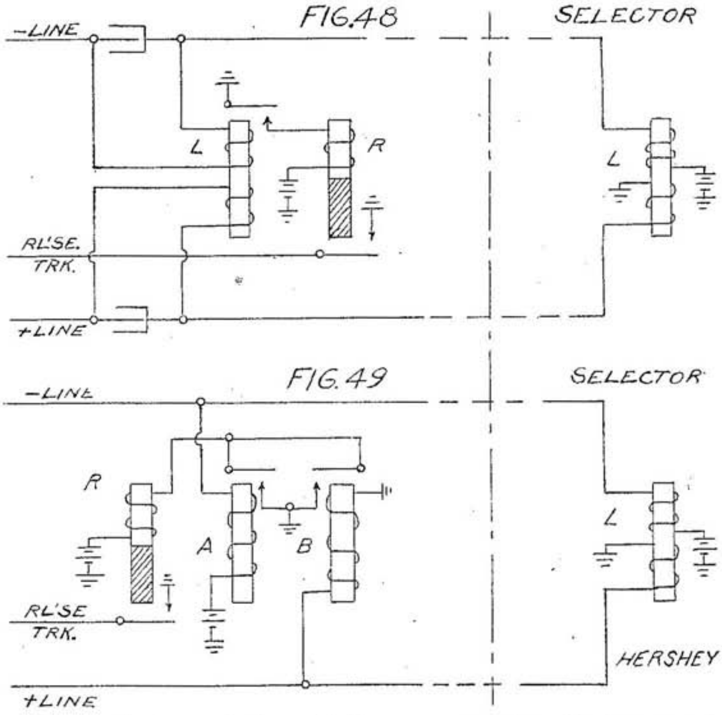
In Fig. 48 is shown what is termed a Series Repeater, it is not a repeater in the true sense of the word, as the impulses are not repeated, but pass directly from the dial to the switches in the distant office. The line relay L is a double wound relay with 10 ohms in each winding. The release relay R is the ordinary slow acting release relay.

When the connection is extended to this repeater a circuit may be traced from ground, thru the lower winding of line relay L of the selector at the distant office, lower winding line relay L, thru the various switches to the calling line, and back thru the upper winding of relay L, upper winding of the line relay L of the selector at the distant office, to negative battery. The line relay L will now energize and close the circuit of the release relay R, which, upon energizing, will place ground upon the release trunk. The line relay L will operate in response to the dial impulses as the connection is extended thru the switches at the distant office, the release relay will, however, remain energized thruout the dialing period. Upon the completion of the conversation the restoration of the receiver to the switch hook at the calling substation will cause the line circuit to be opened, and the release of the switches in the distant office will follow as usual. The opening of the line circuit will also cause the relay L to de-energize, following which relay R will de-energize and remove ground from the release trunk, after which the release of the switches in the local office will take place.

The Bridging Repeater.

In Fig. 49 is shown what is termed a Bridging Repeater, which is in reality no more of a repeater than the so-called Series Repeater. The high resistance relays A and B are bridged from the negative and positive sides of the trunk respectively, the resistance of each relay being 10,000 ohms. The release relay R is the ordinary slow acting release relay.

When the connection is extended to this repeater the relay A will energize in parallel with the upper winding of the line relay L of the selector at the distant office. At the same time relay B will energize in parallel with the lower winding of the line relay of the selector at the distant office. When relays A and B energize a circuit is closed thru the release relay R, which, upon energizing, will place ground upon the release trunk. The make springs on relays A and B are multipled as a precaution against open contacts. The relays A and B will operate in response to the dial impulses as the connection is extended thru the switches at the distant office, the release relay will, however, remain energized thruout the dialing period.



Upon the completion of the conversation the restoration of the receiver to the switch hook at the calling sub-station will cause the release of the switches in the distant office, and also will cause the release of relays A and B. Following which the release relay R will de-energize and remove ground from the release trunk, after which the release of the switches in the local office will take place.

Questions.

A. What would result if the condenser cut-off relay failed to clear the trunk from the condensers?

B. If the trunk were reversed could a connection be extended thru the repeater shown in Fig. 47?

C. What would happen if a switchman shorted an incoming trunk, assuming that Series Repeaters were in use?

D. Why isn't the connector locked up when it reverses battery to a bridging repeater?

Chapter XXV

The Selector Repeater.

For the sake of discussion let us assume that there are 40 first selectors in the office, and that all the contacts in the first six levels lead to repeaters. The seventh and eighth levels will be considered as going to local second selectors. We will now have 40 first selectors and 60 repeaters in our office. In order to reduce the equipment let us replace the first selectors with a new piece of apparatus which is called a Selector Repeater. This switch is capable of performing the functions of an ordinary selector, after which it automatically becomes a repeater and serves to repeat the dial impulses to the switches in the distant office. The two conductor trunks to the other exchanges will now terminate directly on the banks of our first Selector Repeaters. If we call 5 the selector repeater will first select an idle trunk to the 5,000 office, after which it will repeat the dial impulses. If we call 7 the selector repeater will select an idle trunk to the local second selectors, after which it will repeat the impulses and as a result we need only a two wire trunk to the local second selectors.

The selector part of the selector repeater shown in Fig. 50 is essentially the same as the selector shown in Fig. 38. By referring to the drawing you will find the familiar line relay L, release relay R, series relay S, switching relay E, private control relay X, release magnet Y, rotary magnet R M and vertical magnet V M.

The repeater part of the selector repeater shown in Fig. 50 is similar to the repeater shown in Fig. 47, tho not identically the same. In the figure is shown the familiar reverse battery relay A, condenser cut-off relay D, elector polarized relay C, and the relay B which takes the place of the impedance coil B in Fig. 47. The relay B has an upper winding of 750 ohms and a lower winding of 250 ohms resistance.

Let us assume that a line switch has plunged in and extended the connection to the Selector Repeater. The line relay will energize and close the circuit of the release relay R, which in turn will energize and place ground upon the release trunk. If the subscriber now dials the figure 6 the line relay will momentarily de-energize six times. Each time the line relay de-energizes a circuit may be traced from ground, break springs relay L, make springs relay R, break springs relay E, series relay S, vertical magnet, to negative battery. The vertical magnet will energize over this circuit and operator to raise the shaft and wipers to a position opposite the sixth level of bank contacts. The series relay will energize, (at the first vertical impulse) and close a circuit from ground, make springs relay R, make springs relay S, off-Normal springs (which are now closed), private control relay X, to negative battery. The private control relay, upon energizing, will form a locking circuit for itself which may be traced from ground, make springs relay R, break springs rotary magnet, make springs relay X, off-normal springs, relay X, to negative battery. When the series relay de-energizes, (a fraction of a second after the last vertical impulse passes thru it) a circuit may be traced from ground, make springs relay R, break springs relay S, make springs relay X, rotary magnet, to negative battery. The rotary magnet will energize over this circuit and operate to rotate the shaft and wipers into engagement with the first contact in the sixth level. In addition the rotary magnet opens the locking circuit of relay X, which, in turn, will de-energize and open the circuit of the rotary magnet.

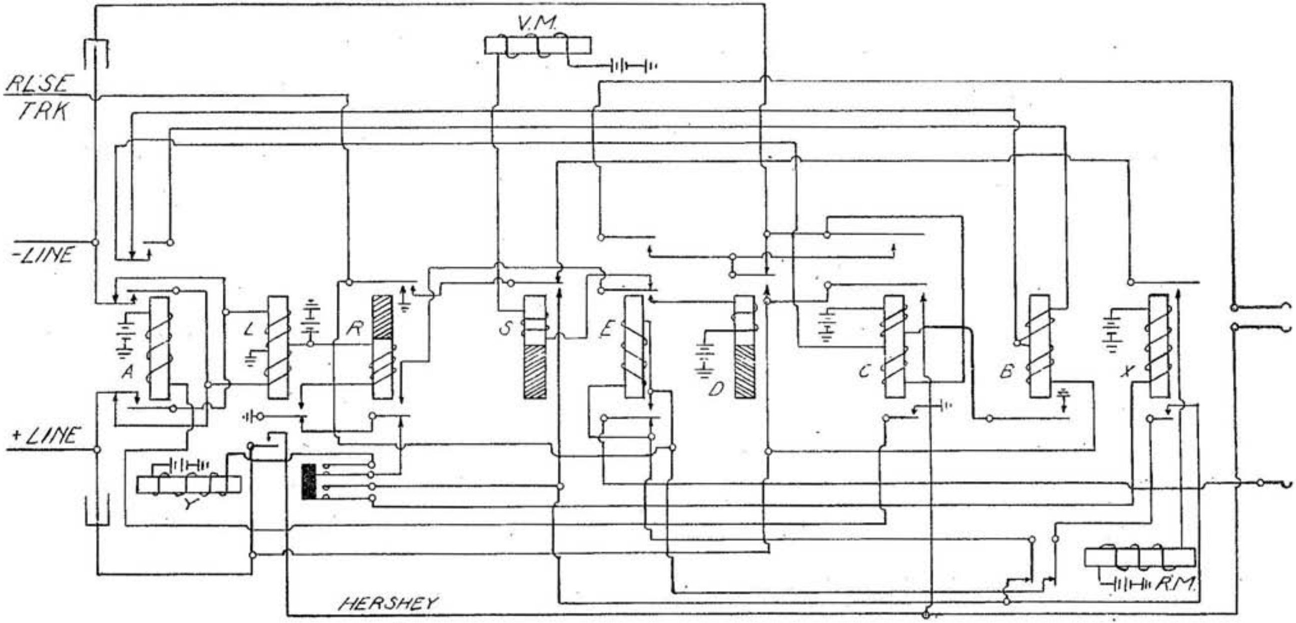
If the first private bank contact is idle a circuit may now be traced from ground, make springs relay R, switching relay E, break springs rotary magnet, off-normal springs, relay X, to negative battery. Relay X will not energize in series with the switching relay, but relay E will energize over the above traced circuit and operate to prepare the repeater circuit.

At this time a circuit may be traced from ground, thru the lower windings of the line relay L of the selector at the distant office, make springs relay L, lower windings relay B, break springs relay A, lower winding relay C, break springs relay D, make springs relay E, thru the upper winding of the line relay L of the selector at the distant office, to negative battery. The line relay of the selector at the distant office will energize over this circuit and stand in readiness to receive the impulses which will be sent it by the repeater.

When relay B energized a circuit was closed thru the upper winding of relay C. The current flowing in the two windings of relay C will at this time oppose each other and as a result the relay will not operate,

When the subscriber dials the next figure, a five for example, the line relay will momentarily release its armature five times. Each time the relay L de-energizes a circuit is closed from ground break springs relay L, make springs relay R, make springs relay E, condenser cut-off relay D, to negative battery. The relay D will energize over this circuit and, since it is a slow acting relay, will maintain its armature in an operated position so long as the line relay is responding to the dial impulses. When relay D energizes the upper talking con-

FIG. 50



denser will be removed from the trunk, and at the same time the lower winding of relay C, and of relay B will be short circuited. Each time the line relay L de-energizes it will open the circuit of the line relay L of the selector in the distant office. In this way the dial impulses are repeated over the trunk to the switches in the distant exchange, which will respond to the repeated impulses and complete the connection in the usual manner.

When the called party answers, the connector will cause the battery on the trunk to be reversed, this will cause the upper and lower windings of relay C to assist each other. And as a result relay C will energize and close the circuit of the reverse battery relay A. Whereupon relay A will energize and cause a reversal of the polarity on the calling line. In addition relay A will cause the two windings of relay B to be cut in series, the object being to increase the impedance of the bridge across the trunk. When relay C energizes the first pair of make springs, at the upper end of the relay, will shunt the impulse springs on relay L, and the second pair of make springs, at the upper end of the relay, will shunt the break springs of relay D.

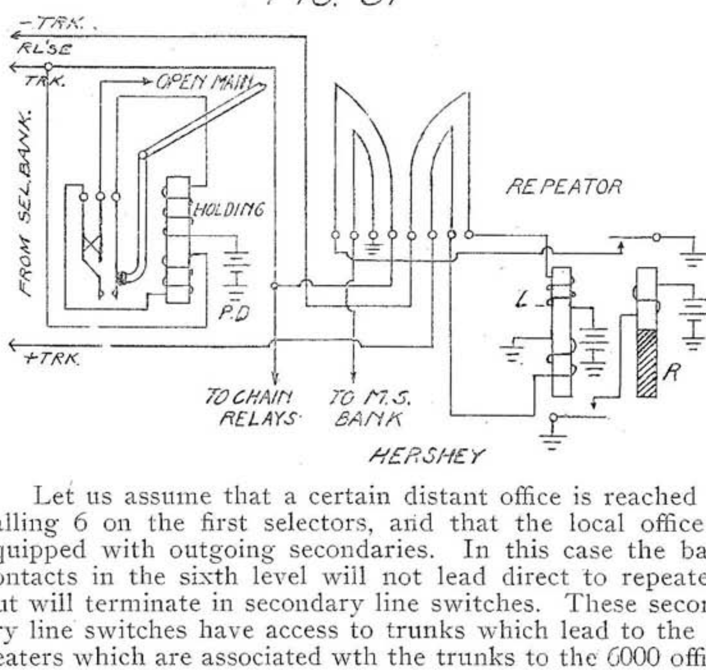
If the first trunk had been busy the selector repeater would have started rotating in an attempt to find an idle trunk, in the same manner as explained in connection with Fig. 38. The selector repeaters carry a private bank which is multipled between each switch, this bank is not connected with the trunks but is used only to protect a trunk from intrusion after a selector repeater has seized it. The private bank contact is made busy over the following circuit, from ground, make springs relay R, make springs relay E, to private wiper.

When the conversation is completed the restoration of the receiver to the switch hook at the calling sub-station will cause the circuit of line relay L to be opened. When the line relay L de-energizes it opens the circuit of relay R, which upon de-energizing, removes the ground from the release trunk, following which the apparatus in the local office will release. When relay L de-energizes it will also open the circuit to the connector in the distant office. Following which the release of the apparatus in that office will take place immediately. In addition relay R will, upon de-energizing, close a circuit through the release magnet Y, the release magnet will energize and operate to effect the release of the selector repeater in the usual manner. If the calling party hangs up first the release of the apparatus in the distant office will not take place mmediately following the de-energization of relay L, but will be dependent upon the release of the switching relay E.

Outgoing Secondary Line Switches.

In our study of line switches we found that the introduction of secondaries resulted in an increased efficiency. Secondary line switches are also used in connection with trunks between offices. When used in this way they are termed "Outgoing Secondaries."

FIG. 51



Let us assume that a certain distant office is reached by calling 6 on the first selectors, and that the local office is equipped with outgoing secondaries. In this case the bank contacts in the sixth level will not lead direct to repeaters, but will terminate in secondary line switches. These secondary line switches have access to trunks which lead to the repeaters which are associated wth the trunks to the 6000 office.

In Fig. 51 an outgoing secondary line switch is shown, this is similar to the secondary line switch in Fig. 40, except that there is no open main relay. After a selector stops on an idle trunk the private wiper receives ground from the make springs of the release relay. Thus, when a selector comes to rest upon the bank contacts associated with the outgoing secondary shown in Fig. 51 a circuit may be traced from ground, make springs of the release relay of the selector, private wiper, bank contact, release trunk, P. D. winding and break springs of the outgoing secondary line switch to open main. The outgoing secondary will plunge into the bank and extend the connection to the line relay L of the repeater. The release relay R of the repeater will return a ground on the release trunk which will maintain both the outgoing secondary and the preceding switches in an operated position. It will be seen that the release relay of the selector must be slow acting enough to maintain a ground on the release trunk until such time as the release relay of the repeater returns a holding ground upon the release trunk.

After the completion of the conversation the removal of the ground from the release trunk will cause the release of the outgoing secondary line switch.

Questions.

A. Would it be possible to extend a call with this selector repeater if the trunk should be reversed?

B. What would result if the make contact of relay D "froze"?

C. What difficulty would be experienced if a side-switchless selector were used in connection with outgoing secondary line switches?

Chapter XXVI

Testing Circuits.

A great deal of thought has been given to the production of adequate testing circuits for use in the maintenance of automatic plants. As a result one of the great advantages of automatic is the speed with which a line in trouble can be "gotten up on test."

For each group of one hundred lines there is provided a test connector. The trunks to these test connectors come from the banks of what is termed a test distributor. Since the test distributor has the usual vertical and rotary motion it is capable of extending the test circuit to any one of a hundred test connectors, which in turn can extend the test circuit to any line in its particular hundred. Therefore, by means of a test distributor and the associated connectors, it will be possible to test any one of 10,000 lines. On the wire chief's desk is provided a set of keys by means of which the trunk to any test distributor may be connected with the testing circuit. Thus it will be seen that centralized testing may be effectively employed in any automatic plant regardless of its size.

The Test Connector.

The Test Connector shown in Fig. 54 is mechanically the same as the ordinary connector except that it has no private magnet, spider arm, or side switch wipers. Referring to the figure you will find the familiar line relay L, release relay R, series relay S, vertical magnet V M, rotary magnet R M, and release magnet Y. The relay X is a series relay, similar to relay S, which operates in series with the rotary magnet R M. It will be seen that relay X is utilized to keep the wipers clear while the connector is rotating.

The Test Distributor.

The Test Distributor shown in Fig. 53 is similar to the ordinary connector except that its shaft carries three sets of wipers, each set of wipers having access to a 200 point bank. The upper bank contains the two private or control conductors associated with each test connector, the middle bank contains a pair of operating conductors to each test connector, and the lower bank contains a pair of test conductors for each test connector. By referring to Fig. 53 you will find the familiar reverse battery relay A, single wound line relay L, release relay R, series relay S, release magnet Y, rotary magnet R M, and vertical magnet V M. The private magnet P is shown in the figure as being a slow acting relay; the reason for this construction will be explained later. Relay C is a 200 ohm relay through which ground is fed to the positive side of the line. The busy relay B is a double wound relay having a resistance of 50 ohms in each winding. The relay D is a slow acting relay of 500 ohms resistance. The springs on this relay are adjusted so that the upper springs make before the lower springs engage. The relay E is 1300 ohms in resistance. The impedance coil F is 50 ohms in resistance.

Trunks to Test Distributors.

In Fig. 52 is shown a trunk from the wire chief's desk to a test distributor. The key K, when operated, serve to connect this particular trunk with the testing circuit. The calling device and operator's circuit are cut on to this trunk by means of the key L. The private control key M allows the tester to plunge in the called line switch in order to make an "in test." The connector release key N allows the tester to release the test connector without releasing the test distributor, thereby saving a great deal of time when several lines in the same hundred are to be tested. The hold key O is provided so that the tester may hold up the conection on this trunk even though it be necessary to set up a call on another test distributor trunk. The relay T is an electro polarized relay similar to relay C in Fig. 47. The relay H is a battery feed relay similar to relay L in Fig. 54. The coil V is of 200 ohms resistance.

Circuit Reading of the Complete Testing Circuit.

We will now assume that the tester operates the test distributor key K and the calling device key L. When key K is operated this particular test distributor trunk is cut onto the testing circuit, and at the same time a circuit is closed through the upper winding of relay T. When key L is operated a circuit is closed from ground, relay C (Fig. 53), break springs relay A, break springs key O, make springs key K, make springs key L, through operators set and calling device, make springs key L, make springs key K, break springs key N, break springs key O, resistance coil V, lower winding of relay T, break springs relay A (Fig. 53), relay L, to negative battery. Relay T will not operate at this time for the current flowing in the lower winding will oppose the current in the upper winding. Relay L and C will operate over the above traced circuit and place the test distributor in readiness to receive the dial impulses.

When the tester dials the first figure, a six for example, the circuit of relays L and C will be opened six times. Each time the line relay L de-energizes a circuit may be traced from ground, break springs relay L, make springs relay R, series relay S, vertical magnets, side switch wiper in first position, to negative battery. The vertical magnets will energize over this circuit and wll operate to raise the shaft and wipers to a position opposite the sixth level of bank contacts. The series relay will energize at the first vertical impulse and will close the circuit of the private magnet P and relay D; the energization of relay D has no effect at this time. After the cessation of the vertical impulses the relay S will de-energize and open the circuit of the private magnet; the private magnet upon de-energizing will allow the side switch wipers to pass to second position.

When the tester calls the next figure, a seven for example, the relay L will momentarily de-energize seven times, and will send seven impulses of current over a circuit which may be traced from ground, break springs relay L, make springs relay R, series relay S, break springs relay B, rotary magnets, side switch wiper in second position, to negative battery. The rotary magnets will energize over this circuit and will operate to rotate the shaft and wipers into engagement with the bank contacts associated with test connector number 67. The series relay will operate as before to close the circuit of the private magnet. After the cessation of the rotary impulses the series relay will de-energize and open the circuit of the private magnet. If the test connector in board 67 is idle the private magnet P will now de-energize and allow the side switch to pass to third position.

When the side switch passes to third position a circuit may be traced from ground, relay E, side switch wiper in third position, to negative battery. When relay E energizes, a circuit may be traced from ground, lower winding relay L (Fig. 54), make springs relay E, make springs relay L, upper winding relay L (Fig. 54), to negative battery. Relay L (Fig. 54) will energize over this circuit and will hold the test connector in readiness to receive the impulses which will be sent it by the line relay of the test distributor. When the tester dials the next figure, an eight for example, the line relay of the test distributor will momentarily de-energize eight times, each time a circuit will be closed from ground, break springs relay L, make springs relay R, series relay S, make springs relay E, resistance F, to negative battery. Each time relay L drops back the circuit of relay L (Fig. 54) is opened. Each time relay L (Fig. 54) de-energizes a circuit may be traced from ground, break springs relay L, make springs relay R, off normal springs (at normal), series relay S, vertical magnet, to negative battery. The vertical magnet will energize over this circuit and will operate to raise the shaft and wipers to a position opposite the eighth level of bank contacts. The series relay S will energize at the first vertical impulse, and will form a new circuit for the vertical magnet which may be traced from ground, break springs relay L, make springs relay R, off normal springs (now operated), make springs relay S, relay S, vertical magnet, to negative battery. Following the cessation of the vertical impulses the relay S will de-energize, and cannot again be energized because its circuit is now open at the break contact of the off normal springs.

When the tester calls the next figure, a nine for example, the line relay of the test distributor will operate as before to repeat the impulses to the line relay of the test connector. Each time the line relay L (Fig. 54) de-energizes a circuit may be traced from ground, break springs relay L, make springs relay R, off normal springs, break springs relay S, relay X, rotary magnet, to negative battery. The rotary magnet will energize over this circuit and operate to rotate the shaft and wipers into engagement with the bank contacts associated with telephone number 6789.

It will be seen that the test wipers of the test connector are held open during the rotary movement by the springs of relay X. During the rotary motion the private wiper of the test connector is held open at the springs of relay S (Fig. 53). Shortly after the last figure is called the relay S (Fig. 53) will de-energize, and a circuit may now be traced from ground, break springs relay D, make springs relay E, break springs relay S, make springs relay C, private wiper of the test connector, B. C. O. winding of the called line switch, to negative battery. The B. C. O. winding will energize and operate to clear the called line of attachments. We now have a clear circuit from the called line, through the test connector and test distributor, to the test circuit on the wire chief's desk.

The tester may now restore the calling device key L to normal; its springs are adjusted to "make before break," and therefore the circuit will still be held up by the short between the springs of key L.

If the tester operates the private control key M a shunt will be placed around relay C (Fig. 53). Relay C, upon de-energizing, will open the circuit of the B. C. O. of the called line switch, thus causing the line relay of the called line switch to be bridged across the line. As a result the tester can now make an "in test."

If the tester desires to release only the test connector he operates the connector releas key N, which by means of its make before break springs places coil B in the circuit in place of relay L (Fig. 53). Relay L, upon de-energizing, opens the circuit of relay L (Fig. 54). The test connector will now release following the de-energization of its line relay. The tester can now operate his dial to call any number to which this test connector has access. If the tester so desires he can advance the test connector across the level, one step at a time, by simply calling the figure one on his dial.

Let us assume that the test connector in the 67 board is busy; the test distributor will now pick up ground on the associated private bank contact and as the series relay S de-energizes after the last rotary impulse a circuit may be traced from this ground, side switch wiper in second position, upper winding relay B, break springs relay S, private magnet P, to negative battery. The private magnet will remain energized over this circuit and will therefore hold the side switch wipers in second position. The relay B will energize over the above traced circuit and place the busy tone on the operating line to indicate to the tester that the called test connector is in a busy condition. The busy relay also opens the circuit to the rotary magnet so that a further rotation of the switch is impossible. Let us assume that the tester leaves the connection up and waits for the test connector to become idle. As soon as ground is removed from the private bank contact the private magnet P and the busy relay B will de-energize. When the private magnet de-energizes the side switch passes to third position and relay E energizes and closes the operating circuit to the test connector. In order to allow the test connector to fully release before its operating circuit is again closed the private magnet P is made slow acting. The de-energization of relay B caused the busy tone to be removed from the line and the tester now proceeds to complete the connection.

If the called line is busy a circuit may be traced from ground at the associated private bank contact, private wiper of the test connector, private wiper of the test distributor, make springs relay C, break springs relay S, make springs relay E, make springs relay D, relay A to negative battery. The relay A will energize over this circuit and will cause the polarity of the calling line to be reversed; as a result relay T (Fig. 52) will now operate and light the lamp A as an indication to the tester that the called line is busy. The relay D will not de-energize following the release of the series relay S but will be locked up over a circuit that may be traced from ground at the busy private bank contact, make springs relay C, break springs relay S, make springs relay E, make springs relay A, make springs relay D, relay D, to negative battery. When the called line becomes idle the protecting ground is removed and as a result relay A and relay D will de-energize. When relay A de-energizes the polarity of the calling line will be returned to normal; relay T will now de-energize and extinguish the light A as an indication to the tester that the called line has become idle. When relay D de-energizes it places ground on the circuit leading to the B. C. O. of the called line switch. Relay D, being a slow acting relay, will allow a certain interval to elapse between the removal of the protecting ground, and the second grounding of this circuit. This interval is required in order that the called line switch may have sufficient time to remove its plunger from the bank before its B. C. O. winding is again energized.

If the tester desires to leave this line up on test he operates the hold key O and restores the test distributor key K. The hold key places a short across the operating lines to hold up the connection, and at the same time relay H is bridged across the line under test. If the subscriber should remove his receiver he would draw battery through relay H, which would then energize and light the lamp B as an indication to the tester that the subscriber had come in on the line.

After the test is completed the restoration of all the keys will cause the circuit of line relay L (Fig. 53) to be opened. When relay L de-energizes it opens the circuit of release relay R, following which the test distributor releases in the usual manner. The de-energization of relay L also opens the circuit of line relay L (Fig. 54), following which the release of the test connector takes place.

The lower winding of relay B is only used when the connection is extended to a test connector selector.

Questions.

A. What indication does the tester receive if an attempt be made to use a test connector that is already busy?

B. If the called line is busy, what notice is given to the tester?

C. What is the function of the lamp B in Fig. 52?

D. What is the object of the lower pair of make springs on relay C?

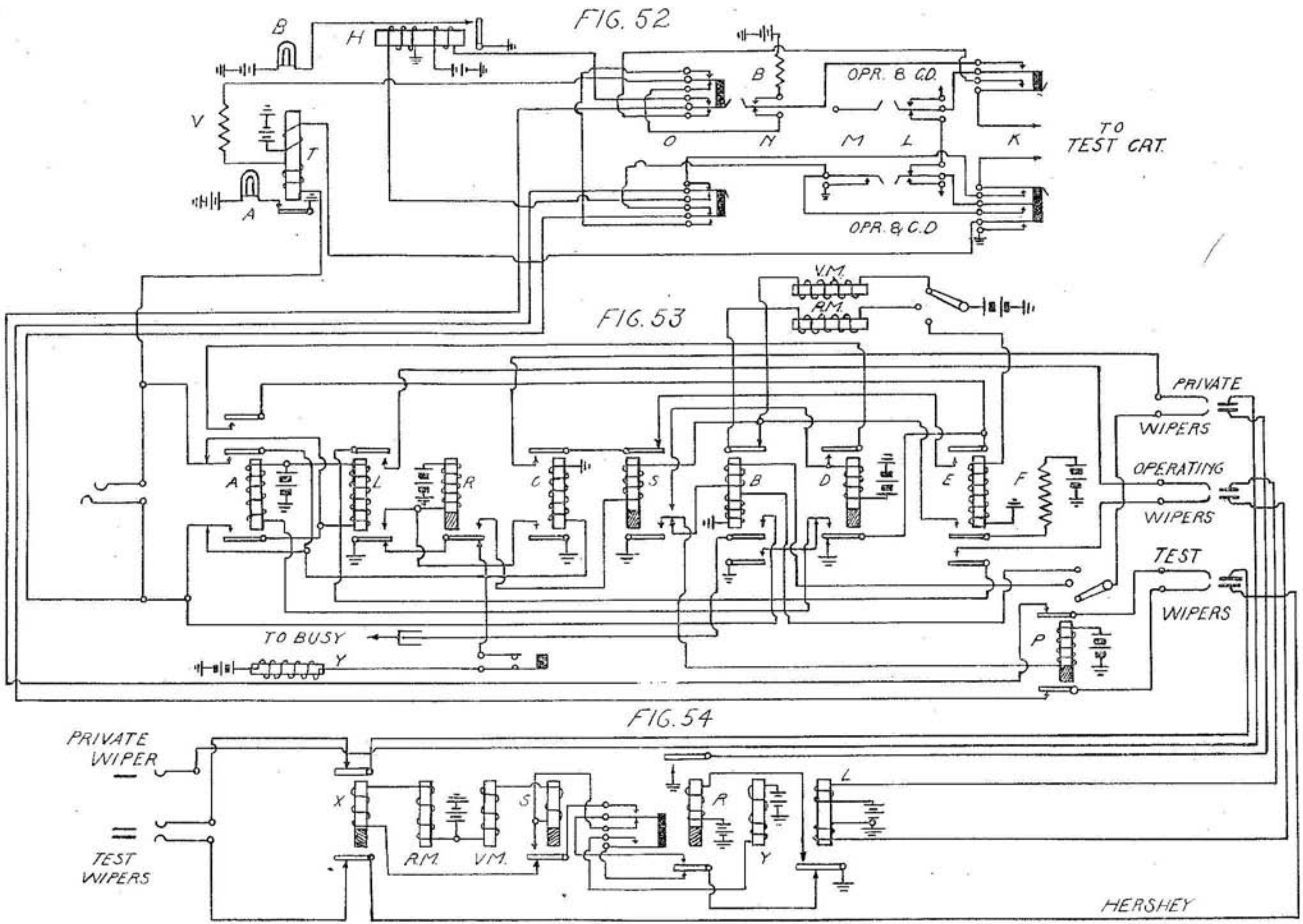


FIG. 52
B
H
V
T
A
B
OPR. & C.D.
O
N
M
L
K
TO
TEST CRT.
OPR. & C.D.
FIG. 53
V.M.
R.M.
PRIVATE
WIPERS
OPERATING
WIPERS
TEST
WIPERS
A
L
R
C
S
B
D
E
F
P
TO BUSY
Y
FIG. 54
PRIVATE
WIPER
TEST
WIPERS
X
R.M.
V.M.
S
R
Y
L
HERSHEY

Chapter XXVII

The Universal Cord Circuit.

In P. B. X.'s which are equipped with jack ending trunks to an automatic exchange it is desirable that the cord circuits provided be such that either local to local, or local to trunk connections can be put up with the same pair of cords. Such an arrangement is termed a Universal Cord Circuit, and as shown in Fig. 55 it embodies the following features:

A. Means of connecting one P. B. X. station with another.

B. The signalling of either subscriber without changing cords.

C. Double supervision to show when called P. B. X. party has answered and when conversation is completed.

D. Through dialing from P. B. X. stations.

E. Dialing can be performed by operator in case calling telephone is not equipped with dial.

The relays E and F in Fig. 55 are each 40 ohms in resistance. The battery feed coil A has 80 ohms in each of its windings. Relays C, D, B and G are wound to 500 ohms. The relay G and the calling device are common to the position.

Let us assume that the operator is notified by the lighting of a line lamp that a subscriber wishes a connection, she then inserts the answering plug of an idle cord into the subscriber's line jack. A circuit may now be traced from ground, lower winding coil A, break springs relay C, night key, relay F, ringing key, through the subscriber's telephone, ringing key, night key, break springs relay C, upper winding of coil A, to negative battery. Talking battery is fed to the calling subscriber over this circuit and as a result relay F operates. The operation of relay F extinguishes the answering supervisory lamp. The calling supervisory lamp continues to burn over a circuit traced from ground, break springs D, break springs relay E, calling lamp, plug seat switch (which was operated when the plug was removed from its seat), to negative battery.

The operator now depresses the listening key and cuts her talking set across the cord circuit. If the calling party desires a local connection she inserts the associated calling plug into the jack of the line wanted, after which she operates the ringing key and signals the called subscriber. When the called party answers a circuit may be traced from ground, lower winding of coil A, break springs relay C, night key, ringing key, break springs relay B, through the subscriber's telephone, break springs relay B, ringing key, relay E, night key, break springs relay C, upper winding coil A, to negative battery. Talking battery will be fed to the called subscriber over this circuit and as a result relay E will operate and open the circuit of the calling supervisory lamp.

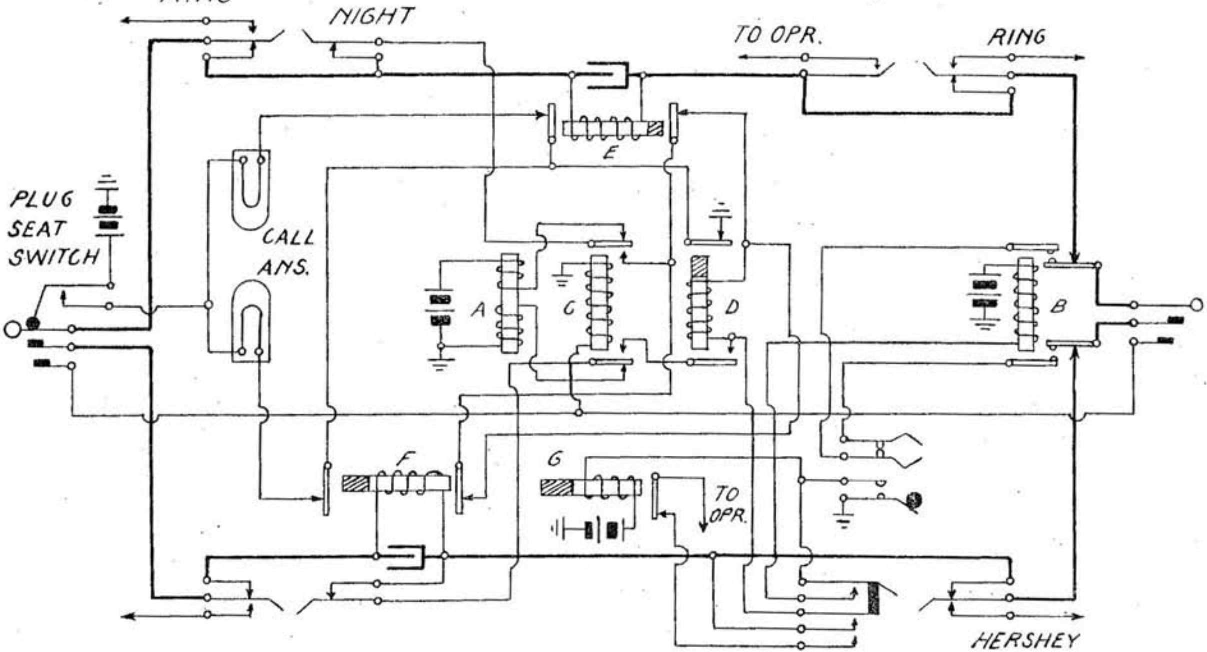
When the conversation is completed the restoration of the receivers to the switch hook will result in the breaking of each circuit, whereupon relays E and F will de-energize. As a result both supervisory lamps will light and indicate to the operator that the connection should be taken down.

If the calling subscriber desires an outside connection the operator inserts the calling plug into an idle trunk jack and notifies the subscriber to dial his own number. When the plug is inserted in the trunk jack a circuit may be traced from ground, relay C, sleeve of plug and jack, through cut-off relay (not shown), to negative battery. Relay C, upon energizing, will remove the impedance coil A from across the cord circuit. When the plug is inserted in the trunk jack an additional circuit may be traced from ground, break springs B. C. O. (of line switch at the automatic office), trunk, break spring, relay B, relay F, subscriber's telephone, relay E, break springs, relay B, trunk, break springs B. C. O., line relay of line switch, to open main. As a result the line switch will plunge in and extend the connection to a first selector. The current flowing in the above circuit will also operate the relays E and F, thereby opening the circuit of the supervisory lamps. The subscriber now operates his dial and completes the connection.

After the conversation is completed the restoration of the receiver to the switch hook at the calling substation will cause the release of the automatic apparatus in the usual manner, furthermore the relays E and F will now de-energize and give the operator disconnect supervision.

If the calling telephone is not equipped with a dial it is necessary for the operator to set up the connection. She will insert the calling plug in a trunk jack as before, and with the listening key thrown she dials the number. When the plug is inserted in the jack the relay C will energize and remove the impedance coil A. At the first movement of the dial two circuits are closed, the first may be traced from ground, dial springs, relay G, to negative battery. Relay G energizes and opens the operator's circuit so that she will not get a click in her receiver each time the relay B operates. The relay G, being a slow acting relay, will remain energized until after

FIG 55


RING
NIGHT
TO OPR.
RING
PLUG
SEAT
SWITCH
CALL
ANS.
E
A
C
D
B
F
G
TO
OPR.
HERSHEY

the last figure in the number has been dialed. The second circuit may be traced from ground, dial springs, listening key, relay B, to negative battery. The relay B will energize over this circuit and will operate to disconnect the cord circuit, and to bridge the impulse springs across the trunk while the impulses are being sent. If the calling subscriber keeps his receiver removed the short at his telephone is utilized to hold up the connection.

If the calling subscriber should hang up his receiver while the operator is dialing, a holding circuit may be traced from the negative side of the trunk, relay E, night key, make springs relay C, break springs relay E (in parallel with break springs relay F) relay D, listening key, to the positive side of the trunk. Relay D and relay E will energize over this circuit. Relay D will open the circuit of the supervisory lamps at its break springs, and in addition will form a locking circuit for itself independent of the listening key. If the operator restores her listening key this bridge remains across the trunk until such time as the subscriber again removes his receiver and causes relay F to energize. Relay F, upon energizing, opens the locking circuit of relay D.

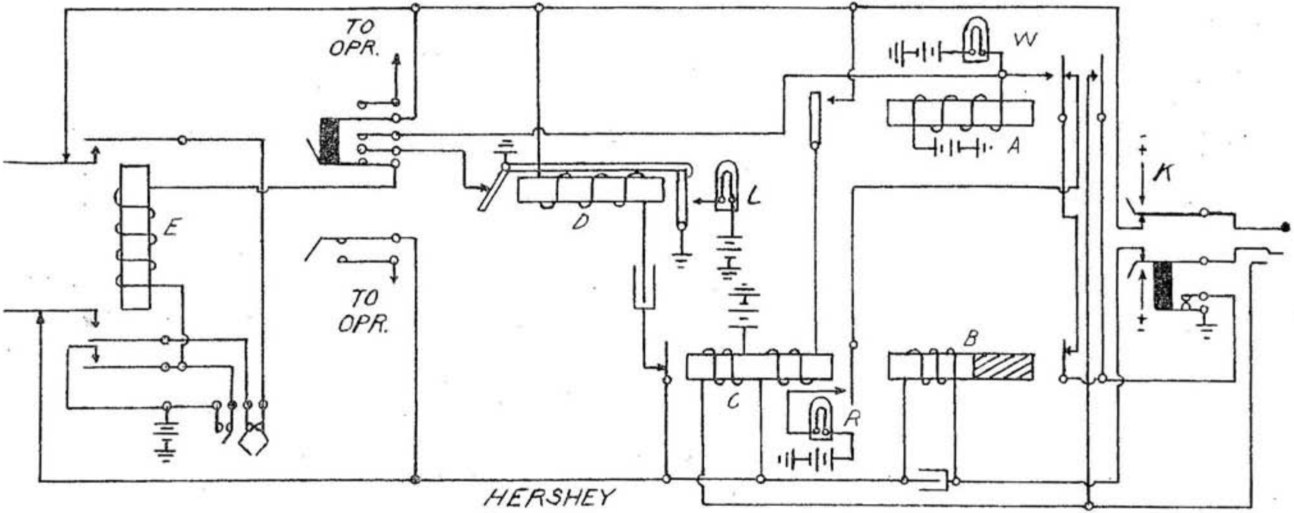
It will be seen that the calling subscriber can dial even though the listening key is thrown, on account of the fact that the bridge circuit passes through the break springs of relay E.

To answer an incoming trunk call the operator inserts an answering plug into the trunk jack. The relay C immediately energizes in series with the cut-off relay (not shown) and removes the impedance coil A. The operator then depresses her listening key and places the holding circuit across the trunk, thus causing the connector to cut off the ring. The bridge is locked across the trunk by means of relay D and is maintained until such time as the called local subscriber removes his receiver, or the plug is removed from the jack.

Plug Ending Trunks.

In Fig. 56 is shown a Dean plug ending trunk which has been rebuilt for use with automatic. The dialing relay E is 1000 ohms in resistance. The ring down relay D is 1000 ohms in resistance. The relay C has 400 ohms in the left hand winding and 780 ohms in the right hand winding. There is a mechanical relationship between the relays D and C, such that the latter, when energized, will operate to restore the armature of the former to normal. The relay A is 500 ohms in resistance. The relay B is a slow-acting relay of 100 ohms resistance.

FIG. 56



If the receiver at a local station is removed the operator will plug into the associated line jack with the answering plug of a local cord circuit. If a trunk connection is desired the operator will remove the local plug and will insert the plug of an idle trunk in its place. The local subscriber can now proceed to dial his number as he has a clear circuit into the automatic exchange. When the trunk plug was inserted in the jack the circuit of relay C was completed by the ground on the sleeve of the jack. When the conversation is completed the restoration of the receiver to the switch hook at the calling substation will cause the release of the automatic apparatus. At the same time the circuit of relay B will be opened, following which it will close a circuit from ground, through key K, break springs relay B, break springs relay A, make springs relay C, lamp R, to negative battery. The lamp R will light as an indication to the operator to take down the connection. Since relay B is a slow acting relay the lamp R will not flicker as the subscriber operates his dial.

If the telephone at the calling station is not equipped with a dial it is necessary for the operator to complete the connection. As before she will exchange the local plug for a trunk plug and will then throw her listening key, after which she will operate the dial to complete the connection. When the listening key is thrown a circuit is closed through lamp W and relay A. At the first movement of the dial a circuit is closed from ground, break springs relay D, listening key, relay E, dial springs, to negative battery. The relay E will energize over this circuit and will operate to disconnect the cord circuit and to bridge the impulse springs across the trunk. At the same time the relay E will lock itself up independent of the dial springs. When relay E operates it opens the circuit of relay B, which upon de-energizing, will form a locking circuit for relay A, which may be traced from ground, key K, break springs relay B, make springs relay A, relay A and lamp W in parallel, to negative battery. After the dialing is completed the operator will restore the listening key, following which the relay E will de-energize and connect the trunk through to the calling substation. The relay B will again energize and open the locking circuit of the relay A and lamp W. After the conversation is completed the restoration of the receiver to the switch hook at the calling substation will cause the release of the automatic apparatus, and the de-energization of relay B, following which the disconnect lamp R will light.

When a connector rings on the trunk shown in Fig. 56 the relay D will operate and light the line lamp L. The operator will now throw her listening key and ascertain the desired number, after which she will place the trunk plug in the line jack of the desired station and will operate the key K to signal the called party. When the listening key is operated the circuit of the relay A and lamp W is closed, the relay A will energize and form the usual locking circuit for itself. When relay A energizes it also bridges one winding of relay C across the trunk, this is to hold the back bridge of the connector operated after the listening key has been returned to normal. When the ringing key K is depressed the circuit of relay A is not opened, for relay A is now held up by the ground on the sleeve of the local jack. When the called party answers he will draw talking battery through relay B, which will energize and open the circuit of relay A and lamp W. The relay A will de-energize and remove the bridge from across the trunk, the lamp W will go out and indicate to the operator that the called party has answered. When the called party hangs up his receiver the relay B will de-energize and give the operator disconnect supervision.

Questions.

A. If the calling subscriber should hang up while the operator in dialing a number for him what would happen in Fig. 55? In Fig. 56?

B. If the operator in Fig. 56 made a trunk call on her own account how would she manipulate her keys in order to be able to talk?

C. What advantage, if any, have plug ending trunks over jack ending trunks?

D. On an incoming trunk call does the operator get answering supervision when the local party answers, in Fig. 55? In Fig. 56?

Chapter XXVIII

Intercom. Systems for Use with Automatic.

The ordinary intercom. system is not provided with a lockout feature since in manual practice no harm is done if a second party chances to depress the key associated with a busy trunk. If an attempt were made to use a manual type intercom. in an automatic system more or less trouble would result from spoiled calls. The calling in automatic is dependent upon the opening of the line circuit, and if a second party should depress the trunk key associated with a busy trunk while the first party is dialing the short through the second telephone would render the dialing ineffective. For successful operation with automatic it is necessary that the intercom. be constructed in such a way that it is impossible to be connected with a busy trunk even though the associated key is depressed. Some authorities maintain that the second party should receive a tone, or at least be able to hear the conversation on the trunk, as an indication that the trunk is busy. In the circuits described herein no indication is given that the trunk is busy beyond the fact that the telephone remains dead.

With the manual intercom. it is customary to leave the trunk key depressed and then cut onto the trunk simply by removing the receiver, but with the automatic intercom. it is necessary to fully depress the trunk key each time a trunk connection is desired.

The Corwin Intercom.

The Corwin Intercom. as shown in Fig. 57 provides a lockout feature for trunk calls, the local connections remaining the same as in a manual intercom. In this system the trunk keys carry three sets of make springs while the local keys carry only two sets of make springs. Two pairs of make springs are associated with the ladder in such a way that they will be operated when any button is fully depressed. In addition each station is provided with a test relay, which, when a trunk key is depressed, will operate to connect the station with that trunk providing the same is idle. The attendant's station is equipped with a ring down line signal, a visual holding signal, a hold key, a release key and a night alarm key.

Let us assume that the attendant at the first station desires a trunk connection, he will then remove his receiver and depress the key K. A circuit may now be traced from the positive side of battery B, through the 500 ohm winding of relay C, make springs D (at the instant that key K is fully depressed), make springs key K, impedance coil E, to the negative side of battery B. The relay C will now energize and form a locking circuit for itself independent of the springs D. This circuit may be traced from the positive side of battery B, through the 100 ohm winding of relay C, make springs relay C, make springs key K, impedance coil E, to negative side of battery B. Upon the energization of relay C another circuit may be traced from the positive side of the trunk, break springs of the hold signal, break springs of the hold key, make springs key K, calling device, transmitter, receiver, upper make springs of the switch hook of the telephone at the first station, make springs relay C, make springs key K, to the negative side of the trunk. The attendant at the first station is now bridged across the trunk and can proceed to dial his number.

If the subscriber at the second station should at this time depress the trunk key associated with trunk No. 1 a circuit may be traced from the positive side of battery B, 500 ohm winding of relay F, make springs G (at the instant that the key K^1 is fully depressed), make springs K^1, impedance coil E, to the negative side of battery B. It will be seen that the 500 ohm winding of relay F is now in parallel with the 100 ohm winding of relay C, as a result relay F is shunted out and will not energize to connect the second station across trunk No. 1. The subscriber at the second station will proceed to operate his dial unless he happens to notice that his receiver is dead.

When the subscriber at the first station restores his receiver to the switch hook the trunk circuit is opened following which the release of the automatic switches will take place. When the receiver is restored to the switch hook a second circuit may be traced from the positive side of battery B, lower contacts of switch hook, make springs relay C, make springs key K, impedance coil E, to the negative side of battery B. As a result the relay C is shunted out, following which it will de-energize and return its springs to normal.

When a connector rings on trunk No. 1 the associated line signal will be operated, the attendant at the first station will then depress key K and cause relay C to bridge the first station across the trunk, thereby causing the connector to cut off the ring. If the calling party desires some other station the attendant will operate the hold key, forming a circuit from the positive side of the trunk, make spring of the hold key, hold signal, to the negative side of the trunk. The hold signal will energize to display its visual and at the same time will form a locking circuit for itself independent of the make springs on the hold key. The attendant will now depress the local key associated with the desired station and will tell the called party to come in on the first trunk. When the attendant depressed the local key the ladder caused key K to release and open the circuit of relay C. Relay C will now de-generzize and free the trunk so that the test relay of the called station can energize upon the operation of the trunk key. When the called station is bridged across the trunk it will serve to shunt out the hold signal, which will de-energize and restore its visual as an indication to the attendant that the called party has answered.

If the called party does not answer the attendant may depress the release key which will momentarily short the trunk and thus release the hold signal. Following which the attendant will depress the trunk key and again come in on the trunk to advise the calling subscriber that the called party does not answer.

An outgoing call made by the attendant can be extended in the same manner as an incoming call.

Local to local calls in this system are made in the same manner as in the ordinary intercom. and need not be discussed here.

While only one trunk is shown in the figure it is to be understood that any number of trunks may be used without additional appartus, excepting of course the extra trunk keys and an impedance coil E for each trunk.

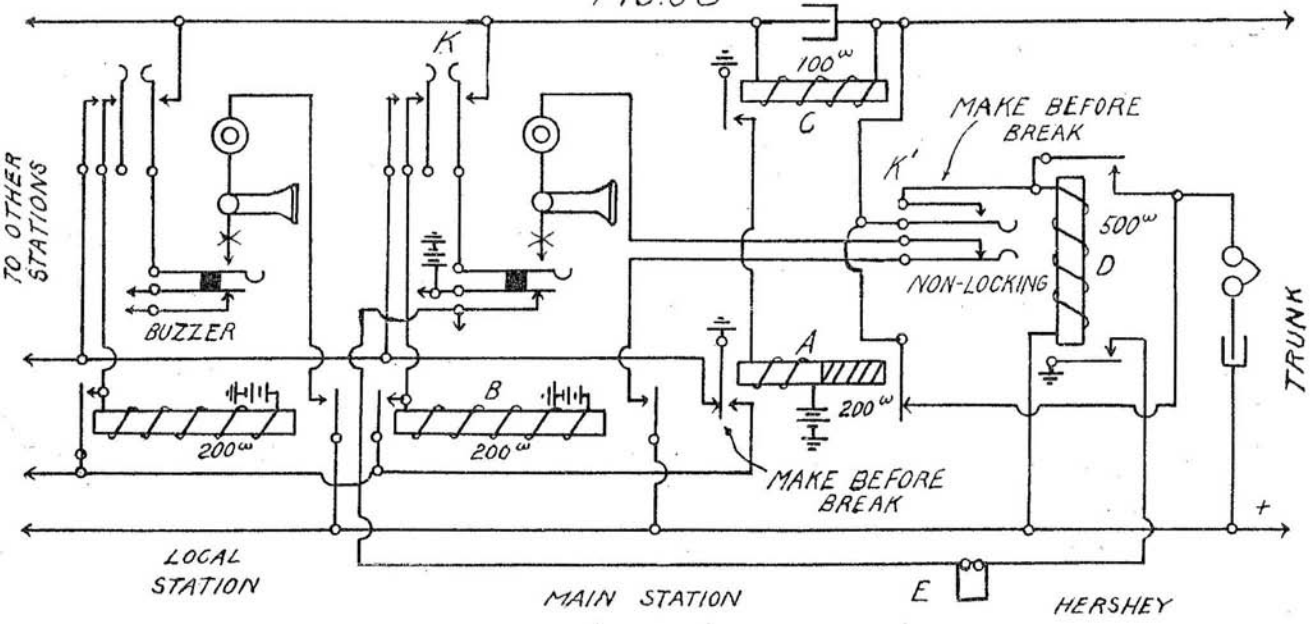
A Manual Intercom. Converted For Use With Automatic.

It sometimes happens that a telephone company will have a number of manual intercom. systems which it desires to convert for use with automatic. The scheme shown in Fig. 58 is quite satisfactory but requires a relay per station per trunk, and three additional relays per trunk at the attendant's station.

Let us assume that the attendant at the main staion desires a trunk connection, he will then remove his receiver and depress the key K. A circuit may now be traced from ground, break springs relay A, make springs key K (at the instant that key K is fully depressed), relay B, to negative battery. The relay B will energize and a circuit may now be traced from the positive side of the trunk, make springs relay B, transmitter, receiver, calling device, make contact of switch hook, make springs key K, relay C, to the negative side of the trunk. The current flowing in the above traced circuit will cause the operation of the line switch at the automatic exchange and the energization of relay C.

Relay C, upon energizing, will close the circuit of relay A. When relay A energizes a locking circuit for relay B may be traced from ground, make springs relay A, make springs relay

FIG. 58


K
100ω
C
MAKE BEFORE BREAK
K'
500ω
D
NON-LOCKING
TO OTHER STATIONS
BUZZER
A
B
200ω
200ω
200ω
TRUNK
MAKE BEFORE BREAK
+
LOCAL STATION
MAIN STATION
E
HERSHEY

B, relay B, to negative battery. Relay A also operates to remove the ringer and condensers from across the trunk during the dialing period.

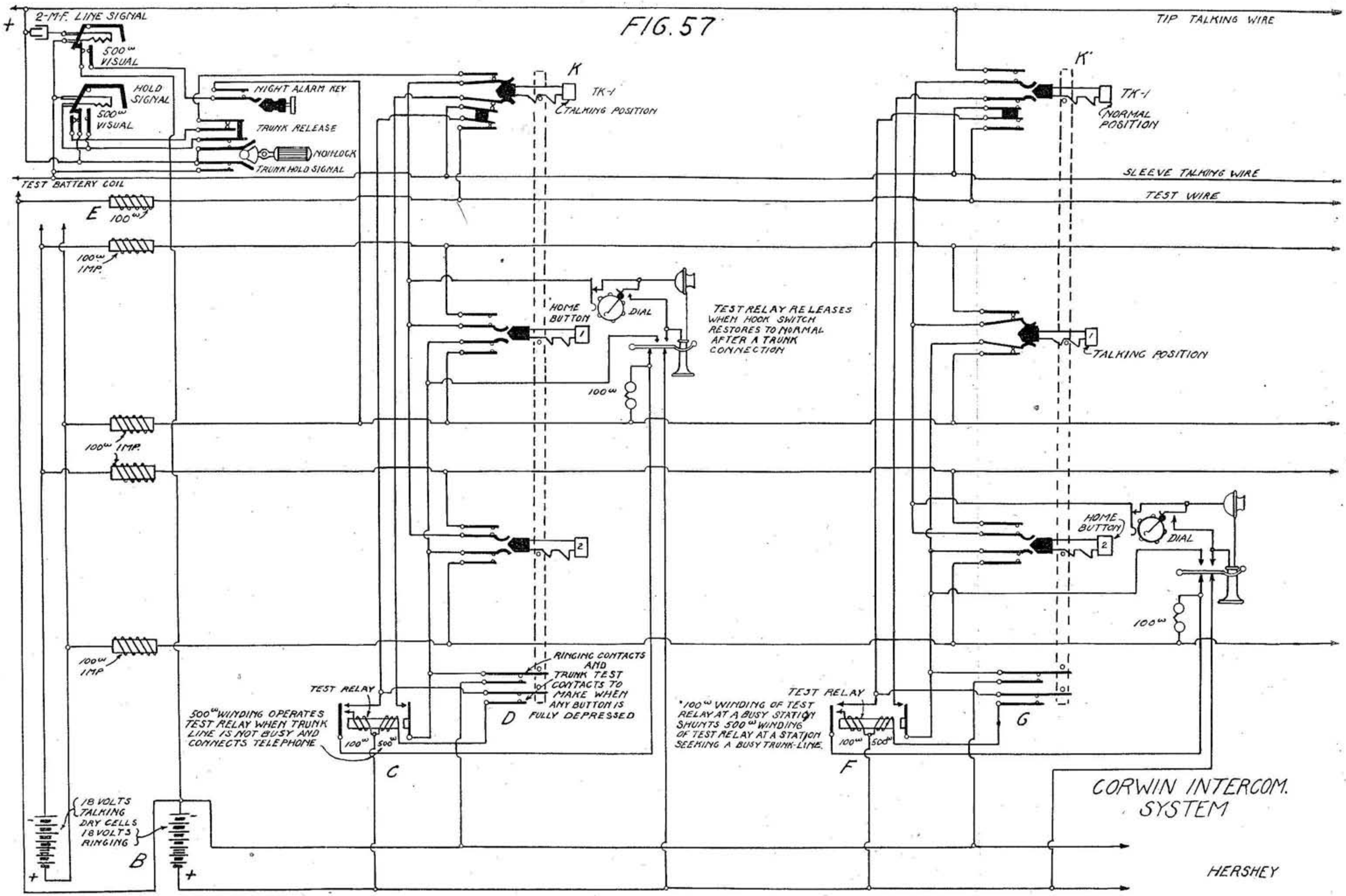
The attendant at the main station will now operate his dial to set up the automatic connection. The relay C will respond to the dial impulses, but relay A, being a slow acting relay, will not release its armature during the momentary interruptions of its circuit.

If a subscriber at one of the local stations should at this time depress his key associated with trunk No. 1 no circuit will be completed through his test relay, due to the open at the break springs of relay A. The subscriber at the local station will proceed to operate his dial unless he happens to notice that his receiver is dead.

When the receiver at the main station is restored the bridge across the trunk will be opened, following which the release of the automatic apparatus will take place. At the same time relay C will de-energize and open the circuit of relay A, a fraction of a second later relay A will de-energize and open the locking circuit of relay B. Relay A, upon de-energizing, will also replace ground on the testing common so that the trunk can again be seized.

When a connector rings on this trunk the bell will sound and the attendant will operate the key K to bridge his telephone across the trunk, thus causing the connector to cut off the ring. If the calling party desires some other station the attendant will operate the hold key K^1. A circuit may now be traced from the positive side of the trunk, hold relay D, make springs key K^1, to the negative side of the trunk. When key K^1 is operated the circuit of the telephone at the main station is opened and as a result relay C will de-energize and open the circuit of relay A, which will in turn de-energize and free the trunk. When relay A de-energizes a locking circuit is formed for holding relay D which is independent of the make springs of key K^1. This holding circuit may be traced from the positive side of the trunk, relay D, make springs relay D, break springs relay A, to the negative side of the trunk. The attendant will now depress the local key associated with the desired station and will tell the called party to come in on the first trunk, after which the attendant will restore his receiver. When the receiver is restored at the main station the buzzer E will be operated over a circuit which may be traced from ground, make springs relay D, buzzer E, break springs of the switch hook, to negative battery.

When the called party comes in on the trunk, current will again flow through relay C, which will operate to close the



CORWIN INTERCOM. SYSTEM

circuit of relay A as usual. When relay A energizes it opens the locking circuit of the hold relay D which will now de-energize and open the circuit of the buzzer E, as an indication to the attendant that the called party has answered.

If the called party does not answer the attendant can again depress the trunk key and come in on the trunk to advise the calling subscriber of the fact. The locking circuit of the hold relay D will now be opened as was previously explained.

An outgoing call made by the attendant can be extended in the same manner as an incoming call.

The local to local wiring remains the same as when the intercom. was in manual service, consequently it is unnecessary to explain the operation here.

Questions.

A. In Fig. 57 what is the object of the break springs on the holding key?

B. In Fig. 58 why are the springs of relay A adjusted to make before break?

Chapter XXIX

Selector Terminals.

In automatic practice it is customary to multiple the banks of ten selectors and then to bring the three hundred bank wires out to what are called terminal strips. A terminal strip consists of a piece of fibre about two feet long which carries one hundred terminals or contacts. The contacts are placed twenty in a group, and of course there are five groups to the strip. These terminals extend slightly on either side of the fibre, the bank wires are attached to one end of the terminal and the other is long enough to bend down and be soldered to whatever contacts happen to be below it.

Each group of ten selectors is termed a shelf and for each shelf there is provided three terminal strips. The upper strip is termed the private terminal, the middle strip the even line terminal, and the lower strip the odd line terminal.

By referring to Fig. 59 it will be seen that the ten wires from the first level of the private bank lead to the first ten contacts in the private terminal strip. The wires from the second level go to the second group of ten terminals, and so on throughout the levels.

The wiring of the line terminals is rather more complicated. In the figure it will be seen that the twenty wires from the second level of the line bank lead to the first twenty contacts in the middle terminal strip. The wires from the fourth level go to the second group of twenty terminals, and so on throughout the even-numbered levels in the line bank.

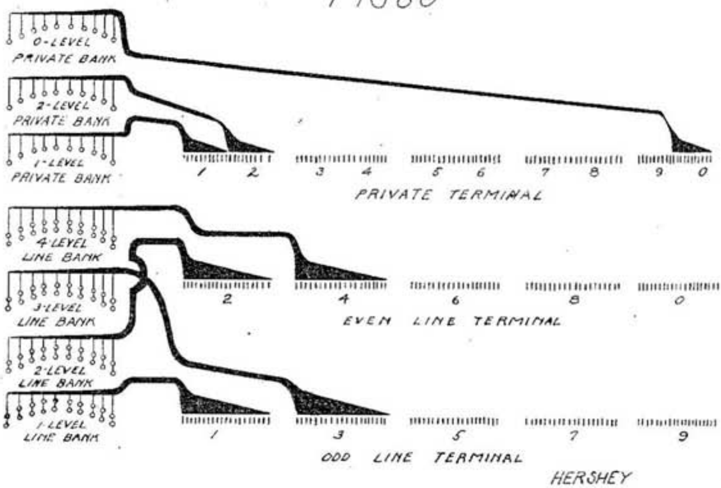
Again referring to the figure it will be seen that the twenty wires from the first level of the line bank lead to the first twenty contacts in the lower terminal strip. The wires from the third level go to the second group of twenty terminals and so on throughout the odd-numbered levels in the line bank.

All the wires from the even-numbered levels of the line bank terminate on the middle terminal strip, and as a result it is referred to as the even terminal. All the wires from the odd-numbered levels of the line bank terminate on the lower terminal strip, and therefore this strip is called the odd terminal.

Slip Multiple Between Shelves.

By means of these terminals it is possible to multiple the banks of the various selector shelves. In Fig. 60 only one level is shown, but this can be considered as representing all the levels in both the line and private banks. The banks of the selectors in shelf A are multipled as shown, and then brought out to a set of terminals. These terminals are now

FIG 59



connected with others which carry the trunks to the various groups of connector switches. Still a third set of terminals carry the wires which multiple the banks of the A shelf with those of the B shelf. This up-and-down multiple, as it is called, extends throughout the five shelves as shown.

It will be seen that 1 up and 1 in on shelf A will lead to the first connector trunk, while 1 up and 1 in on shelf B will lead to the second connector trunk. This is what is termed the slip multiple between shelves and gives the following result:

First choice from the A shelf will be the first connector.

First choice from the B shelf will be the second connector.

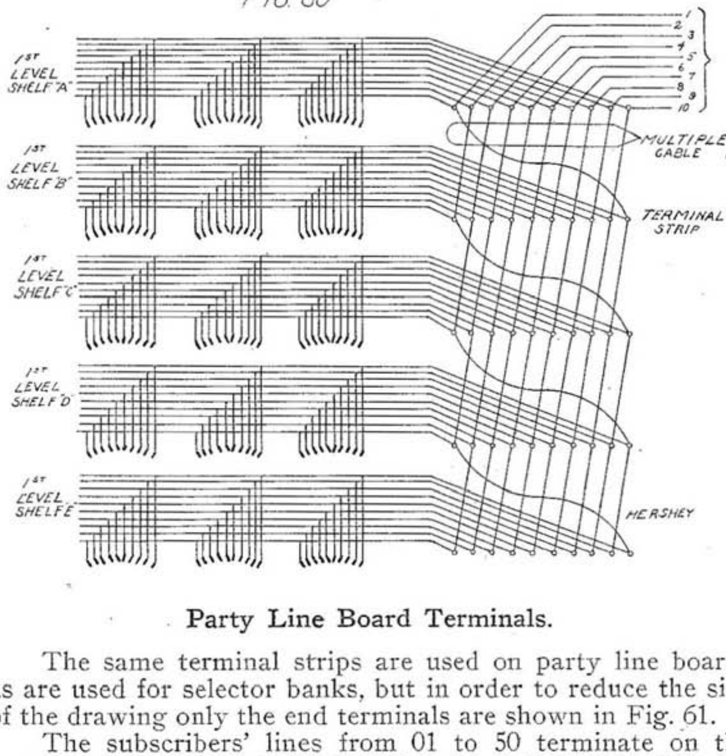
First choice from the C shelf will be the third connector.

First choice from the D shelf will be the fourth connector.

First choice from the E shelf will be the fifth connector.

The object of making this slip is to reduce the rotary motion of the selectors when seeking an idle trunk. If the multiple were straight and the first five connectors were busy, it would be necessary for the next selector calling that particular level to make six rotary steps before an idle trunk could be found. But if a slip multiple be used and the first five trunks become busy a selector in shelf E will find an idle trunk on the second rotary step, a selector in shelf D on the third step, a selector in shelf C on the fourth step, a selector in shelf B on the fifth step, and a selector in shelf A will, of course, have to take six steps before an idle trunk can be reached.

FIG. 60



Party Line Board Terminals.

The same terminal strips are used on party line boards as are used for selector banks, but in order to reduce the size of the drawing only the end terminals are shown in Fig. 61.

The subscribers' lines from 01 to 50 terminate on the upper strip in assembly B, the subscribers' lines from 51 to 00 terminate on the upper strip in assembly C. The middle strip in assembly B is a multiple leading to assembly F and from thence to assembly G. The lower strip in assembly B goes to the line switches associated with the lines from 01 to 50.

The middle strip in assembly C is a multiple leading to assembly H and from thence to assembly 1. The lower strip in assembly C goes to the line switches associated with the lines 51 to 00.

The upper strip in assemblies F and H goes to the line banks of the 16 cycle connectors. The lower strip in assemblies F and H goes to the line banks of the 33 cycle connectors. The upper strip in assemblies G and I goes to the line banks of the 50 cycle connectors. The lower strip in assemblies G and I goes to the line banks of the 66 cycle connectors.

The lower strip in assembly A goes to the release trunk conductors of the various line switches. The upper strip in assembly A is a multiple leading to assembly D and from thence to assembly E. The upper strip of assembly D goes to the private banks of the 16 cycle connectors. The lower strip in assembly D goes to the private banks of the 33 cycle connectors. The upper strip in assembly E goes to the private banks of the 50 cycle connectors. The lower strip in assembly E goes to the private banks of the 66 cycle connectors.

Thus it will be seen that if any connector steps 1 up and 1 in it will operate the B. C. O. of line switch No. 11, and will ring out on line No. 11 with the frequency with which it is supplied.

Placing Lines on Traffic.

If a party line telephone is removed it is essential that provision be made whereby a subscriber calling this number will be automatically connected with an operator who can give him the necessary information. This is termed placing a line on traffic and is accomplished by disconnecting the line and private terminals associated with this telephone from the multiple, and then connecting them to a traffic trunk.

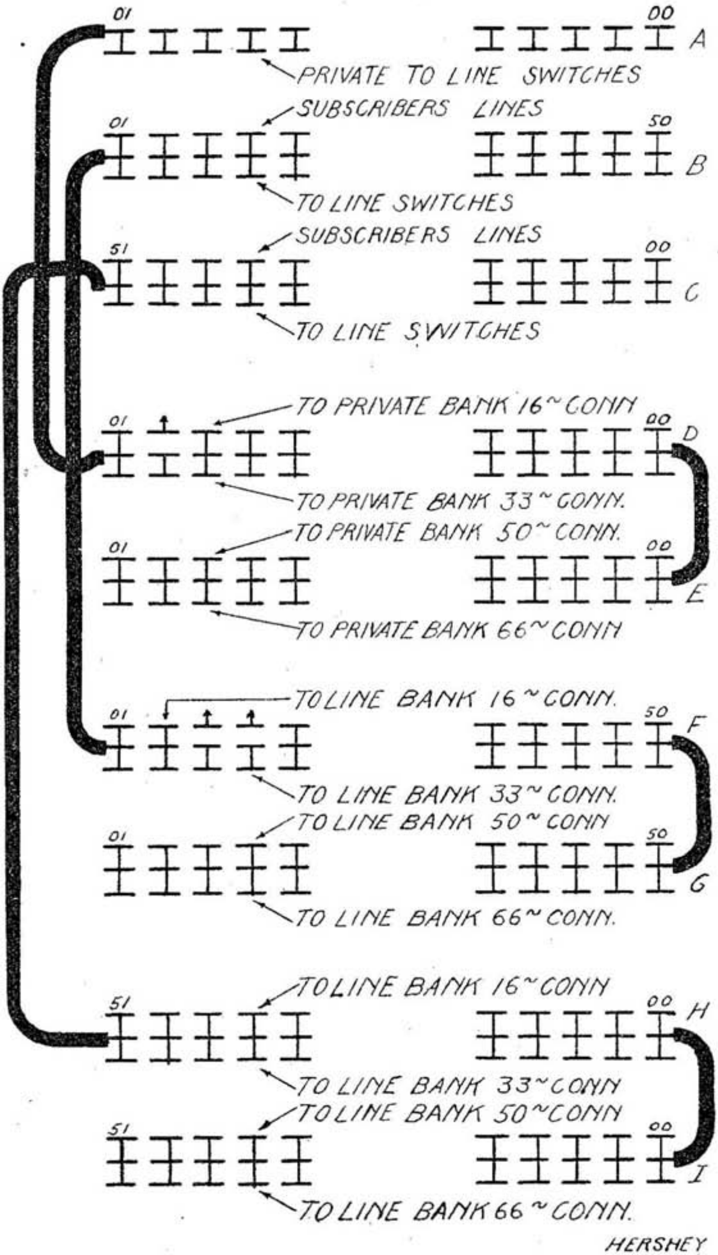
In Fig. 61 it is assumed that the 16 cycle telephone on line 02 has been disconnected, therefore the lines and private terminals associated with line 02 in the banks of the 16 cycle connector have been disconnected from the multiple and connected to a traffic trunk. The traffic trunk is simply a ringdown trunk which terminates in front of an operator. It is customary to connect several disconnected lines to a single traffic trunk.

If someone should now call 102 the 16 cycle connector can no longer ring out on the line, but will ring on the traffic trunk and signal the operator who will inquire what number is desired and then will give the required information.

The placing of the 16 cycle telephone on traffic will, of course, not interfere with the incoming calls to the other telephones, as none of the calls will pass through the banks of the 16 cycle connectors.

When a connector rings on a traffic trunk it will, of course, ground the private, thus busying all the lines multipled with that particular traffic trunk, the object being to keep another connector from ringing in while the operator and subscriber are conversing.

FIG. 61


01
00
A
PRIVATE TO LINE SWITCHES
SUBSCRIBERS LINES
01
50
B
TO LINE SWITCHES
SUBSCRIBERS LINES
51
00
C
TO LINE SWITCHES
TO PRIVATE BANK 16~ CONN
01
00
D
TO PRIVATE BANK 33~ CONN.
TO PRIVATE BANK 50~ CONN.
01
00
E
TO PRIVATE BANK 66~ CONN
TO LINE BANK 16~ CONN.
01
50
F
TO LINE BANK 33~ CONN.
TO LINE BANK 50~ CONN
01
50
G
TO LINE BANK 66~ CONN.
TO LINE BANK 16~ CONN
51
00
H
TO LINE BANK 33~ CONN
TO LINE BANK 50~ CONN
51
00
I
TO LINE BANK 66~ CONN.
HERSHEY

When a straight line telephone is disconnected the line is merely connected to a traffic trunk at the main frame without any changes being made at the switchboard.

Questions.

A. In Fig. 59 point out the line and private terminals associated with the following selector bank contacts: 11, 28, 00, 29, 30 and 56.

B. When placing a line on traffic what would result if the line private were not opened, and the traffic trunk private were tied directly to it?

C. What would result if the traffic trunks become too heavily loaded?

Chapter XXX

The Solenoid Ringing Interrupter.

If all the connectors in an automatic exchange should ring at the same instant a very heavy load would be placed on the generator. In order not to overload the ringing machines it is customary to have the connectors ring in groups. Let us assume that the connectors in the first thousand are now ringing, after they have stopped the connectors in the second group will ring, and so on throughout the thousands, thus it will be seen that the load on the machines at any given time is greatly reduced.

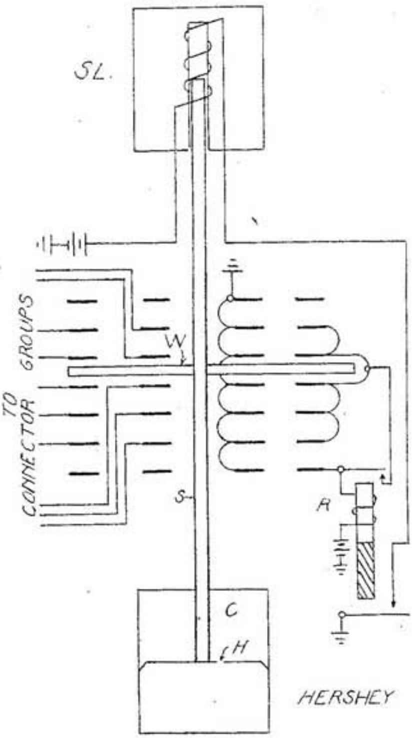
In order to have the groups ring at different times it is necessary that we provide a ringing interrupter. In Fig. 62 is shown what is termed a Solenoid Ringing Interrupter. The shaft S moves up and down through a hole in the top of the cylinder C. This cylinder is full of oil, and the piston on the end of the shaft is so constructed that the oil passes around the edge of the piston when the shaft it raised, and as a result there will be very little resistance offered to the upward movement of the shaft. When the shaft moves downward the oil can no longer pass around the edge of the piston, but can only creep through the small hole H, consequently the downard movement of the shaft will be quite slow, depending upon the size of the vent.

The top portion of the shaft serves as an armature for the solenoid S L. The solenoid, upon energizing, will operate to raise the shaft, following which the circuit of the solenoid is opened and the shaft slowly returns to normal, the force of gravity being opposed by the oil in the dash pot or cylinder.

In the figure is shown a bank containing 28 contacts. These contacts are placed four in a level and seven levels high. The contacts on the left are shown as going to the various connector groups. The shaft S also carries the wiper W, which shorts all the contacts in each level as it passes over them.

When the wiper reaches the bottom set of contacts a circuit is closed from ground, through the bank contacts, slow acting relay R, to negative battery. The slow acting relay R will energize and close the circuit of the solenoid, which in turn will energize and operate to raise the shaft. The relay R also forms a locking circuit for itself which may be traced from ground, bank contacts (while the shaft is rising), make spring relay R, relay R, to negative battery. This locking circuit will maintain the relay R energized until the shaft rises above the sixth contact. The relay R, being a slow acting relay, will not release its armature for a fraction of a second

FIG. 62



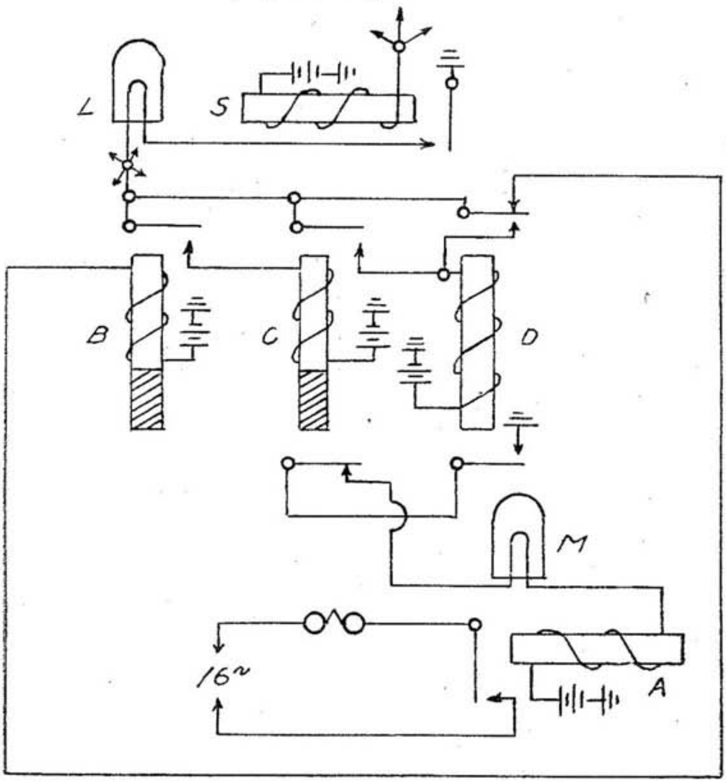
after the wiper opens its circuit at the sixth contact, and as a result the circuit of the solenoid will be held closed long enough to insure that the shaft is fully raised. When relay R finally releases, the circuit of the solenoid will be opened, following which the shaft will slowly descend. The circuit of the relay R will not be again closed until the wiper has reached the lowest level.

As the shaft descends ground will be placed on the ringing interrupter lead to each group in turn. When using the connector shown in Fig. 11 this ground goes direct to the A and B relays, but if the connector shown in Fig. 12 is used this ground energizes a relay which in turn operates the set of springs shown at R I in that figure. The up movement of the wiper is so rapid that the ground impulses at this time will be too short to cause the connectors to ring.

Slow Acting Signals.

In the various figures the release magnet has always been shown as being connected directly to negative battery. In practice it is customary to feed battery to the release magnets through a pilot or supervisory relay, the object being to provide an alarm should a switch fail to release properly. It would not do to have this relay sound an alarm each time it is energized, for it is continually pulling up and dropping back, due to the normal traffic in the office. But if a switch

FIG. 63



HERSHEY

should fail to release this supervisory relay would remain energized, and after an interval of a few seconds it is essential that an alarm be given.

In Fig. 63 is shown a scheme by which the supervisory relay S may operate the alarm relay A, provided it remains energized long enough. The relays B and C are slow acting relays of 1300 ohms each. The relay D is made only 30 ohms in resistance so that the lamp L will light up through it. The relay A is also 30 ohms in resistance as it is in series with the lamp M.

When relay S energizes a circuit may be traced from ground, make springs relay S, lamp L, break springs relay D, relay B, to negative battery. The lamp L will not light at this time due to the resistance of the relay B. The relay B will energize and close a circuit from ground, make springs relay S, lamp L, make springs relay B, relay C, to negative battery. Relay C will energize and close a circuit which may be traced from ground, make springs relay S, lamp L, make springs relay C, relay D, to negative battery. The lamp L will now light and the relay D will operate to open the circuit of the slow acting relay B, and at the same time will form a locking circuit for itself independent of relay C. When relay B de-energizes it will open the circuit of the slow acting relay C, which in turn upon de-energizing will complete a circuit from ground, make springs relay D, break springs relay C, lamp M, relay A, to negative battery. The lamp M will light and the relay A will operate to close the circuit of the alarm bell. The alarm will continue to sound until such time as the supervisory relay S de-energizes. It takes several seconds for the slow acting set to operate, and if the supervisory relay de-energizes before the operation is complete the alarm will not sound, and the various relays will return to normal.

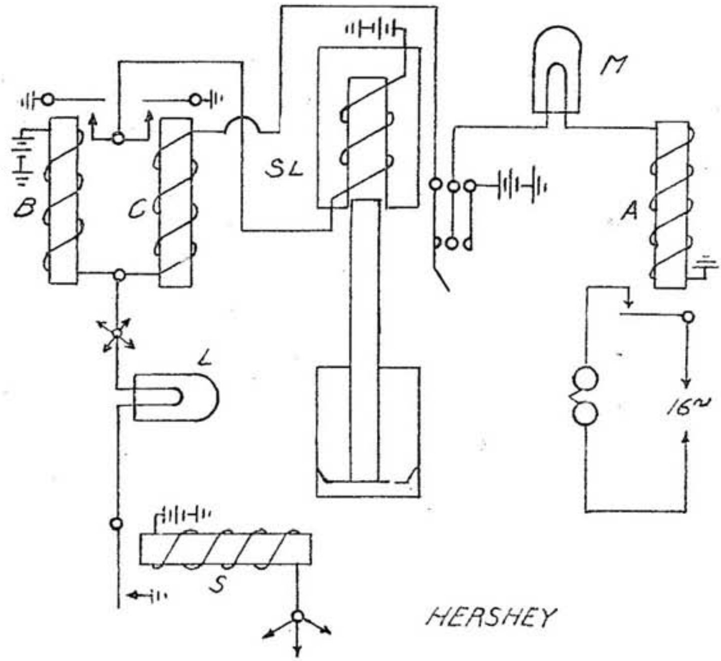
The Solenoid Slow Acting Set.

When it is desired to delay the signal for any great length of time it is preferable to use a Solenoid Slow Acting Set, for in order to make the relay chain hold up for a corresponding length of time it would be necessary to materially increase the number of relays.

By referring to Fig. 64 a solenoid and dash pot will be found which are similar to those shown in Fig. 62. It will be noticed, however, that the piston is reversed, therefore the upward movement under the control of the solenoid will be slow, while the downward movement will be fast. When the shaft reaches the top it will cause a set of springs to be operated. The relay S is the usual supervisory relay. Relay B is a 1000 ohm relay, relays C and A are of 30 ohms each.

When relay S is energized a circuit may be traced from ground, make springs relay S, lamp L, relay B, to negative battery. The lamp L will not light at this time due to the resistance of the relay B, relay B will, however, energize and

FIG 64



close the circuit of the solenoid. When the shaft reaches the top the relay B is shunted by the relay C. The lamp L will now light and relay C will operate to keep the circuit of the solenoid closed. The shaft springs also close a circuit through lamp M and relay A, following which the lamp M will light and relay A will operate to sound the alarm. The alarm will continue to sound until such time as the supervisory relay S de-energizes. If the supervisory relay de-energizes before the plunger reaches the top the alarm will not sound, and the relay B and the solenoid S L will de-energize and return to normal.

Counter Cells.

For the successful operation of an automatic plant it is imperative that the voltage be maintained between 46 and 48 volts. In order to do this it is necessary to adopt some means of voltage control.

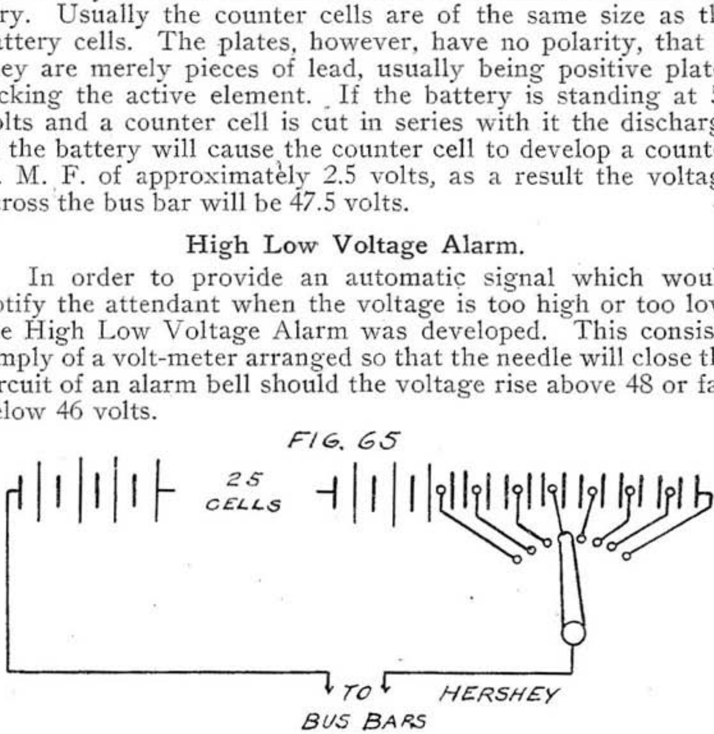
Nearly all automatic plants use what is termed the counter cell method of voltage control. If the battery voltage is high a number of these counter cells are cut in series with the battery to bring the voltage down to 48. As the battery discharges these counter cells are cut out one at a time so as to maintain the voltage at not less than 46. When all the counter cells are cut out, and the voltage again falls below 46, it is of course necessary to recharge the battery.

As shown in Fig. 65 these counter cells are placed at the negative end of the battery, and by means of the counter cell switch any number of them can be cut in series with the battery. Usually the counter cells are of the same size as the battery cells. The plates, however, have no polarity, that is they are merely pieces of lead, usually being positive plates lacking the active element. If the battery is standing at 50 volts and a counter cell is cut in series with it the discharge of the battery will cause the counter cell to develop a counter E. M. F. of approximately 2.5 volts, as a result the voltage across the bus bar will be 47.5 volts.

High Low Voltage Alarm.

In order to provide an automatic signal which would notify the attendant when the voltage is too high or too low, the High Low Voltage Alarm was developed. This consists simply of a volt-meter arranged so that the needle will close the circuit of an alarm bell should the voltage rise above 48 or fall below 46 volts.

FIG. 65



Questions.

A. Why are the interrupter leads not connected to the contacts in the first and seventh level of the solenoid interrupter?

B. What advantages has the counter cell method of voltage control over the end cell method? Over the resistance method?

C. Would the slow acting signal be used in connection with anything other than the release magnets?

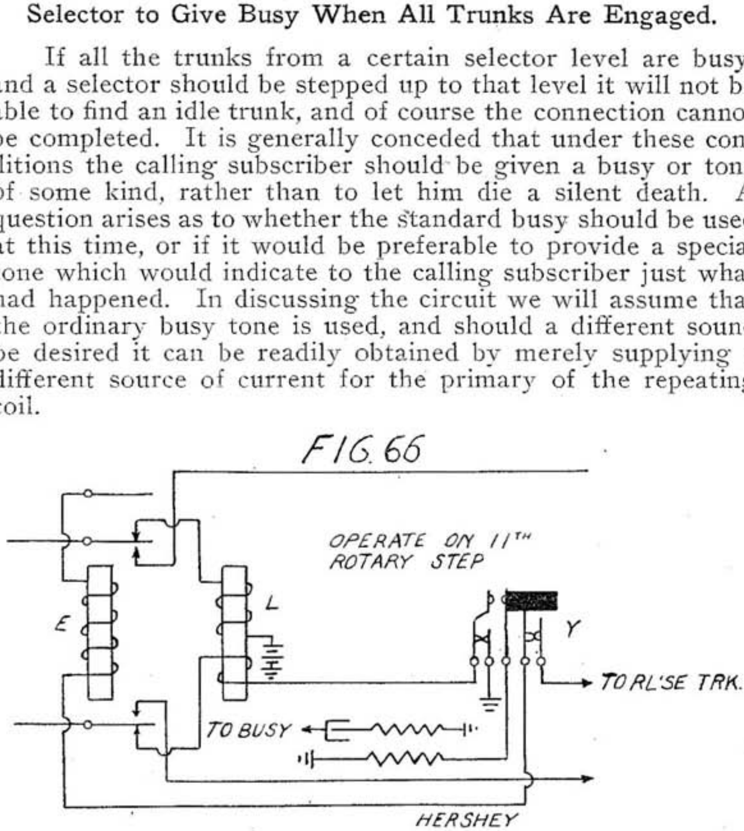
D. Would a slow acting signal be used in connection with a fuse alarm?

Chapter XXXI

Selector to Give Busy When All Trunks Are Engaged.

If all the trunks from a certain selector level are busy, and a selector should be stepped up to that level it will not be able to find an idle trunk, and of course the connection cannot be completed. It is generally conceded that under these conditions the calling subscriber should be given a busy or tone of some kind, rather than to let him die a silent death. A question arises as to whether the standard busy should be used at this time, or if it would be preferable to provide a special tone which would indicate to the calling subscriber just what had happened. In discussing the circuit we will assume that the ordinary busy tone is used, and should a different sound be desired it can be readily obtained by merely supplying a different source of current for the primary of the repeating coil.

FIG. 66



In Fig. 66 we find the familiar line relay L and the switching relay E. The spring assembly Y, shown at the right of the figure, will be operated by the shaft of the selector when it makes the eleventh rotary step. When operating under ordinary conditions the ground feed to relay L passes through a pair of break springs in the assembly Y. If all the trunks in the level are busy the selector will take eleven rotary steps, thus moving the line and private wipers off of the bank and causing the spring assembly Y to be operated. Ground is now fed to relay L through the secondary of the repeating coil X, and make springs of the assembly Y. Since the busy tone is continually passing through the primary winding of the repeating coil a corresponding tone will be induced in the secondary winding which will pass out over the calling line and actuate the receiver at the calling substation. The spring assembly Y also operates to open the circuit to the switching relay E, so that the latter cannot energize and open the circuit to the line relay L.

When the receiver at the calling substation is restored the release takes place in the usual manner.

Back Release Connector.

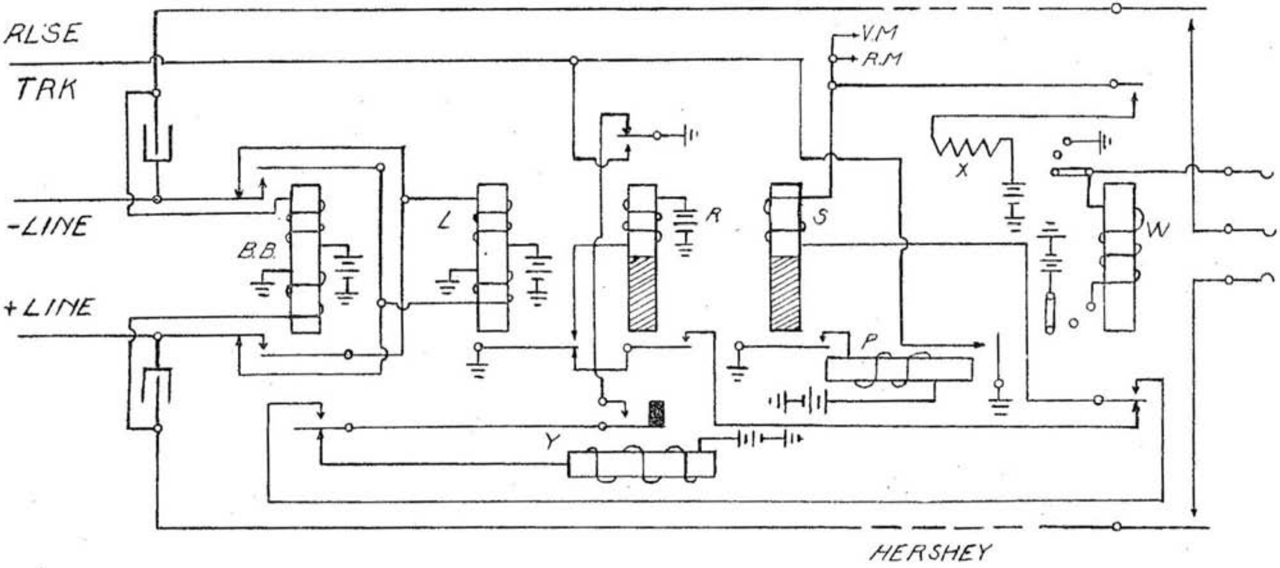
In the connector circuit which we have been discussing it will be remembered that the calling subscriber controls the release of the switch. If the calling subscriber should be the first to restore his receiver the switches would release, thus opening the circuit through the B. C. O. winding of the called line switch. As a result the line relay of the called line switch will again be cut across the line, and since the called subscriber still has his receiver removed the connection will be extended to a selector, where it will remain until such time as the called subscriber hangs up his receiver. Consequently a first selector trunk will be tied up unnecessarily, and in order to overcome this possibility a Back Release Connector has been developed.

If the calling subscriber hangs up first, when back release connectors are used, the connector will operate to remove ground from the release trunk and thus cause the release of the selectors and the calling line switch. The connector, however, will not release until such time as the called party restores his receiver. Since the connector is in an operated position it is essential that the ground be removed from the release trunk only long enough to allow the selectors to release, after which it must be returned in order to protect the connector from again being seized by a selector.

In Fig. 67 is shown the familiar line relay L, release relay R, series relay S, back bridge relay B B, private magnet P and release magnet Y. The wiper cut-off relay W is usually 1300 ohms and operates to cut the wipers through to the back bridge as soon as the side switch reaches third position. The resistance coil X consists of 300 ohms of German silver and is usually carried by the busy relay as a non-inductive winding.

Let us assume that the calling subscriber hangs up first, as soon as his receiver is restored the circuit of line relay L is opened, following which relays L and R will de-energze. When relay R de-energzes it removes ground from the release trunk following which the selectors and calling line switch will release. The connector will not release at this time for the circuit of release magnet Y is held open at the springs

FIG 67



of the back bridge relay B B. When relay R de-energizes a circuit is closed which may be traced from ground, break springs relay R, off normal springs, make springs relay B B, make springs relay W, series relay S, make springs relay W, resistance X, to negative battery. The series relay will energize over this circuit and operate to close the circuit of private magnet P. The private magnet P will energize and again place ground on the release trunk to protect the connector against seizure by a selector.

When the called party hangs up his receiver the back bridge relay B B will de-energize and close the circuit of the release magnet, following which the release of the connector will take place in the usual manner.

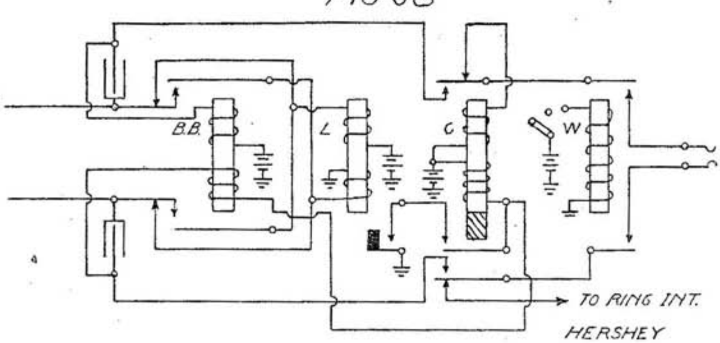
Ringing Induction.

In any telephone system it is very desirable that the calling subscriber be notified in some way that the called party is being signalled. In automatic practice this is of particular importance because of the fact that there is no operator to talk to disgruntled subscribers who insist that "there is someone there."

With the connector shown in Fig. 19 it was customary to place a high resistance cross between the break springs of the D relay, thus allowing a very small portion of the ringing current to pass through the talking condensers and actuate the receiver at the calling substation. This high resistance cross usually consisted of lead pencil marks drawn across the bushings which separate the break springs.

In the later type of connectors an induced current is used to indicate to the calling subscriber that the called party is being signalled. In Fig. 68 is shown the familiar line relay L, back bridge relay B B, wiper cut-off relay W, and ring cut-off relay C. When the connector is ringing the alternating

FIG 68



current passing through the low resistance winding of relay C will induce an alternating current in the second winding of the same relay. This induced current will flow over a circuit which may be traced from battery, through the high resistance winding of relay C, lower winding of relay B B, lower talking condenser, calling telephone, upper winding relay L, to negative battery. The current flowing in this circuit will actuate the receiver at the calling substation and will indicate to the calling subscriber that the distant bell is ringing.

The second scheme is an improvement over the first in that the calling subscriber will not receive ringing induction unless the circuit of the called line is complete, since the ringing induction is dependent upon an actual flow of ringing current through the low resistance winding of relay C.

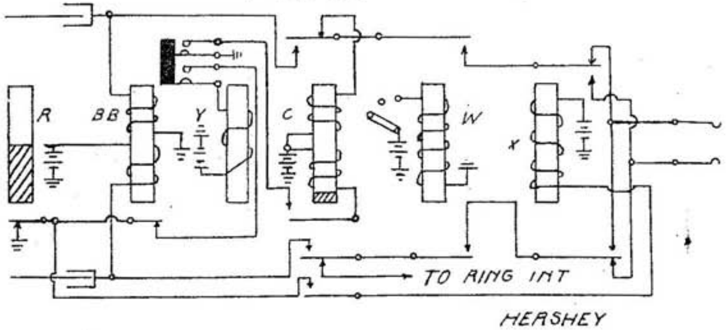
In Fig. 12 there was no provision made for unlocking the relay C. In the present figure it will be noticed that the relay C locks itself up to off normal ground, and as a result its locking circuit will be opened when the shaft reaches normal.

Trunk Reverse Connector.

In neither of the P. B. X. circuits discussed in Chapter XXVII was provision made for answering supervision on trunked calls. In some P. B. X. circuits the battery reversal from the connector is utilized to extinguish the calling supervisory light as an indication to the operator that the called party has answered. With such a circuit the supervisory lamp must light with normal polarity, but with reversed polarity the lamp must go out.

On outgoing calls this is a simple matter, but on incoming calls some complications are introduced. When a connector extends a connection to a P. B. X. the polarity must be such that the supervisory lamp will be extinguished. Upon

FIG. 69



the release of the connector the polarity to the P. B. X. must be returned to normal so that the supervisory lamp will again light. This is accomplished by reversing the trunk conductors in the connector banks; thus when a connector extends a connection to a P. B. X. the polarity is reversed, and the supervisory lamp is extinguished. When the connector releases, the line relay is again cut on to the trunk and as a result normal polarity now prevails, consequently the supervisory lamp will light and indicate to the operator that the distant subscriber has released.

Upon the advent of the back release connector this scheme could no longer be used since the connector does not release when the calling party hangs up. When a connection is extended to a P. B. X. by a back release connector the polarity is reversed due to the circuit of the connector. When the calling party releases, the connector causes the polarity of the trunk to be returned to normal and as a result the supervisory lamp lights and indicates to the operator that the calling party has released.

Referring to Fig. 69 you will find the familiar release relay R, back bridge relay B B, ring cut-off relay C, release magnet Y, wiper cut-off relay W and the trunk reversing relay X, which is usually 1300 ohms in resistance. Your attention is called to the fact that when the connection is completed negative battery will be fed through the lower winding of the back bridge to the lower line wiper, instead of to the upper line wiper as is customary. As a result the polarity of the trunk is reversed. When the calling subscriber restores his receiver to the switch hook the release relay will de-energize, but since this is a back release connector the wipers will remain upon the banks of the called trunk. When the release relay de-energizes a circuit may be traced from ground, break springs relay R, make springs relay C, trunk reversing relay X, to negative battery. The relay X will energize and operate to restore the polarity of the trunk to normal, thus causing the supervisory lamp at the P. B. X. to light.

When the P. B. X. operator clears the trunk the back bridge relay will de-energize and the release of the connector will follow in the usual manner.

Questions.

A. What objections may there be to using the usual busy tone as an indication that all the trunks to a certain group are busy?

B. Could a back release connector be used in a one hundred line system employing line switches and connectors?

C. What effect does the copper slug on relay C have upon the current induced in the secondary winding?

D. Is it desirable to have a P. B. X. circuit which will give trunk supervision?

E. When the connector in Fig. 69 is ringing negative battery is fed through the upper line wiper. What difficulty would be encountered if positive battery were on the upper line wiper at this time?

Chapter XXXII

Switching Connectors.

In small P. A. X.'s it is customary to terminate the lines on line switches which have access to trunks leading to connectors. Thus inter-department calls can be made by dialing only two figures. Unless it happens to be an isolated P. A. X. it is necessary to provide means by which P. A. X. subscribers can extend a connection through the Main Exchange and is also necessary to provide means by which subscribers in the Main Exchange can call subscribers on the P. A. X. It is customary to list all the P. A. X. numbers in the directory, and to allow the Main Exchange subscriber to dial the department desired.

The tenth level in the banks of the P. A. X. connectors is usually reserved for out-going trunks to the Main Exchange. The conductors from these connector bank contacts lead to repeaters which are associated with with trunks terminating on line-switches at the Main Exchange. To make an outgoing call the P. A. X. subscriber dials the figure O, which causes the connector to raise the shaft and wipers to a position opposite the tenth level of bank contacts. The connector now assumes the properties of a selector and automatically rotates to find an idle trunk, after which the connection is extended to the associated repeater. The P. A. X. subscriber now dials the directory number of the desired party and thus completes the connection.

In Fig. 70 you will find the familiar line relay L, release relay R, series relay S. switching relay E, ring cut off relay C, back bridge relay BB, private magnet P, release magnet Y, vertical magnet VM and rotary magnet RM. The wiper cut off relay W is here shown as a double wound relay, the inside winding is of 250 ohms and the outer winding of 1300 ohms resistance. The interrupter relay F carriers two windings, an inside winding of 600 ohms, and an outside winding of 300 ohms resistance. The latter is a non-inductive winding. The A relay has a resistance of 1300 ohms. The relay X is wound to 5 ohms resistance.

The operations of this switch differs from any that we have studied and for that reason the circuits will be traced in detail. When a connection is extended to this switch the relays L and R operate in the usual manner. Upon energizing the relay R will place ground upon the release trunk over the following circuit, from ground, switching springs, make springs relay R, to release trunk. We will now assume that the subscriber dials the figure 6. As the dial returns to normal the circuit of the line relay L is momentarily opened six times. Each time the armature of relay L falls back it opens the circuit of relay R. Relay R does not de-energize, however, on account of its being a slow acting relay. Each time the armature of relay L falls back a circuit may be traced from ground, break springs relay F, break springs relay L, make springs relay R, side switch wiper in first position, series relay S, vertical magnet, side switch wiper in first position, to negative battery. The current flowing in this circuit will cause the vertical magnets to energize six times and thereby lift the shaft and wipers to a position opposite the sixth level of bank contacts. The first flow of current thru the relay S will cause it to become energized, and, since it is a slow acting relay, it will maintain its armature in an operated position until a fraction of a second after the last impulse has passed thru it. When relay S energizes, a circuit is closed thru the private magnet P. The private magnet energizes, and, as has previously been explained, no change in the position of the side switch wipers takes place at this time. Shortly after the last impulse of current has passed thru the relay S, it will de-energize, thus opening the circuit of the private magnet. The private magnet, upon de-energizing, will cause the side switch wipers to pass to second position.

All is now in readiness for the subscriber to call the second figure. Let us assume that the subscriber dials the figue 5, thus opening the line circuit five times and causing the line relay to momentarily release its armature a like number of times. Each time the line relay L de-energizes a circuit may be traced from ground, break springs relay F, break springs relay L, make springs relay R, side switch wiper in second position, series relay S, break springs relay A, rotary magnet, break springs relay X, side switch wiper in second position, to negative battery. The current flowing in this circuit will cause the rotary magnets to energize five times and thereby rotate the shaft and wipers into engagement with the bank contacts associated with telephone number 65. At the first rotary impulse relay S will energize, as before, and close a circuit thru the private magnet. The private magnet will energize, but without changing the electrical condition at the side switch. Shortly after the last impulse of current has passed thru relay S, it will de-energize, and thereby open the circuit of the private magnet. The private magnet, upon de-energizing, will cause the side switch wipers to pass to third position.

As soon as the side switch wipers pass to third position a circuit may be traced from ground, switching springs, make

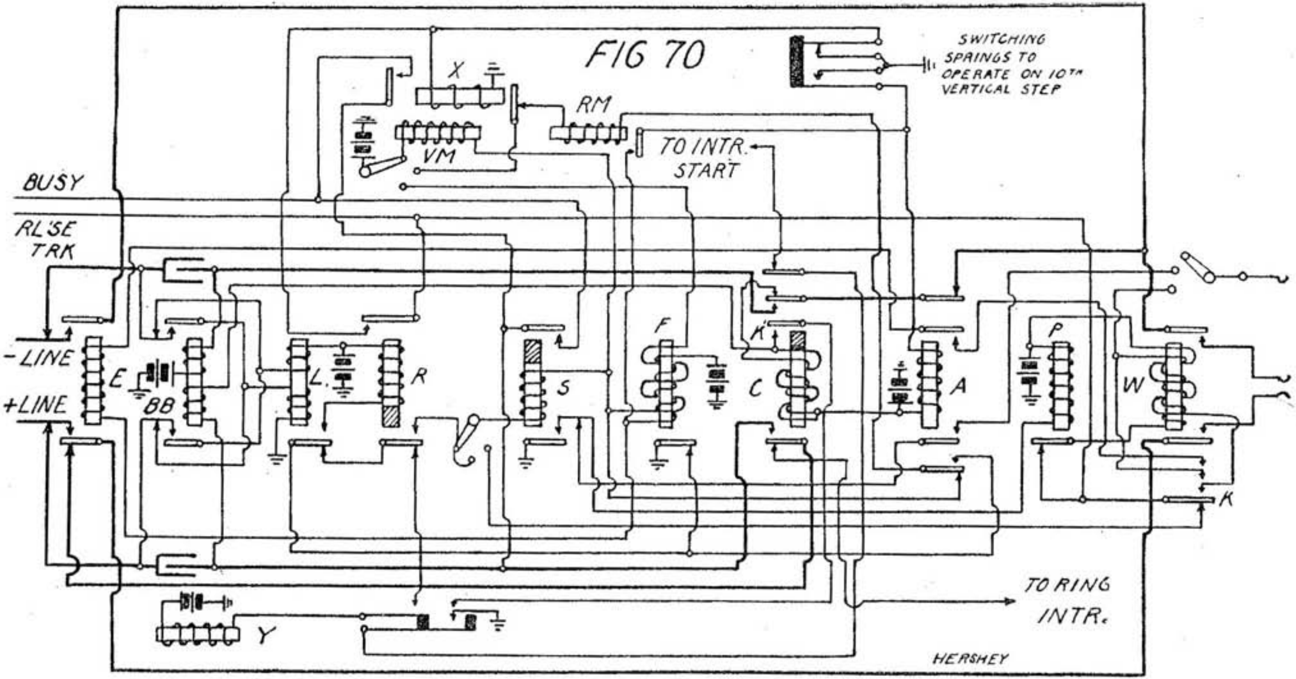


FIG 70
SWITCHING SPRINGS TO OPERATE ON 10TH VERTICAL STEP
X
RM
VM
TO INTR. START
BUSY
RL'SE TRK
-LINE
+LINE
E
BB
L.
R
S
F
K'
C
A
P
W
K
Y
TO RING INTR.
HERSHEY

springs relay R, break springs private magnet, low winding of relay W, side switch wiper in third position, private wiper, thru B. C. O. of the called line switch, to negative battery. The B. C. O. of the called line switch will operate over this circuit, the relay W will also operate sufficiently to close the springs K. When springs K are closed a circuit may be traced from ground, switching springs, make springs relay R, make springs relay W, high winding relay W, to negative battery. The current flowing in this circuit will cause relay W to become fully operated. Direct ground is now placed on the private bank contact over the following circuit, from ground, switching springs, make springs relay R, make springs relay W, side switch wiper in third position, private wiper, to private bank contact. This operation of the relay W will be so slow that the B. C. O. of the called line switch will have sufficient time in which to clear the called line of attachments.

The switch is now in position to signal the called party, and a circuit may be traced from ring interrupter, break springs relay C, break springs relay E, make springs relay W, ringer and condenser at the called telephone, make springs relay W, break springs relay A, break springs relay C, low winding of relay C, to negative battery. The condenser will prohibit the flow of direct current in this circuit, but the alternating current will cause the ringer at the called substation to be operated. The alternating current passing through the low winding of relay C does not cause it to energize, as has previously been explained. Let us assume that the called subscriber removes his receiver during the time that the generator is in the circuit. As soon as the transmitter and receiver are bridged across the line there will be a flow of direct current, over the above traced circuit, in addition to the alternating current already flowing. This flow of direct current will cause relay C to attract its armature. The springs of relay C are so arranged that springs K' make before the other springs are operated. When the springs K' are made a circuit may be traced from ground, off normal springs, make springs relay C, high winding relay C, to negative battery. The current flowing in this circuit will cause relay C to become fully operated and cut the back bridge through to the line wipers.

A circuit may now be traced from ground, off normal springs, make springs relay C, lower winding relay B B, make springs relay C, break springs relay E, make springs relay W, to called telephone, make springs relay W, break springs relay A, make springs relay C, upper winding of relay B B, to negative battery. Talking battery will be fed to the called subscriber over the above traced circuit, and the relay B B will also operate to reverse the polarity of the calling line.

Upon the completion of the conversation the restoration of the receiver to the switch hook at the calling substation will bring about the release of the switch in the usual manner.

If the called line is busy this switch will not lock in second position, but **will pass to third position.** Since the private bank contact is grounded there will, of course, be no circuit for the low winding of relay W. A circuit, however, may be traced from ground, switching springs, make springs relay R, break springs relay W, side switch wiper in third position, series relay S, 300 ohm non-inductive winding of relay F, to negative battery. The series relay S will energize over this circuit and will give the calling subscriber the busy tone in the usual manner. The series relay also closes the circuit of the private magnet, which in turn operates to open the circuit to the low winding of relay W. If it were not for this provision the relay W would energize if the called line became idle while the calling party was receiving the busy tone. When the calling subscriber hangs up his receiver the release takes place in the usual manner.

The repeater which is attached to each trunk in the O level of the connector banks is similar to the repeater shown in Fig. 47, except that its release trunk is permanently tied to negative battery through a 1200 ohm non-inductive resistance. If it were not for this battery feed it would be impossible for the relay W to energize and cut the circuit through to the repeater.

If the P. A. X. subscriber desires to call an outside number he first dials the figure O, and as a result the shaft and wiper are raised to a position opposite the tenth level of bank contacts, thus causing the switching springs to be operated. When the switching springs are operated the shunt is removed from around relay X; relay X will, however, not energize in series with the B. C. O. of the calling line switch. When the switching springs are operated a circuit may be traced from ground, switching springs, relay A, to negative battery. Relay A will energize and close a circuit which may be traced from ground, break springs relay F, make springs relay A, rotary magnet, break springs relay X, side switch wiper in second position, to negative battery. The rotary magnet will energize over this circuit and will operate to rotate the shaft and wipers into engagement with the first set of bank contacts. The rotary armature on this switch carries a "rotary arm finger" which operates to depress the armature of the private magnet each time the rotary magnet is energized. Upon energizing the rotary magnet closes a circuit which may be traced from ground, switching springs, make springs rotary magnet, 600 ohm winding of relay F, to negative battery. The relay F will energize and open the circuit of the rotary magnet, following which the rotary magnet will de-energize and open the circuit of relay F, and at the same time the "rotary arm finger" will release the armature of the private magnet. If the first private bank contact is idle the private magnet will de-energize and allow the side switch to pass to third position. As soon as the side switch reaches third position the relay W will operate to cut the circuit through to the wipers. A circuit may now be traced from ground, relay X, make springs relay R, make springs relay W, make springs relay A, switching relay E, 600 ohm winding of relay F, to negative battery. The relay X will not energize at this time, but relays E and F will operate. When relay E energizes the circuit is cut straight through to the line relay of the repeater. The line relay L will now de-energize, but the release of the connector will not take place on account of the open at the springs of the F relay. When the connection is extended to the repeater its line and release relay will energize in the usual manner. The release relay of the repeater will return ground on the release trunk which will take the place of the ground fed through the make springs of relay R. It is evident that the release relay R must be slow acting enough to remain energized until such time as the release trunk ground is returned by the repeater.

The calling subscriber now proceeds to dial the directory number of the called party. When the receiver at the calling sub-station is restored the circuit of the line relay of the repeater will be opened, following which the release of the apparatus in the main exchange will take place. When the release relay of the repeater de-energizes the ground will be removed from the release trunk following which relay F will de-energize and cause the release of the connector.

If the first trunk in the O level is busy the private wiper will pick up ground from the private bank contact and will maintain the private magnet energized. The rotary magnet and the relay F will now operate in the usual manner to advance the wipers into engagement with an idle trunk.

If all the trunks in the O level are busy the switch will rotate off the bank. The private magnet will then de-energize, and the calling subscriber will receive the busy tone in the same manner as was explained above.

Discriminating Service.

In a P. A. X. it oftentimes is desirable to limit certain stations to the making of only inside calls. This is more likely to be the case where the service to the main exchange is metered.

In order to give this service the B. C. O. windings of the restricted line switches are each shunted by a 350 ohm non-inductive resistance. In ordinary service this, of course, has no effect except the increased current consumption. If an attempt should be made to call outside on a restricted line the connector would respond to the O impulses in the usual way. When the switching springs are operated a circuit may be traced from ground, relay X, make springs relay R, release trunk, through B. C. O. and 350 ohm shunting coil of the calling telephone, to negative battery. The relay X is so adjusted that it will pull up under these conditions. When the relay X energizes it will open the circuit of the rotary magnet, so that the connector will not seek an idle trunk, and at the same time will give the calling subscriber the busy tone.

The restricted telephones can, of course, receive incoming calls the same as an ordinary telephone. If it is desired to restrict certain lines from receiving incoming calls it is merely a question of opening up the private multiple and grounding the private bank contacts associated with these lines in the banks of the incoming connectors. These connectors are located at the P. A. X. and are the terminals of trunks leading from selector repeater banks at the Main Exchange.

Series Repeating Connector.

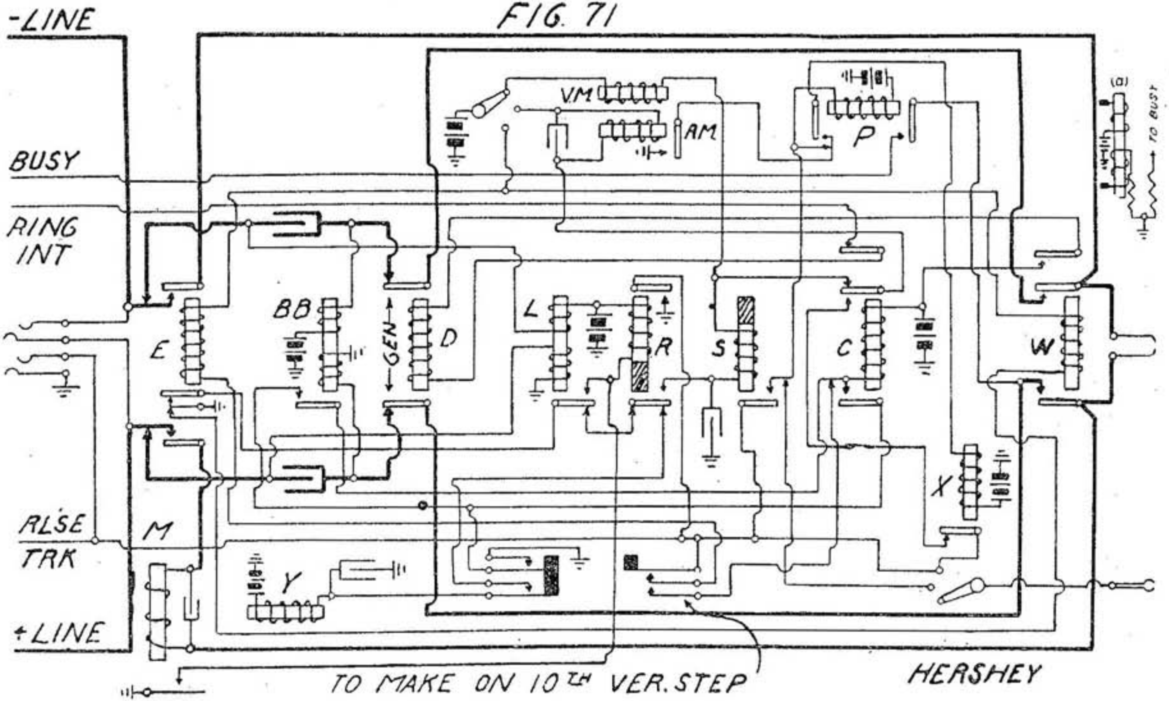
In order to save the expense of a repeater for each trunk, a Series Repeating Connector has been developed. This connector does not repeat the impulses, but operates in a manner similar to that of the series repeater shown in Fig. 48.

In Fig. 71 will be found the familiar line relay L, release relay R, series relay S, ring cut off relay C, ringing relay D, back bridge relay B B, switching relay E, wiper cut off relay W, interrupter relay X, private magnet P, release magnet Y, vertical magnet V M, rotary magnet R M, and series relay M. The relay M is a slow acting relay of 10 ohms resistance.

It will be noticed that this connector does not reverse the polarity of the calling line. Another peculiarity is that the busy tone is thrown on the positive line by means of the private magnet, and that the connector does not "lock on busy." The ring cut off relay C is also used to close the circuit of the rotary magnet, following the operation of the switching springs. When calling a local number no complications are introduced, and therefore that operation will not be discussed here.

When desiring to make an outside call the local subscriber will first call the figure O. The line relay L will respond to the dial impulses and cause the shaft and wipers to be raised to a position opposite the tenth level of bank con-

FIG. 71


-LINE
BUSY
RING
INT
RLSE
TRK
+LINE
VM
AM
P
(a)
TO BUSY
E
BB
GEN
D
L
R
S
C
W
X
M
Y
TO MAKE ON 10TH VER. STEP
HERSHEY

tacts. When the switching springs are operated a circuit may be traced from ground, make springs relay R, switching springs, break springs relay C, relay C, to negative battery. The relay C will energize over the above traced circuit and will form a locking circuit for itself which may be traced from ground, off normal springs, make springs relay C, relay C, to negative battery. When relay C energizes a circuit may be traced from ground, make springs relay R, break springs relay X, make springs relay C, rotary magnet, to negative battery. The rotary magnet will energize over this circuit and will operate to rotate the shaft and wipers into engagement with the first set of contacts in the O level. In addition the rotary magnet will, upon energizing, close a circuit which may be traced from ground, make springs, rotary magnet, break springs private magnet, private magnet to negative battery. The private magnet will energize over this circuit, and it may also be said that the springs on the private magnet are adjusted so that the break contact is not opened until the armature has very nearly reached its operated position. The rotary magnet also closes a circuit which may be traced from ground, make springs rotary magnet, make springs private magnet, relay X, to negative battery. The relay X will energize and operate to open the circuit of the rotary magnet, following which the rotary magnet will de-energize and open the circuit to the private magnet. If the first trunk is idle the private magnet will de-energize and allow the side switch to pass to third position. A circuit may now be traced from ground, make springs relay R, switching springs, switching relay E, side switch wiper in third position, to negative battery. The switching relay will energize over this circuit and will operate to extend the connection to the switch in the distant office. A circuit may now be traced from ground, through the lower winding of the line relay of the selector in the distant office, relay M, make springs relay E, through the calling telephone, make springs relay E, upper winding of the line relay of selector at the distant office, to negative battery. The relay M will energize over this circuit and will operate to form a holding circuit for relay R, so that the latter will not release following the de-energization of the line relay. The calling subscriber will now proceed to dial the directory number. The relay M will operate in response to the dial impulses, but the relay R will, of course, remain energized.

Upon the completion of the conversation the restoration of the receiver to the switch hook at the calling sub-station will cause the switches in the main office to release in the usual manner. The series relay M will also de-energize and open the circuit of the release relay R. When relay R de-energizes it will cause the release of the apparatus in the local office.

If the first trunk in the O level is busy the private wiper will pick up ground from the private bank contact and will maintain the private magnet energized. The rotary magnet and the relay X will now operate in the usual manner to advance the wipers into engagement with an idle trunk.

When using the connector shown in Fig. 71 it is necessary to provide a "busy bridge" to give the calling subscriber the busy tone should all the trunks be engaged. Let us assume that there are six trunks, then a coil as shown at (a) in Fig. 71 is bridged across the line contacts of the seventh trunk. Ground, on which the busy tone is superimposed, is fed to one side of this coil, consequently if the six trunks are busy the connector will step to the seventh contact and the calling subscriber will receive the busy tone. The multiple between the private bank contacts associated with trunk number seven will be opened, thus allowing two or more subscribers to receive the busy tone at the same time.

Conference Calling.

In P. A. X. service it is desirable to be able to get several departments on the line at the same time in order that a conference may be held. To do this, some number, for instance 50, is designated as the conference number, the line switch will be removed and an impedence coil will be bridged across the line contacts. In addition the multiple between the private bank contacts associated with line 50 is opened.

The office boy can now call the various departments and instruct them to dial the conference number. As each department calls the conference number his connector will cut out to third position on line 50, following which the ring will be cut off by the impedence coil. The number that can get in on the conference is of course limited to the number of connectors in the P. A. X.

Interrupter Start.

In large installations the ringing interrupter is operating continuously, but in a P. A. X. it is desirable that the ringing machine and the ringing interrupter should only operate when a connector is in use. By referring to Fig. 70 a conductor will be found which is labeled "To interrupter start." This starting conductor is multipled throughout the connectors, and as soon as any connector is operated its off normal springs cause the interrupter starting conductor to be grounded. When the called party answers the C relay will energize and remove ground from the starting conductor, whereupon the ringing machine and the ringing interrupter will stop, providing, of course, that no other connector is in ringing position.

Chapter XXXIII

Inter-Office Trunking.

In order to qualify for a first class switchman it is imperative that a man not only know the trunking in his own office, but must also be familiar with the general scheme of inter-office trunking used in the network of which his office forms a part. For obvious reasons it would not be ethical to give herein a complete trunking scheme as used by any operating company, therefore the trunking shown in Figures 72 and 73 is not exactly as used in the Twin Cities, but still will serve to illustrate the principles of trunking.

By reference to Fig. 72 it will be seen that this network consists of fourteen offices. When an office is assigned a complete ten thousand lines it is spoken of as a main office, such as Center and Main in the figure. If the ten thousand lines are divided between two offices it is necessary to pass through one office when calling the other. The office that receives all the calls is spoken of as a main office, while the second office is spoken of as a branch office.

When calling from North to Spruce, or from Spruce to North, each office is considered as a branch out of the other. When calling from any other office both North and Spruce are considered as branch offices working out of fourth switching.

When calling from any office, Center is considered as a Main office.

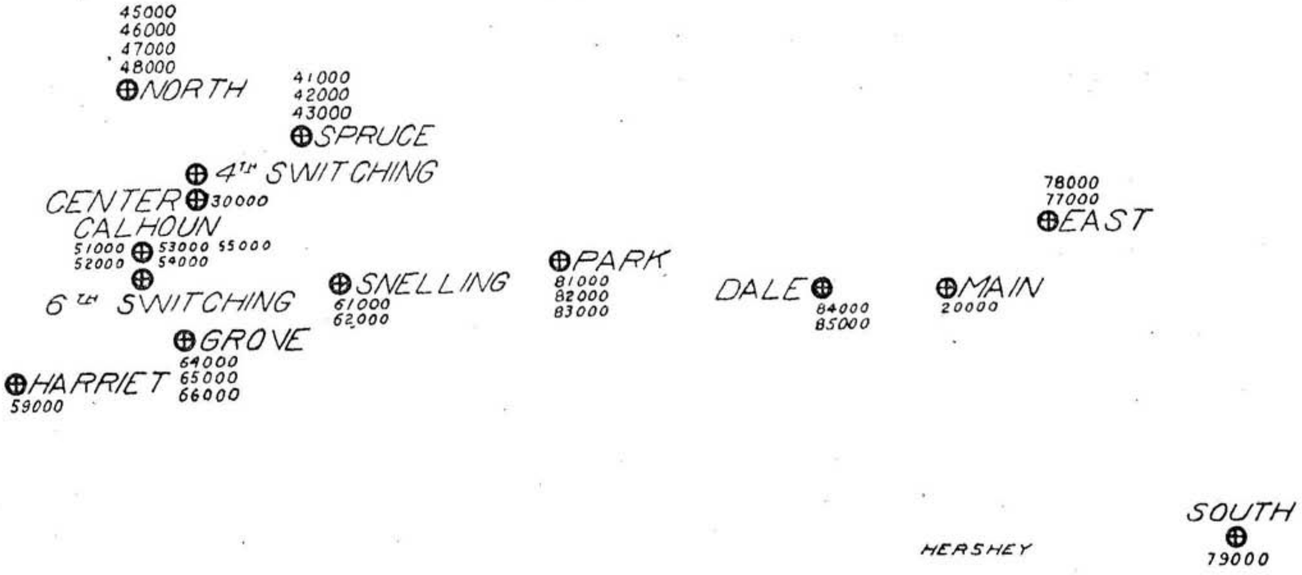
When calling from Harriet to Calhoun the latter will be considered as a branch of the former. When calling from any office but Harriet, Calhoun is considered as a Main office. When calling from any other office Harriet is considered as a branch office working out of Calhoun.

When calling from Snelling to Grove, or from Grove to Snelling, each office is considered as a branch of the other. When calling from Spruce, North, Center, Calhoun or Harriet, both Grove and Snelling are considered as branch offices working out of 6th Switching. When calling from South, East, Main, Dale or Park, Grove is considered as a branch office working out of Snelling.

When calling from Spruce, North, Center, Calhoun, Harriet, Grove or Snelling, Dale is considered as a branch office working out of Park. When calling from South, East or Main, Park is considered as a branch office working out of Dale.

Main is considered as a Main office when calling from any office.

FIG 72


45000
46000
47000
48000
NORTH
41000
42000
43000
SPRUCE
4TH SWITCHING
CENTER 30000
CALHOUN
51000
52000
53000 55000
54000
6TH SWITCHING
SNELLING
61000
62000
GROVE
64000
65000
66000
HARRIET
59000
PARK
81000
82000
83000
DALE
84000
85000
MAIN
20000
78000
77000
EAST
HERSHEY
SOUTH
79000

When calling from East to South, or from South to East, each office is considered as a branch out of the other. When calling from any other office both East and South are considered as branches working out of Main, although this is not apparent from Fig. 72.

Switchboard Equipment.

Across the top of Fig. 73 will be found the names of the various pieces of equipment, just below the name is the symbol indicating that particular switch. A large circle indicates a primary line switch and also a secondary line switch. A rectangle with ten banks below it represents a group of first selectors. Three small circles close together represent outgoing secondary line switches. A number of small rectangles. side by side, represent groups of repeaters. Second selectors, third selectors and four selectors are represented in the same manner as are first selectors. When the selectors are terminals of incoming trunks they bear the letter I, when they are the terminals of local trunks they bear the letter L. Selector repeaters are indicated by the same figure as are selectors, except that the upper portion is divided into a secondary rectangle. The various groups of connectors are represented by small circles at the extreme right.

Location of Switches.

Primary Line Switches will be found in all offices except 4th and 6th Switching.

Secondary Line Switches will be found in all offices except 4th and 6th Switching, Harriet, Snelling and South.

First Selectors will be found in all offices except 4th and 6th Switching.

Repeaters from First Selector Levels will be found in all offices except 4th and 6th Switching.

Incoming Second Selector Repeaters will be found only in 4th Switching, Center, Calhoun, Snelling and Main.

Local Second Selectors will be found in all offices.

Incoming Second Selectors will be found in all offices except Spruce, North, Harriet, Grove, East and South.

Repeaters from Second Selector Levels will be found in all offices except Center.

Incoming Third Selectors will be found in all offices except 4th and 6th Switching, Center and Main.

Local Third Selectors will be found in all offices except 4th and 6th Switching.

Fourth Selectors will be found in all offices except 4th and 6th Switching.

Connectors will be found in all offices except 4th and 6th Switching.

The Equipment in the Various Offices.

Spruce. Primary line switches, secondary line switches and first selectors. The second and seventh level in the banks of the first selectors are multipled. The second, third, fifth, sixth and eight levels go to corresponding groups of repeaters. The second group of repeaters are attached to trunks which terminate on incoming second selectors at Main. The third group of repeaters lead to incoming second selectors at Center. The fifth group of repeaters lead to incoming second selectors at Calhoun. The sixth group of repeaters lead to incoming second selectors at 6th switching. The eighth group of repeaters lead to incoming second selectors at Park. The fourth level in the banks of the first selectors lead to local second selectors. The first, second and third levels in the banks of the local second selectors lead to local third selectors. The fifth, sixth, seventh and eighth levels in the banks of the local second selectors lead to corresponding groups of repeaters, which are attached to trunks terminating on incoming third selectors at North. The banks of the incoming and local third selectors are multipled and lead to groups of connectors, with the exception of the ninth level in the last group which leads to fourth selectors. The banks of the fourth selectors lead to the party line connectors.

North. Primary line switches, secondary line switches and first selectors. The second and seventh levels in the banks of the first selectors are multipled. The second, third, fifth, sixth and eighth levels in the banks of the first selectors lead to corresponding groups of repeaters. The second group of repeaters are attached to trunks which terminate on incoming second selector repeaters at Main. The third group of repeaters lead to incoming second selectors at Center. The fifth group of repeaters lead to incoming second selectors at Calhoun. The sixth group of repeaters lead to incoming second selectors at 6th Switching. The eighth group of repeaters lead to incoming second selectors at Park. The fourth level in the banks of the first selectors lead to local second selectors. The first, second and third levels in the banks of the local second selectors lead to corresponding groups of repeaters, which are attached to trunks which terminate on incoming third selectors at North. The fifth, sixth, seventh and eighth levels in the banks of the local second selectors lead to local third selectors. The banks of the incoming and local third selectors are multipled and lead to corresponding groups of connectors, with the exception of the ninth level in the last group, which leads to fourth selectors. The banks of the fourth selectors lead to the party line connectors.

Fourth Switching. The banks of the incoming and local second selectors are multipled, and the first, second, third, fifth, sixth, seventh and eighth levels lead to corresponding groups of repeaters. The first, second and third groups of repeaters are attached to trunks which terminate on incoming third selectors at Spruce. The fifth, sixth, seventh and eighth groups of repeaters lead to incoming third selectors at North. The first, second, third, fifth, sixth, seventh and eighth levels in the banks of the incoming second selector repeaters are connected to the corresponding groups of trunks between the repeaters and the incoming third selectors.

Center. Primary line switches, secondary line switches and first selectors. The second and seventh level in the banks of the first selectors are multipled. The second, fifth, sixth and eighth levels go to corresponding groups of repeaters. Outgoing secondary line switches are inserted between the fifth level of the first selector banks and the corresponding group of repeaters. The second group of repeaters are attached to trunks which terminate on incoming second selectors at Main. The fifth group of repeaters lead to incoming second selectors at Calhoun. The sixth group of repeaters lead to incoming second selectors at 6th Switching. The eighth group of repeaters lead to incoming second selectors at Park. The third level in the banks of the first selectors lead to local second selectors. The fourth level in the banks of the first selectors lead to local second selectors at 4th Switching. The banks of the incoming and local second selectors and of the incoming second selector repeaters are multipled and lead to local third selectors. The banks of the third selectors lead to groups of connectors, with the exception of the ninth level in the last group, which leads to fourth selectors. The banks of the fourth selectors lead to the party line connectors.

Calhoun. Primary line switches, secondary line switches and first selectors. The second and seventh level in the banks of the first selectors are multipled. The second, third, fourth and eighth levels go to corresponding groups of repeaters. Outgoing secondary line switches are inserted between the third level of the first selector banks and the corresponding group of repeaters. The second group of repeaters are attached to trunks which terminate on incoming second selector repeaters at Main. The third group of repeaters lead to incoming second selectors at Center. The fourth group of repeaters lead to incoming second selectors at 4th Switching. The eighth group of repeaters lead to incoming second selectors at Park. The fifth level in the banks of the first selectors lead to local second selectors. The sixth level in the banks of the first selectors lead to local second selectors at 6th Switching. The first, second, third, fourth and fifth levels in the banks of the incoming second selectors, the local second selectors and the incoming second selector repeaters are multipled and lead to local third selectors. The ninth level in the banks of the incoming and local second selectors are multipled and lead to a group of repeaters which are attached to trunks which terminate on incoming third selectors at Harriet. The ninth level in the banks of the incoming second selector repeater is connected to the corresponding group of trunks between the repeaters and the incoming third selectors. The banks of the incoming and local third selectors are multipled and lead to groups of connectors, with the exception of the ninth level in the last group which leads to fourth selectors. The banks of the fourth selectors lead to the party line connectors.

Sixth Switching. The banks of the incoming and local second selectors are multipled, and the first, second, fourth, fifth and sixth levels lead to corresponding groups of repeaters. The first and second groups of repeaters are attached to trunks which terminate on incoming third selectors at Snelling. The fourth, fifth and sixth groups of repeaters lead to incoming third selectors at Grove.

Harriet. Primary line switches and first selectors. The second and seventh levels in the banks of the first selectors are multipled. The second, third, fourth, sixth and eighth levels go to corresponding groups of repeaters. The second group of repeaters is attached to trunks which terminate on incoming second selector repeaters at Main. The third group of repeaters lead to incoming second selectors at Center. The fourth group of repeaters lead to incoming second selectors at 4th Switching. The sixth group of repeaters lead to incoming second selectors at 6th Switching. The eighth groups of repeaters lead to incoming second selectors at Park. The fifth level in the banks of the first selectors lead to local second selectors. The first, second, third, fourth and fifth levels in the banks of the local second selectors lead to corresponding groups of repeaters, which are attached to trunks terminating on incoming third selectors at Calhoun. The ninth level in the banks of the local second selectors lead to local third selectors. The banks of the incoming and local third selectors are multipled and lead to groups of connectors, with the exception of the ninth level in the last group which leads to fourth selectors. The banks of the fourth selectors lead to the party line connectors.

Snelling. Primary line switches and first selectors. The second and seventh levels in the banks of the first selectors are multipled. The second, third, fourth, fifth and eighth levels go to corresponding groups of repeaters. The second group of repeaters are attached to trunks which terminate on incoming second selectors at Main. The third group of repeaters lead to incoming second selectors at Center. The fourth group of repeaters lead to incoming second selectors at 4th Switching. The fifth group of repeaters lead to incoming second selectors at Calhoun. The eighth group of repeaters lead to incoming second selectors at Park. The sixth level in the banks of the first selectors lead to local second selectors. The first and second levels in the banks of the incoming second selectors, the local second selectors and the incoming second selector repeaters are multipled and lead to local third selectors. The fourth, fifth and sixth levels in the banks of the incoming and local second selectors are multipled and lead to corresponding groups of repeaters, which are attached to trunks terminating on incoming third selectors at Grove. The fourth, fifth and sixth levels in the banks of the incoming second selector repeaters are connected to the corresponding groups of trunks between the repeaters and the incoming third selectors. The banks of the incoming and local third selectors are multipled and lead to groups of connectors, with the exception of the ninth level in the last group which leads to the fourth selectors. The banks of the fourth selectors lead to the party line connectors.

Grove. Primary line switches, secondary line switches and first selectors. The second and seventh level in the banks of the first selectors are multipled. The second, third, fourth, fifth and eighth levels go to corresponding groups of repeaters. The second group of repeaters are attached to trunks which terminate on incoming second selector repeaters at Main. The third group of repeaters lead to incoming second selectors at Center. The fourth group of repeaters lead to incoming second selectors at 4th Switching. The fifth group of repeaters lead to incoming second selectors at Calhoun. The eighth group of repeaters lead to incoming second selectors at Park. The sixth level in the banks of the first selectors lead to local second selectors. The first and second levels in the banks of the local second selectors lead to corresponding groups of repeaters, which are attached to trunks terminating on incoming third selectors at Snelling. The fourth, fifth and sixth levels in the banks of the local second selectors lead to local third selectors. The banks of the incoming and local third selectors are multipled and lead to groups of connectors, with the exception of the ninth level of the last group which leads to fourth selectors. The banks of the fourth selectors lead to the party line connectors.

Park. Primary line switches, secondary line switches and first selectors. The second and seventh level in the banks of the first selectors are multipled. The second, third, fourth, fifth and sixth levels go to corresponding groups of repeaters. The second group of repeaters are attached to trunks which terminate on incoming second selectors at Main. The third group of repeaters lead to incoming second selectors at Center. The fourth group of repeaters lead to incoming second selectors at 4th Switching. The fifth group of repeaters lead to incoming second selectors at Calhoun. The sixth group of repeaters lead to incoming second selectors at Snelling. The eighth level in the banks of the first selectors lead to local second selectors. The first, second and third levels in the banks of the incoming and local second selectors are multipled and lead to local third selectors. The fourth and fifth levels in the banks of the incoming and local second selectors are multipled and lead to corresponding groups of repeaters, which are attached to trunks terminating on incoming third selectors at Dale. The banks of the incoming and local third selectors are multipled and lead to groups of connectors, with the exception of the ninth level in the last group which leads to fourth selectors. The banks of the fourth selectors lead to the party line connectors.

Dale. Primary line switches, secondary line switches and first selectors. The second and seventh level in the banks of the first selectors are multipled. The second, third, fourth, fifth and sixth levels go to corresponding groups of repeaters. The second group of repeaters are attached to trunks which terminate on incoming second selectors at Main. The third group of repeaters lead to incoming second selectors at Center. The fourth group of repeaters lead to incoming second selectors at 4th Switching. The fifth group of repeaters lead to incoming second selectors at Calhoun. The sixth group of repeaters lead to incoming second selectors at Snelling. The eighth level in the banks of the first selectors lead to local second selectors. The first, second and third levels in the banks of the incoming and local second selectors go to corresponding groups of repeaters, which are attached to trunks terminating on incoming third selectors at Park. The fourth and fifth levels in the banks of the incoming and local second selectors are multipled and lead to local third selectors. The banks of the incoming and local third selectors are multipled and lead to groups of connectors, with the exception of the ninth level in the last group which leads to fourth selectors.

The banks of the fourth selectors lead to the party line connectors.

Main. Primary line switches, secondary line switches and first selectors. The second and seventh level in the banks of the first selectors are multipled. The third, fourth, fifth, sixth and eighth levels go to corresponding groups of repeaters. The third group of repeaters are attached to trunks which terminate on incoming second selectors at Center. The fourth group of repeaters lead to incoming second selectors at 4th Switching. The fifth group of repeaters lead to incoming second selector repeaters at Calhoun. The sixth group of repeaters lead to incoming second selectors at Snelling. The eighth group of repeaters lead to incoming second selectors at Dale. The second level in the banks of the first selectors lead to local second selectors. The first, second, third, fourth, fifth and sixth levels in the banks of the incoming and local second selectors, and in the incoming second selector repeaters are multipled and lead to local third selectors. The seventh, eighth and ninth levels in the banks of the incoming and local second selectors are multipled and lead to corresponding repeaters. The seventh and eighth groups of repeaters terminate on incoming third selectors at East. The ninth group of repeaters terminate on incoming third selectors at South. The seventh, eighth and ninth levels in the banks of the incoming second selector repeaters are connected to corresponding groups of trunks between the repeaters and the incoming third selectors. The banks of the local third selectors lead to connectors, with the exception of the ninth level in the last group which leads to fourth selectors. The banks of the fourth selectors lead to the party line connectors.

East. Primary line switches, secondary line switches and first selectors. The second, third, fourth, fifth, sixth and eighth levels in the banks of the first selectors go to corresponding groups of repeaters. The second group of repeaters are attached to trunks which terminate on incoming second selectors at Main. The third group of repeaters lead to incoming second selector repeaters at Center. The fourth group of repeaters lead to incoming second selector repeaters at 4th Switching. The fifth group of repeaters lead to incoming second selector repeaters at Calhoun. The sixth group of repeaters lead to incoming second selector repeaters at Snelling. The eighth group of repeaters lead to incoming second selectors at Dale. The seventh level in the banks of the first selectors lead to local second selectors. The seventh and eighth levels in the banks of the local second selectors lead to local third selectors. The ninth level in the banks of the local second selectors go to repeaters, which are attached to trunks terminating on incoming third selectors at South. The banks of the incoming and local third selectors are multipled and lead to groups of connectors, with the exception of the ninth level in the last group which leads to fourth selectors. The banks of the fourth selectors lead to the party line connectors.

South. Primary line switches and first selectors. The second, third, fourth, fifth, sixth and eighth levels in the banks of the first selectors go to corresponding groups of repeaters. The second group of repeaters are attached to trunks which terminate on incoming second selectors at Main. The third group of repeaters lead to incoming second selector repeaters at Center. The fourth group of repeaters lead to incoming second selector repeaters at 4th Switching. The fifth group of repeaters lead to incoming second selector repeaters at Calhoun. The sixth group of repeaters lead to incoming second selector repeaters at Snelling. The eighth group of repeaters lead to incoming second selectors at Dale. The seventh level in the banks of the first selectors lead to local second selectors. The seventh and eighth levels in the banks of the local second selectors go to repeaters which are attached to trunks terminating on incoming third selectors at East. The ninth level in the banks of the local second selector lead to local third selectors. The banks of the incoming and local third selectors are multipled and lead to groups of connectors, with the exception of the ninth level in each group which leads to fourth selectors. The banks of the fourth selectors lead to party line connectors.

The Tracing of Calls Through the Network.

Calling 62500 from Spruce.

At Spruce; primary line switch, secondary line switch and call 6 on first selector. Seize repeater and outgoing trunk which terminates on an incoming second selector at 6th Switching. Call 2 on incoming second selector, seize repeater and outgoing trunk which terminates on an incoming third selector at Snelling. Call 5 on incoming third selector and complete connection by the use of the seized connector.

Calling 62500 from Calhoun.

At Calhoun; primary line switch, secondary line switch and call 6 on first selector. Seize local second selector at 6th Switching. Call 2 on a local second selector, seize repeater and outgoing trunk which terminates on an incoming third selector at Snelling. Call 5 on incoming third selector and complete connection by the use of the seized connector.

Calling 62500 from East.

At East; primary line switch, secondary line switch and call 6 on first selector. Seize repeater and outgoing trunk which terminates on an incoming second selector repeater at Snelling. Call 2 on incoming second selector repeater and seize a local third selector. Call 5 on local third selector and complete connection by the use of the seized connector.

Calling 78500 from North.

At North; primary line switch, secondary line switch and call 7 on first selector. Seize repeater and outgoing trunk which terminate on incoming second selector repeater at Main. (Since the second and seventh levels are tied together.) Call 8 on incoming second selector repeater and seize trunk terminating on an incoming third selector at East. Call 5 on incoming third selector and complete connection by the use of the seized connector.

Calling 78500 from South.

At South; primary line switch and call 7 on first selector, seize local second selector. Call 8 on local second selector and seize repeater and outgoing trunk terminating on an incoming third selector at East. Call 5 on incoming third selector and complete connection by the use of the seized connector.

It will be seen that sometimes an incoming trunk terminates on an incoming second selector, and then again it may terminate on an incoming second selector repeater. When the resistance of the loop between repeater and associated incoming selector exceeds 1,200 ohms it is customary to use a selector repeater. The loop into the selector repeater never varies, and therefore the repeater part of the selector can be adjusted to compensate for its particular circuit.

From the trunking scheme shown in Fig. 73 it is apparent that both East and South are branches working out of Main, notwithstanding the fact that the first figure in their numbers is a 7 instead of a 2. This is done in order to save cable pairs, for if East were made a main office and South a branch out of East, it would mean that each office in the network would have to have a group of trunks leading to East. So long as there are three thousands to spare in Main, East and South can work out of that office and thus utilize the incoming trunks to Main. But if Main should grow to such an extent as to need these three thousand numbers it will be necessary to make East a Main office. In order to provide for this contingency the second and seventh levels in the banks of the first selectors in all offices except East and South have been multipled. Thus when a person calls an East or South number the call is made as though East were a Main office, but the call passes through the switchboard as though both East and South were branches out of Main. When the time comes to make the change the extra cable pairs will be run and the multiple between the second and seventh levels in the bank of the first selectors will be cut. As a result the calls will go through in the new way, but there will be no change in the directory numbers.

Center and 4th Switching are housed in the same building, as are also Calhoun and 6th Switching.

Questions.

Trace the following calls:

A. Calling 839500 from Spruce, from Harriet, from North.

B. Calling 36500 from Center, from South.

C. Calling 831992 from Harriet, from Main.

D. Calling 799000 from South, from East, from Calhoun.

E. Calling 85500 from Spruce, from East.

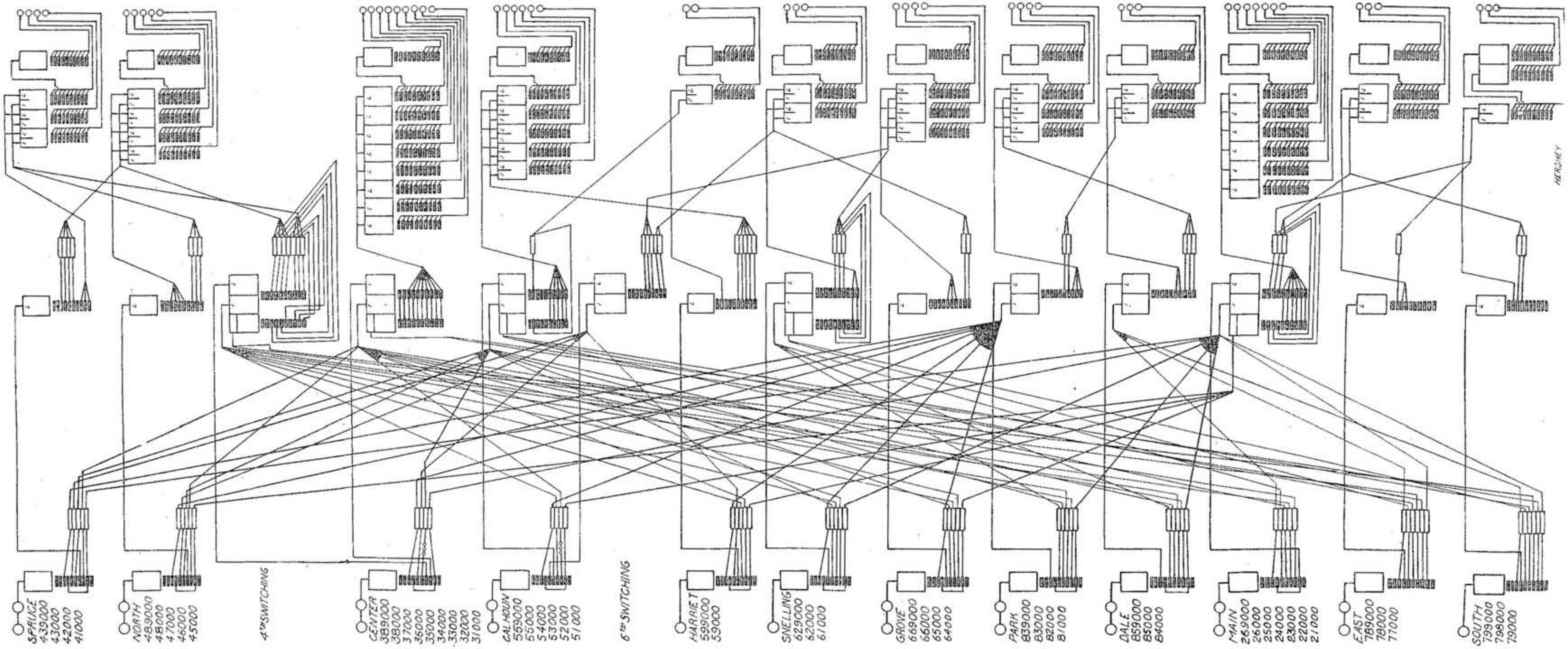


FIG 73

PRIMARY LINE SWITCHES
SECONDARY LINE SWITCHES
1ST SELECTOR
OUTGOING SECONDARIES
REPEATERS
2ND SELECTORS
SELECTOR-REPEATERS
REPEATERS
3RD SELECTORS
4TH SELECTORS
CONNECTORS

TRUNKING SCHEME

Chapter XXXIV

Special Service Trunking.

In a single office automatic plant the special service features, Long Distance, Complaint, Information, etc., introduce no particular complications. In a multi-office system, however, this service becomes quite complicated and it is essential that all the switchmen in every office thoroughly understand the scheme as employed in their particular network.

At the right in Fig. 74 is represented a main office in which is located the trouble, information and test desks. Just below is represented a toll office, it being assumed that the toll board is housed in the same building as one of the branch offices. At the left of the figure is represented a local office which may be considered as any office in the network with the exception of Main and Toll.

In the local office a primary and secondary line switch are shown as having access to a first selector. The second level in the banks of the first selectors leads to repeaters which are attached to trunks terminating on incoming second selectors at Main. The eighth level in the banks of the first selectors leads to repeaters which are attached to trunks terminating on incoming second selectors at Toll. The first level in the banks of the first selectors leads to special second selectors in the local office.

The second, third, fourth and sixth levels in the banks of the special second selectors are multipled together, and are also multipled with the second level in the banks of the first selectors. The first level in the banks of the special second selectors leads to the local Wire Chief's desk. The eighth level in the banks of the special second selectors leads to the reverting call switches. The ninth level in the banks of the special second selectors leads to the Fire and Police repeaters.

The tenth level in the banks of the incoming second selectors at Main leads to special third selectors. The second level in the banks of the special third selectors leads to the Information desk. The third level in the banks of the special third selectors leads to the Complaint desk. The fourth level in the banks of the special third selectors leads to the Time desk. The sixth level in the banks of the special third selectors leads to the Test desk.

The tenth level in the banks of the incoming second selectors at Toll leads to the Toll Recording switchboard.

To call Information 1202. Primary line switch, secondary line switch and first selector. Call 1 on first selector and seize special second selector. Call 2 on special second selector and seize repeater associated with regular trunk which terminates on an incoming second selector at Main. Call 0 on incoming second selector at Main and seize special third selector. Call 2 on special third selector and seize trunk to Information desk.

To call Complaint 1303. Primary line switch, secondary line switch and first selector. Call 1 on first selector and seize special second selector. Call 2 on special second selector and seize repeater associated with regular trunk which terminates on an incoming second selector at Main. Call 0 on incoming second selector at Main and seize special third selector. Call 3 on special third selector and seize trunk to Complaint desk.

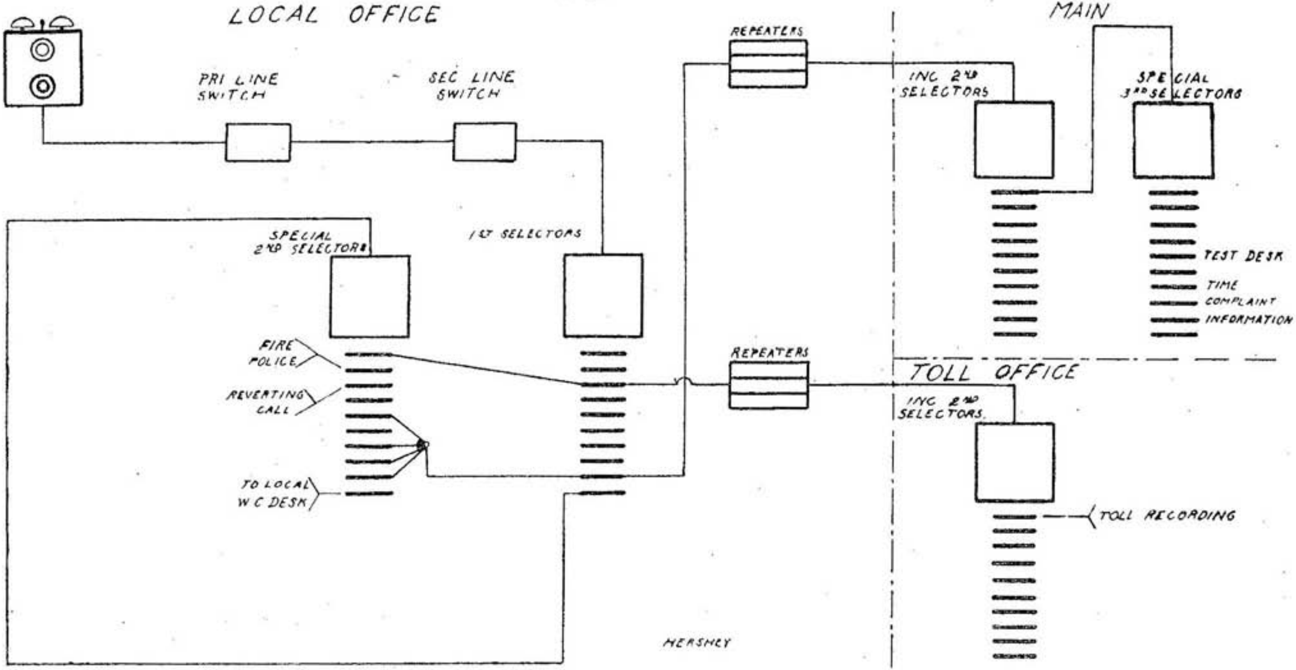
To call Time 1404. Primary line switch, secondary line switch and first selector. Call 1 on first selector and seize special second selector. Call 4 on special second selector and seize repeater associated with regular trunk which terminates on an incoming second selector at Main. Call 0 on incoming second selector at Main and seize special third selector. Call 4 on special third selector and seize trunk to the Time desk.

To call the Test Desk 1606. Primary line switch, secondary line switch and first selector. Call 1 on first selector and seize special second selector. Call 6 on special second selector and seize repeater associated with regular trunk which terminates on an incoming second selector at Main. Call 0 on incoming second selector at Main and seize special third selector. Call 6 on special third selector and seize trunk to Test desk. It will be seen that the tester cannot test back over a 1606 trunk, when the calling trouble man is in a distant exchange, for the reason that there is a repeater in the circuit. In order to test under these conditions it will be necessary for the tester to set up the connection on a test distributor. If the trouble man is working out of Main he can call 1606 and get a test immediately, for under these conditions there will be no repeater in the circuit.

To call Long Distance 100. Primary line switch, secondary line switch and first selector. Call 1 on first selector and seize special second selector. Call 0 on special second selector and seize repeater associated with regular trunk which terminates on an incoming second selector at Toll. Call 0 on incoming second selector at Toll and seize trunk to the Toll Recording switchboard.

To call Fire or Police 19. Primary line switch, secondary line switch and first selector. Call 1 on first selector and seize special second selector. Call 9 on special second selec-

FIG 74


LOCAL OFFICE
PRI LINE SWITCH
SEC LINE SWITCH
SPECIAL 2ND SELECTORS
1ST SELECTORS
FIRE
POLICE
REVERTING CALL
TO LOCAL W C DESK
REPEATERS
REPEATERS
MAIN
INC 2ND SELECTORS
SPECIAL 3RD SELECTORS
TEST DESK
TIME
COMPLAINT
INFORMATION
TOLL OFFICE
INC 2ND SELECTORS.
TOLL RECORDING
HERSHEY

tor and seize Fire repeater. This fire repeater will extend the connection to an attendant at Main who can further extend the call to the Fire or Police Department, as desired. The fire repeater also locks up the connection and furthermore sounds an audible alarm. The attendant in the local office then traces the connection and makes a memorandum of the number of the calling telephone, after which he trips the repeater, allowing the connection to release.

To call the Reverting Call Switch 18. Primary line switch, secondary line switch and first selector. Call 1 on first selector and seize special second selector. Call 8 on special second selector and seize Reverting Call Switch. See Fig. 42.

Emergency Call 11. Primary line switch, secondary line switch and first selector. Call 1 on first selector and seize special second selector. Call 1 on special second selector and seize trunk to local Wire Chief's desk.

The great advantage in this scheme is that the special service calls are routed over the regular inter-office trunks. If this were not done there would be required a group of special service trunks from each office into Main, and a group of recording trunks from each office into Toll.

Since the second, third, fourth and sixth levels in the banks of the special second selectors are multipled with the second level in the banks of the first selectors, it is evident that the Complaint desk may be reached by dialing any of the following numbers, 1202, 1302, 1402 or 1602. A more simple scheme is that in which only the second level in the banks of the special second selectors is multipled with the second level in the banks of the first selectors. The call numbers for special service now become Information 1202, Complaint 1203, Time 1204 and Test 1206. The latter scheme would be satisfactory if it were not for the fact that it is desirable to be able to answer special service calls in the local office should an emergency arise.

The special service trunks between the banks of the special second selectors and the banks of the first selectors are usually looped through the local Wire Chief's desk in such a way, that, with the associated keys at normal the calls go through as shown in Fig. 74. When it is desired to "head off" the special service calls in the local office the keys are operated, after which the first two figures of a special service call will cause that call to come into the local Wire Chief's desk at the proper position. The last two figures in the special service call will, of course, be lost.

The majority of operating companies favor a scheme by which double number complaints are completed by the complaint operator. The complaint desk is equipped with a number of outgoing trunks, and if A reports that he cannot call B the complaint operator will complete the connection, allowing A and B to carry on their conversation through her board. If the called line tests busy the complaint operator can cut herself across that line, by means of her test distributor trunk, and ascertain if the line is in use or in trouble.

The outgoing trunks from the Toll board are usually special open wire trunks direct to each office. These trunks terminate on Toll second selectors, which in turn have access to the Toll third selectors in that office. The Toll third selectors have access to the Toll connectors, there usually being one of the latter for each one hundred line board. The Toll selectors and connectors are similar to the ordinary selector and connector, the important difference being that the ringing is under the control of the Toll operator.

Since the Toll operator picks the office, as she plugs into the trunk jack, she must disregard the first figure of the number when operating the dial.

The Toll board is also equipped with a number of "overflow" trunks, which terminate on line switches in the Toll office. If the Toll connector in a certain hundred is busy, and it is desired to call another number in that hundred, it will be necessary for the Toll operator to use an overflow trunk and put up the connection by dialing the directory number. The transmission on the overflow trunks will naturally be inferior to that on the regular Toll trunks.

Automatic Telephone Practice

1917

Harry E Hershey

Scanning and Document Preparation

By

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