PRINCIPLES OF

Automatic Telephony

Circuits and Trunking

STROWGER AUTOMATIC

REG. U. S. PAT. OFF.

Automatic Electric Company

CHICAGO

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By
HARRY P. MAHONEY

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THIS book is not intended to be an exhaustive treatise on Automatic Telephony. Its purpose is rather to give the student a brief yet reasonably thorough understanding of the principles underlying the operation of Strowger Automatic telephone apparatus, as manufactured by Automatic Electric Company.

The subject matter is the text used for many years by Automatic Electric Company's Operating Department in teaching the fundamentals of the Strowger Automatic system. The material has been thoroughly revised and amplified and is presented here in permanent form.

In order that the circuits may be easily studied, each one has been divided into as many parts as it has functions to perform, and the circuit of each function sketched and described separately.

Operating Department
Automatic Electric Company

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CHAPTER 1

Symbols and Abbreviations

TO simplify telephone circuits and facilitate circuit reading as much as possible, it is customary to use certain standard symbols and abbreviations to represent various pieces of apparatus. Some of the more commonly used of these are shown in Figs. 1 and 2.

A.C. —Alternating Current
Ans. —Answer
Arm. —Armature

B.B. —Bus Bar
B.C.O. —Bridge Cut-Off
Bd. —Board
Bk. —Bank
Brk. —Breaker

Cct. —Circuit
C.D. —Calling Device or Dial
C.E.M.F. —Counter Electro Motive Force
Chg. —Charge
Ckt. —Circuit
Comb. —Combination
Comp. —Complaint
Cond. —Condenser
Conn. —Connector
∿ —Cycle

D.C. —Direct Current
Diff. —Differential
Dis. —Discharge
Dist. —Distributor
D.T. —Dial Tone

E.M.F. —Electro Motive Force
Equip. —Equipment

Freq. —Frequency

Gen. —Generator
Grd. —Ground
Grp. —Group

Harm. —Harmonic

I.D.F. —Intermediate Distributing Frame
Inc. —Incoming
Inf. —Information
Int. —Interrupter

L.D. —Long Distance
List. —Listening
Lock. —Locking
L.Sw. —Line Switch

Mach. —Machine
Mas.Sw. —Master Switch
M. B. —Main Battery
M.D.F. —Main Distributing Frame
M.F. —Micra Farad
M.S. —Master Switch

Neg. —Negative
N.I. —Non-Inductive
No. —Number
Nor. —Normal

ω —Ohms
O.M. —Open Main
O.N. —Off Normal
Oper. —Operator

P. —Private
P.D.C. —Pull Down Coil
Pos. —Positive
Prim. —Primary
Priv. —Private
Pw. —Power

R. —Ring
Rec. —Receiver
Reg. —Regular

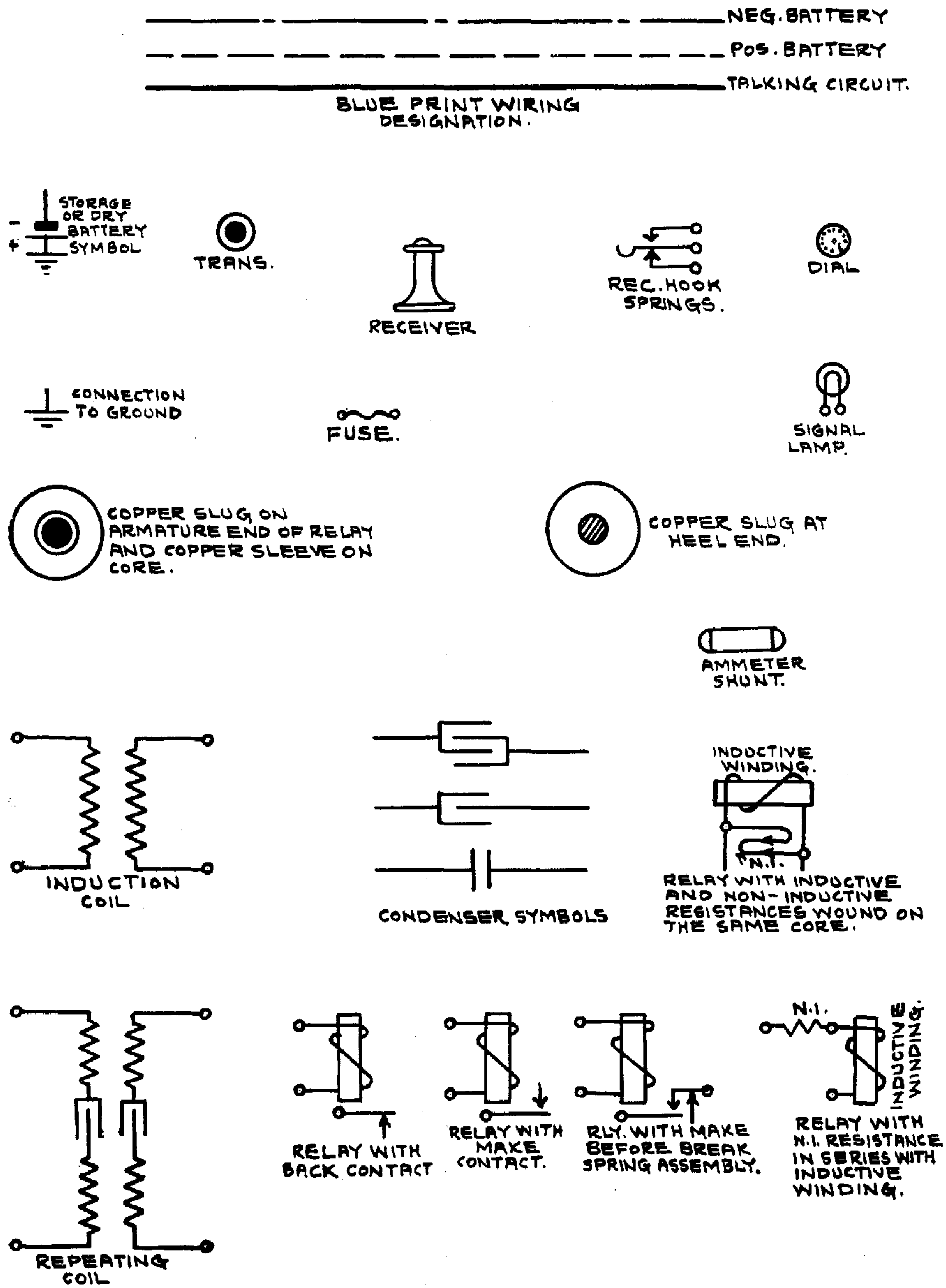


Fig. 1. Symbols used in telephone circuit drawings

Rept.	—Repeater
Rev. Call	—Reverting Call
Rlse.	—Release
Rly.	—Relay
Rot.	—Rotary
S.	—Sleeve
Sec.	—Secondary
Sel.	—Selector
Sl.	—Slipped
Sprgs.	—Springs
St.	—Straight
Supy.	—Supervisory
Sw.	—Switch
T.	—Tip
Tel.	—Telephone
Trans.	—Transmitter
Trk.	—Trunk
T.T.	—Tell Tale
Vert.	—Vertical
W.C.	—Wire Chief

Fig. 2. Automatic wall telephone

CHAPTER 2

The Telephone

THERE have been and still are several kinds of telephone circuits in use between the central office and the subscriber's station. The metallic circuit is by far the most widely used of all, and has now practically displaced all others. The metallic circuit consists of two wires between the telephone switchboard and the subscriber's premises.

Practically all telephone bells are rung with alternating current. The telephone must therefore be constructed so that in its normal condition a path is provided over which alternating current will flow to ring the bells, but over which direct current cannot pass. This condition is accomplished by a telephone condenser placed in series with the bell. A telephone condenser

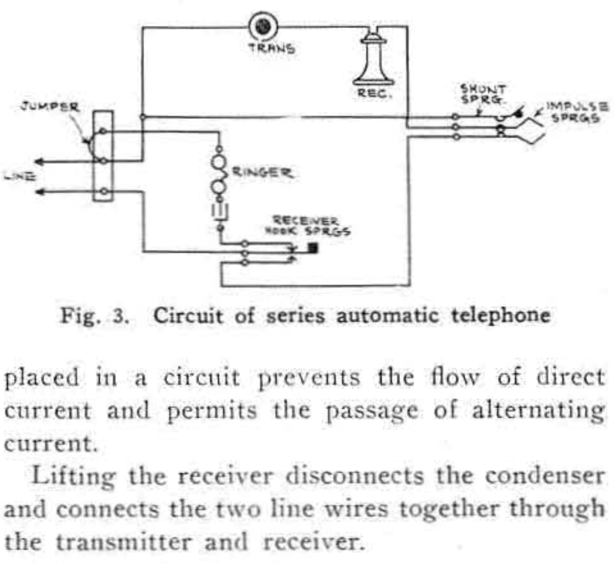


Fig. 3. Circuit of series automatic telephone

placed in a circuit prevents the flow of direct current and permits the passage of alternating current.

Lifting the receiver disconnects the condenser and connects the two line wires together through the transmitter and receiver.

Automatic Series Telephone

In Fig. 3 is shown the circuit of an ordinary telephone of the "series" type, equipped with automatic calling device or dial. The dial is essentially a circuit interrupter. When the dial is released after being turned from its normal position, it interrupts the line circuit a number of times in quick succession corresponding to the digit dialed. Each time the line is so interrupted, what is known as an impulse is transmitted to the telephone switchboard. Throughout this book the circuit interruptions of the dial will be referred to as "impulses." It is the impulses, sent over the line, at the will of the subscriber, which start the automatic switches in motion and cause them to establish connections between subscribers.

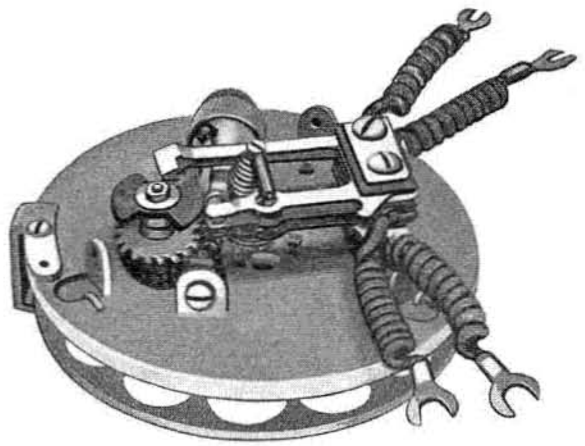


Fig. 4. Calling device or dial mechanism

The automatic telephone, generally speaking, differs from the common battery manual telephone only in this one respect, viz., the addition of the calling device or dial. Fig. 4 shows the mechanism of a calling device.

Series telephone circuit

In Fig. 5 is shown the impulse circuit of the telephone after the receiver has been lifted from the hook and the dial turned preparatory to sending out impulses. Turning the dial closes the shunt springs placing a shunt around the transmitter and receiver. This not only reduces the resistance of the telephone circuit to a minimum during the sending of impulses, but also prevents the impulses from sounding in the subscriber's ear.

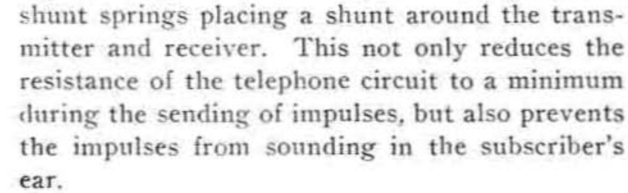


Fig. 5. Impulse circuit of telephone

Dial Speed

The dial is adjusted to operate at a speed of 10 impulses per second. However, the switches in the central office are adjusted to operate on impulses received from a motor driven impulse machine running at a speed of 50 per cent greater than this or 15 impulses per second. Dials will operate the switches satisfactorily if running as slow as 8 impulses per second or as fast as 12.

Review

1. Describe the normal line conditions.
2. What change is made in the telephone circuit after the hook is raised?
3. What change is made in the telephone circuit after the dial is turned?
4. What is the normal speed of the dial?

CHAPTER 3

The 100 Line System

TELEPHONE No. 33 in Fig. 8 is shown connected to a connector switch and its associated bank of 100 sets of line terminals or contacts.

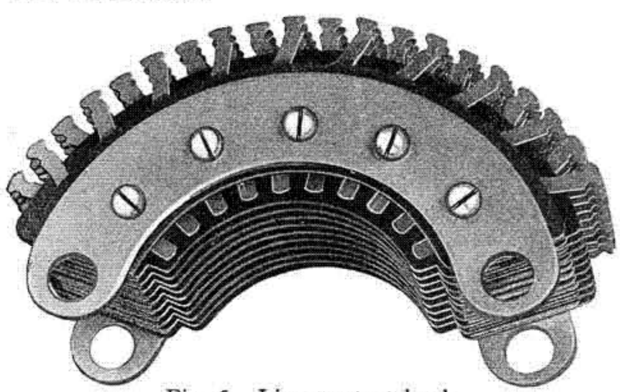


Fig. 6. Line contact bank

Contact Bank

The bank is in two parts. The private bank consists of 100 single contacts in 10 rows of 10 contacts each, and the line bank consists of 100 pairs of contacts arranged in rows the same as

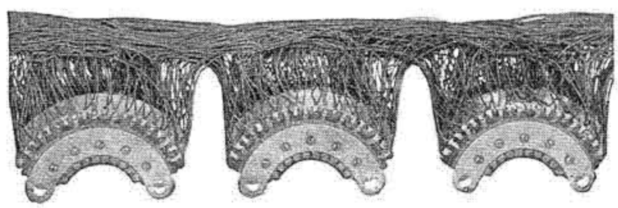


Fig. 7. Bank multiple cable

the private bank contacts. Fig. 6 shows a line contact bank.

Bank numbering

The numbers appearing on the bank in Fig. 8 are the numbers of the telephones connected to those contacts. This arrangement of numbering is made necessary because of the mechanical operation of the connector, whose wipers connect with the bank contacts. It will be observed that 11 is the first contact of the first row and that

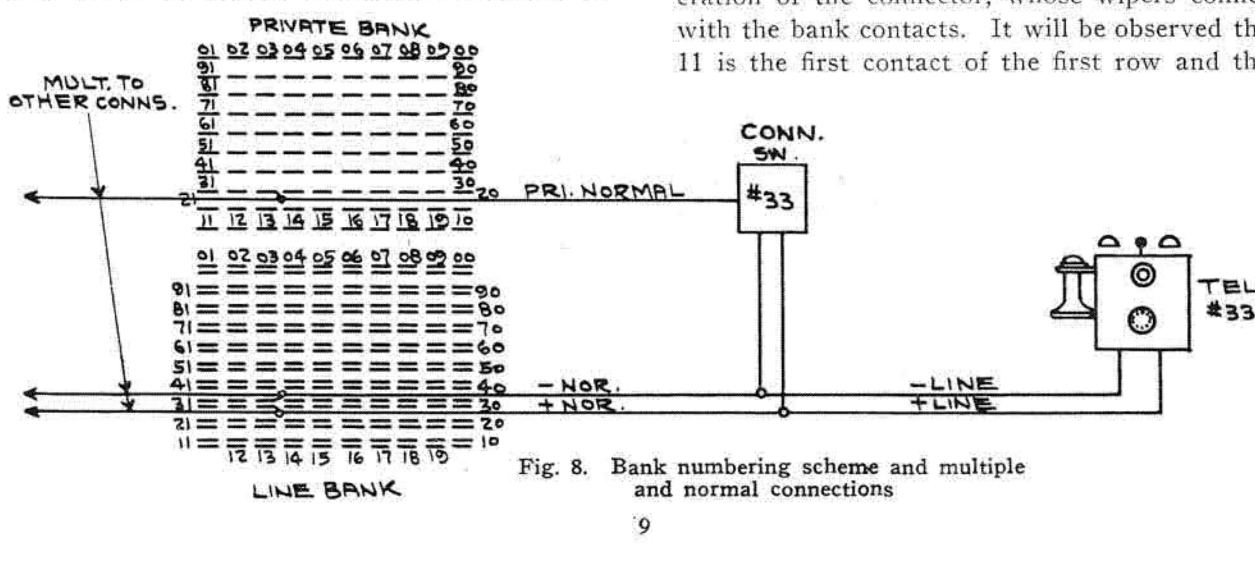


Fig. 8. Bank numbering scheme and multiple and normal connections

10 is the 10th contact of the first row. The reason for this is that when the dial is turned from "0," 10 impulses are sent out. Therefore, dialing the digit "1" would step the connector wipers opposite the first row of contacts and dialing the "0" would cause them to travel 10 contacts in a horizontal direction, thus coming

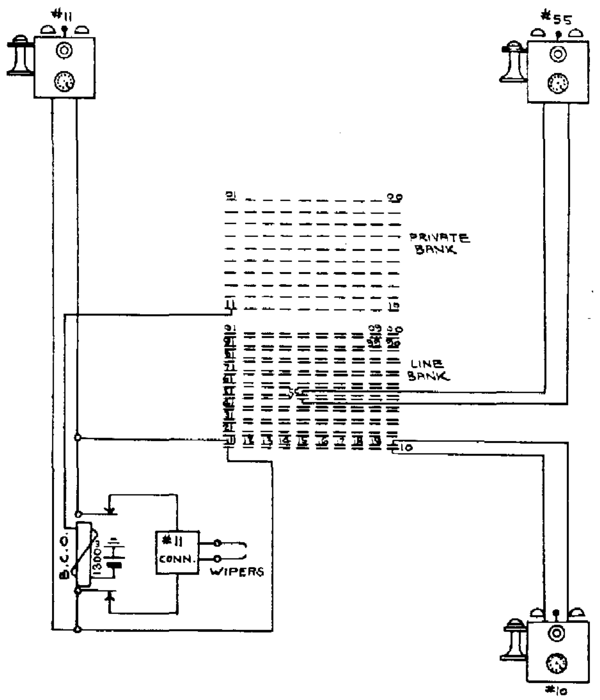


Fig. 9. Showing connections for a simple 100 line system

to rest on the tenth set of contacts in the first level or on the terminals of telephone number 10.

The normal wires are a multiple of the subscribers' lines from the line switches to the connector banks, and are comparable with the multiple between the answering jacks and subscribers' multiple on a manual multiple switchboard.

The private wire in an automatic system performs the same function as the sleeve wire in manual practice, while the + and — lines correspond to the tip and ring wires.

In Fig. 9 is shown the simplest form of an automatic telephone system. Each telephone is connected direct to a connector and the capacity of such a system is limited to 100 lines or the capacity of one bank, as discussed above. Each telephone number has two digits.

Bank multiple

To provide means whereby each telephone may connect with any one of all the other telephones, similar contacts on all banks are multiplied together. Fig. 9 shows three telephones, numbered 11, 10 and 55; these numbers would appear in exactly the same positions on the bank of all of the connectors. The physical form of the bank multiple is shown in Fig. 7.

In the figure the connector of telephone No. 11 is shown with a cut-off relay which is operated when the telephone receives a call, disconnecting the line relays, etc., of the connector from the line so they will not interfere with ringing the called telephone.

In explanation of the above, it should be said that a system employing a connector for each telephone is rarely, if ever, installed. The idea is used here merely to convey an understanding of the system.

Review

Fig. 8

1. What are the two banks of a switch called?
2. Which bank has double contacts?
3. What are the normal wires? Compare with manual equipment.
4. How many impulses are sent over the line when O is dialed?

Fig. 9

5. What equipment is necessary for a 100 line system?
6. What is the function of the cut-off relay?

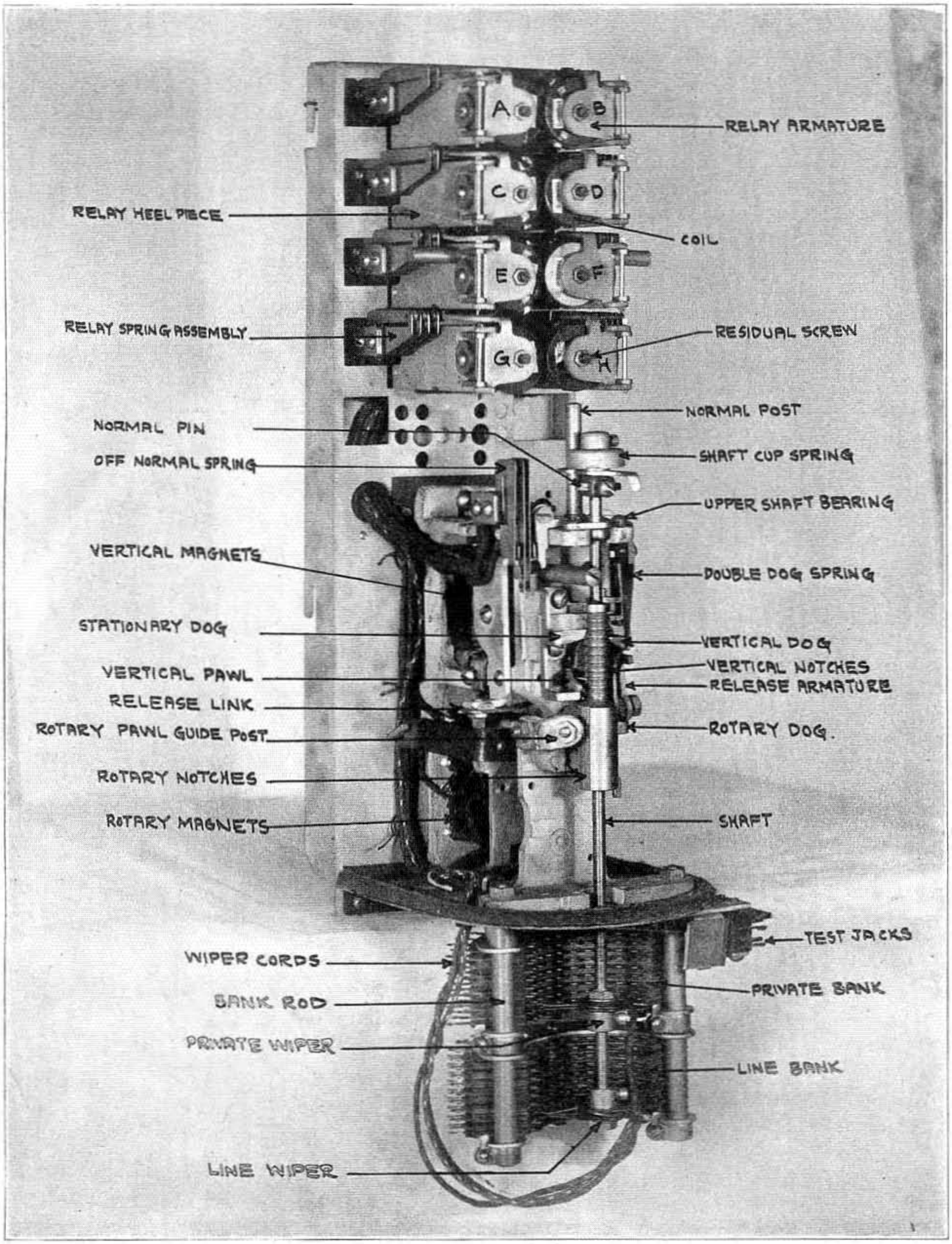


Fig. 10. Connector switch

CHAPTER 4

The Connector Switch

THE connector switch consists of several relays mounted on a base, a frame of cast iron on which are mounted two bearings, a shaft capable of being driven step by step by magnets first in a vertical direction and then being given a step by step rotary motion, and a set of banks to which are connected the lines of 100 telephones. To the shaft is attached a pair of bronze wipers for making connection to the lines leading to the telephones.

In Fig. 10, the parts mentioned above as well as many others which go to make up the complete connector will be found.

An established connection between two subscribers of an automatic system may, and usually does, involve line switches, selectors (the number of selectors in the series is determined by the size of the system) and a connector. Regardless of the amount and kind of equipment comprising an exchange the connector is usually operated by the dialing of the last two digits of the telephone number. This is true regardless of the number of digits comprising the number.

The many duties which the connector performs are listed below as its functions and are named in the order in which they take place in operation.

The functions of the connector resemble those of the manual operator and the connector corresponds with the equipment with which she completes telephone connections. Its banks correspond to the line jacks in a manual board equipped with 100 lines. The shaft of the switch corresponds to the operator's hand and arm, the wiper cords to the switchboard cord, and the shaft wipers to the plug which the hand and arm of the operator elevates to the desired number.

The functions of the connector switch are as follows:

1. Execute the vertical and rotary movement of the shaft under the control of the dial.
2. Keep the wipers disconnected during rotation so as not to interfere with lines over whose terminals they rotate.
3. Test the called line to see if it is busy. This busy test consists of two parts:
   (a) Guard against connection with the busy line.
   (b) Provide an audible signal to notify the calling subscriber that the line is busy.
4. Protect both the called and calling lines from intrusion.
5. Clear the called line of attachments. (See B. C. O. relay Fig. 9.)

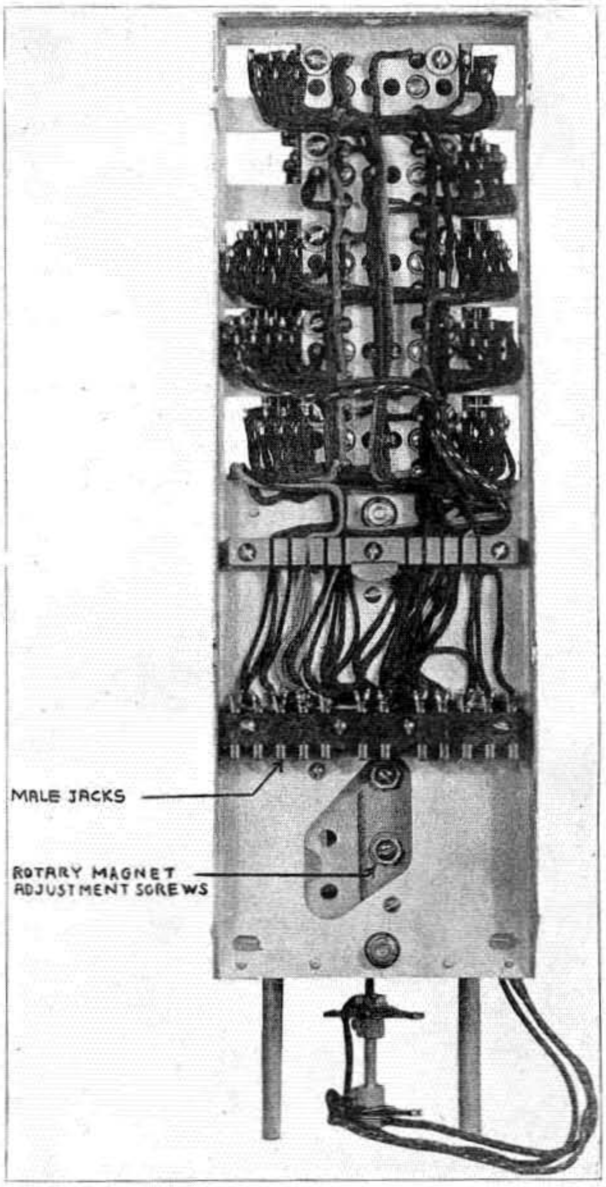


Fig. 11. Rear view of connector showing wiring

6. Ring the bell at the called telephone.
7. Supply talking current to both telephones.
8. Release itself without interfering with other lines.
9. Release other switches (selectors, etc.) associated with it in the connection.

Each function will now be taken up in its proper order and explained in detail.

quarter to one-half the length of the core. The length of the copper slug is determined by the length of time it is desired to have the relay remain operated after its circuit has been broken. For instance, a relay with a slug one-half its length, would remain operated longer than one with a slug one-quarter of its length, other conditions being equal.

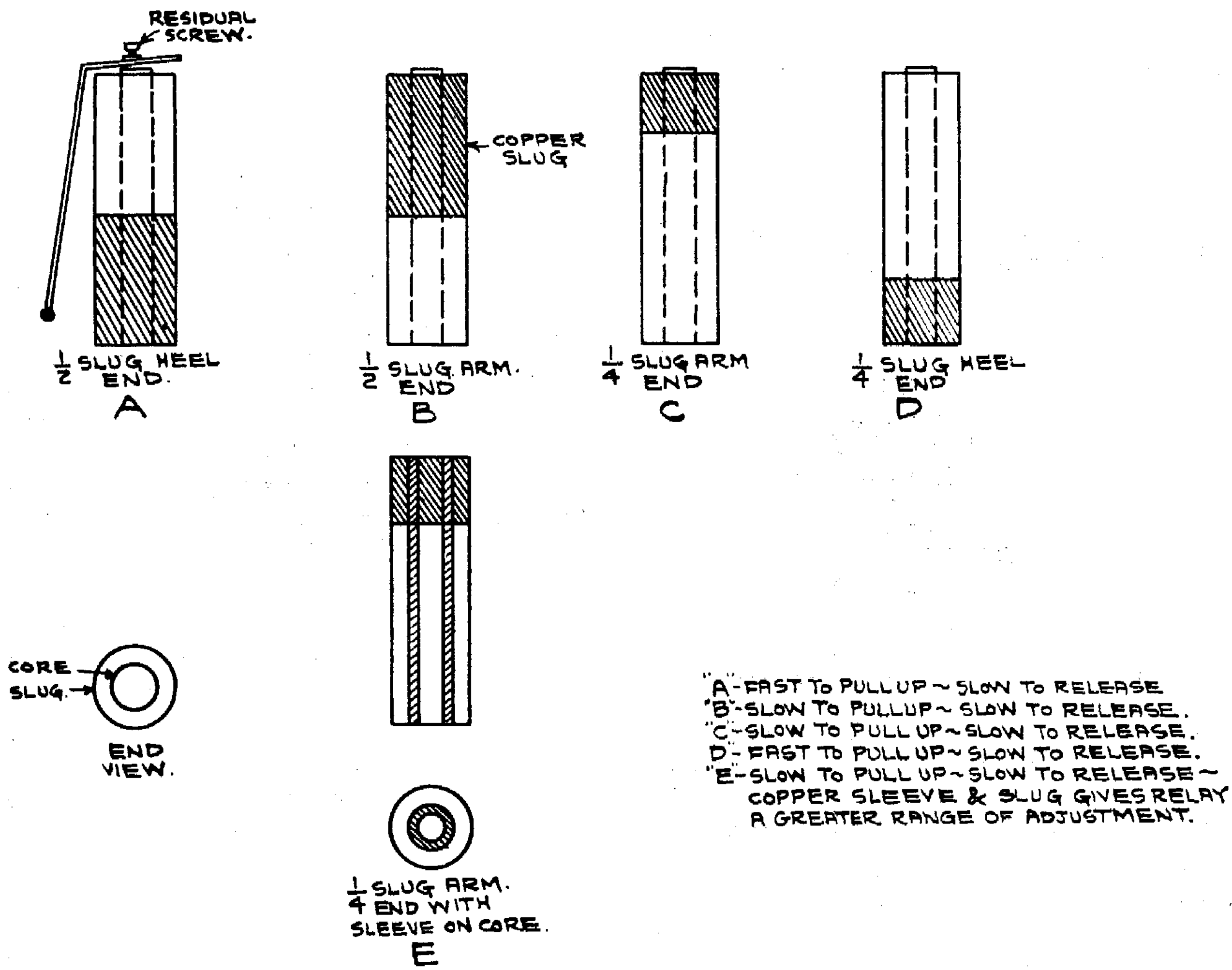


Fig. 12. Conventional symbols for slow acting relays

Slow Acting Relays

In the operation of some circuits, such as the impulse circuit which will be later described, it is necessary that certain relays remain operated while their circuits are momentarily broken. To accomplish this the slow acting relay shown in Fig 12 is used. This relay has a copper slug fitted tightly to the core. The slug extends from one-

Copper slugs

Placing the copper slug at the heel end of the core does not delay the armature in pulling up when the coil is energized, but does make it slow to release when de-energized. This type is illustrated in Fig 12. (A and D.)

When the copper slug is placed on the armature end it will, in addition to making the armature slow to release, also cause it to be slow in pulling up when the relay coil is energized. This type is illustrated in Fig 12. (B and C.)

Connector Circuit

Impulse circuit

Fig. 13 shows the impulse and vertical and rotary magnet circuits of a connector. Assuming that the calling subscriber's line is connected directly to the windings of relay A, when the receiver is lifted or removed from the hook, relay A will be energized by current flowing

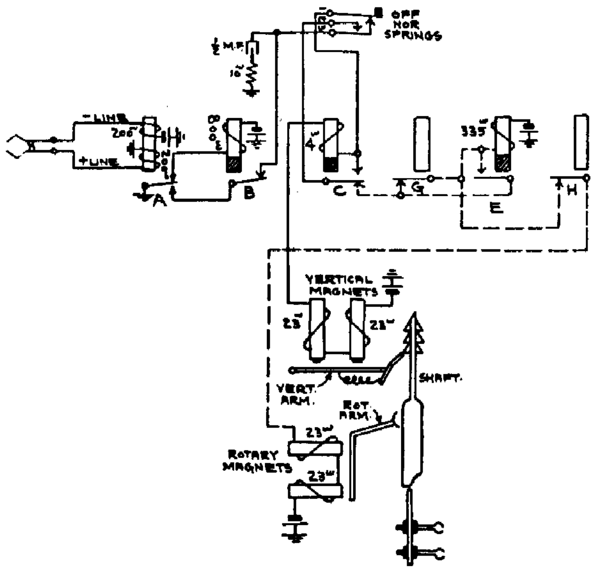


Fig. 13. Impulse circuit of connector

from (+) battery through one winding, the (+) side of the line, through the impulse springs at the telephone, the (—) side of the line, the other winding of relay A to (—) battery.

Relay A, by the operation of its spring contacts energizes relay B which prepares the vertical magnet circuit to receive the impulses. The dial is now turned and impulses are sent from the telephone causing A to release a number of times in quick succession depending on the figure dialed. Relay B being slow acting holds up during the series of impulses. When the first impulse causes relay A to fall back a circuit is closed from (+) battery through back contact relay A, make contact relay B, off normal springs, through winding of series relay C, vertical magnet to (—) battery. This elevates the shaft one step.

The instant the shaft is elevated one step, the off normal springs are released mechanically. They now shift their positions so that springs No. 1 and No. 3 separate and No. 2 and No. 3 make contact. When the next or second impulse from the telephone again de-energizes relay A, the circuit is closed from (+) battery at its springs, through off normal springs 2 and 3, through make contact relay C, winding relay C, vertical magnet to (—) battery. Relay C, being slow acting remains energized while the impulses are passing through its winding. Each succeeding impulse of this series takes the same circuit. After this series of vertical impulses has been completed, relay C, receiving no more current, falls back and switches the impulse circuit from the vertical to the rotary magnets through its back contact.

The impulses delivered to relay A by the dialing of the next digit have a similar effect except that each time relay A falls back, it completes a circuit from (+) battery through its back contact, through make contact relay B, off normal springs Nos. 2 and 3, back contacts of relays C, G and H, through the rotary magnet to (—) battery. This steps the wipers around in a horizontal direction.

The ½ M. F. condenser in series with the 10 ohm resistance to ground connected to the make contact of relay B prevents undue sparking at the springs of relay A during impulsing.

Relay E is connected in multiple with the rotary magnet and receives a portion of the impulse current delivered by the A relay during the rotary motion. It energizes on the first rotary step and, being slow acting, remains operated during the series of rotary impulses. When operated, its springs form a shunt around the back contacts of relay G, so that in case G should operate, the rotary magnet circuit will not be opened because it is maintained through the make contacts of relay E.

Relay G is the busy relay and operates each time the private wiper of the connector passes over the private contact of a busy line.

Testing for busy

During the time of rotary movement relay E, due to its slow acting feature, remains operated, connecting the private wiper through to

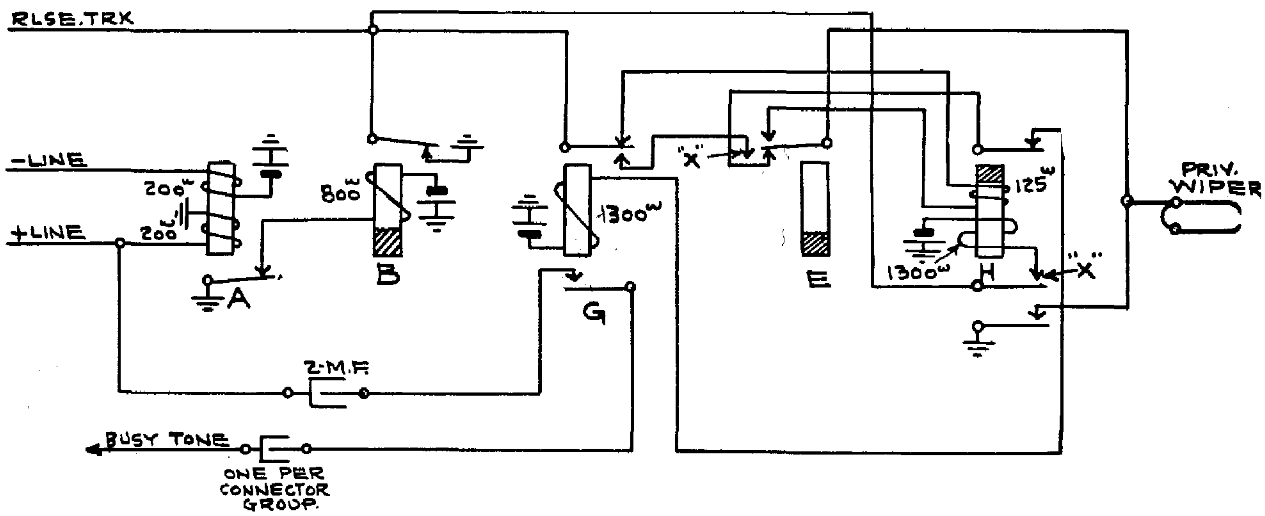


Fig. 14. Circuit showing busy test of called line

the winding of the busy relay G. Fig. 14 shows this circuit in detail.

It should be noted here that whenever a line is busy, either by reason of being called or by making a call, the private bank contact of that number is connected to (+) battery.

When the private wiper reaches the private bank terminal of the number, a circuit is completed from (+) battery to the busy relay G through the contacts of relays E and H. Relay G, operating, connects the busy tone to the calling line.

Relay E, the rotary impulses being finished, now releases, transferring the circuit of relay G from (+) battery on the private bank contact to (+) battery on the springs of relay B. Locking the circuit of the busy relay in the foregoing manner assures that it will not permit the connector to cut in on the line when the called line becomes disengaged, or in other words, when (+) battery is removed from the private bank contact.

Relay E is equipped with "make before break" springs so as to accomplish the transfer of this circuit from the private wiper to (+) battery of relay B, without any chance of the circuit being broken.

The rotary impulse circuit is opened at relay G, (Fig. 13) when the connector is giving the busy signal to the calling line so that in case the calling subscriber operates the dial, the connector cannot step from the busy line. The only way to accomplish connection to a number which has been found busy is to hang up the receiver, allow the connector to restore to normal, and dial the number again.

A line that is not busy has its private contact connected through the winding of the cut-off relay of its line switch to (—) battery.

Assuming now that the called line is not busy, relay G will not energize, but, as soon as relay E has released a circuit will be closed from (—) battery at the cut-off relay, through its winding to the private contact and private wiper, through the back contact of relay E, the 125 ohm winding of relay H, the back contact of relay G, to (+) battery at the springs of relay B. This energizes the 125 ohm winding of relay H, giving it sufficient power to make its spring contacts, designated "X" in Fig. 14. This connects the 1300 ohm winding of relay H to (+) battery at the contact of relay B, operating relay H its full stroke, and maintaining it in operation throughout the time the connector is in use.

Ringing circuit

Fig. 15 illustrates in addition to the ringing circuit, three other operations of the connector, which are so closely related to the ringing and answering of the called telephone that they have been shown together.

When the wipers of the connector have been elevated to the bank contacts of the called line and it is found to be idle, relay H immediately connects (+) battery to the interrupter equipment. This interrupting device operates the

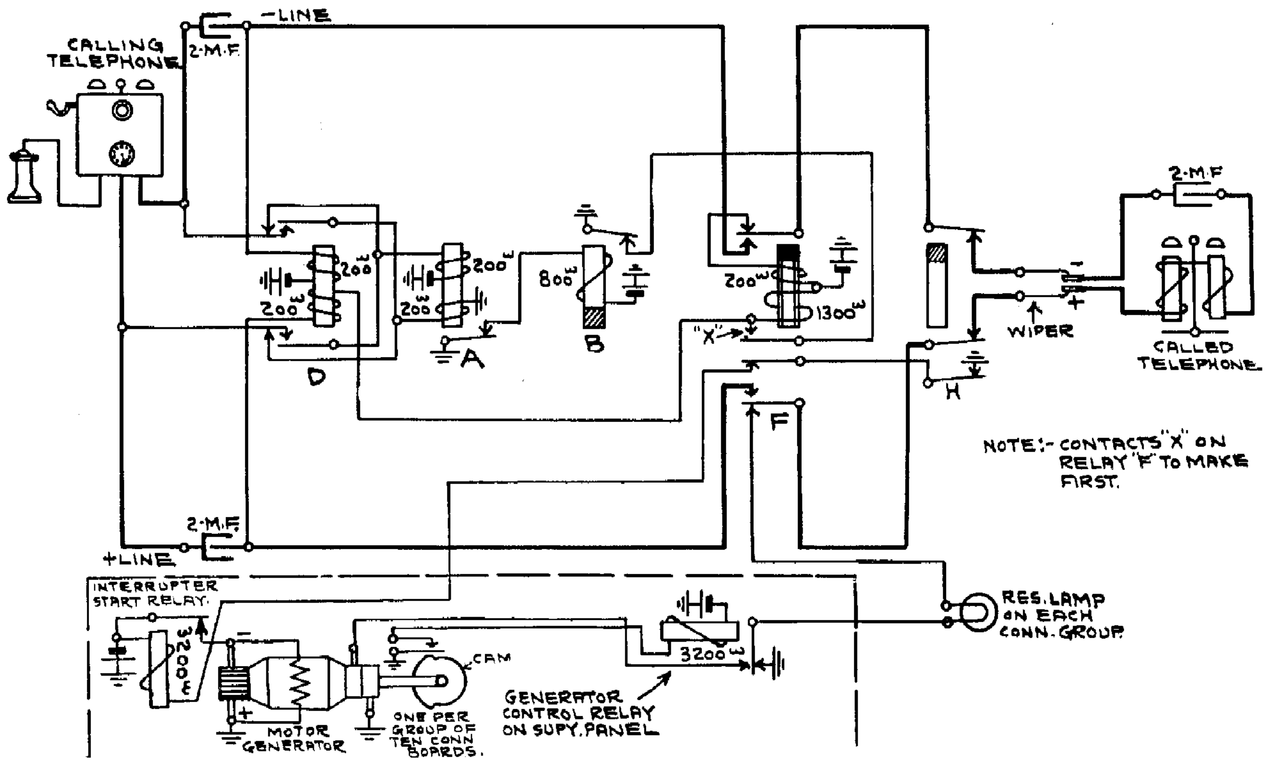


Fig. 15. Ringing and ring-cut-off circuits using ground connected generator

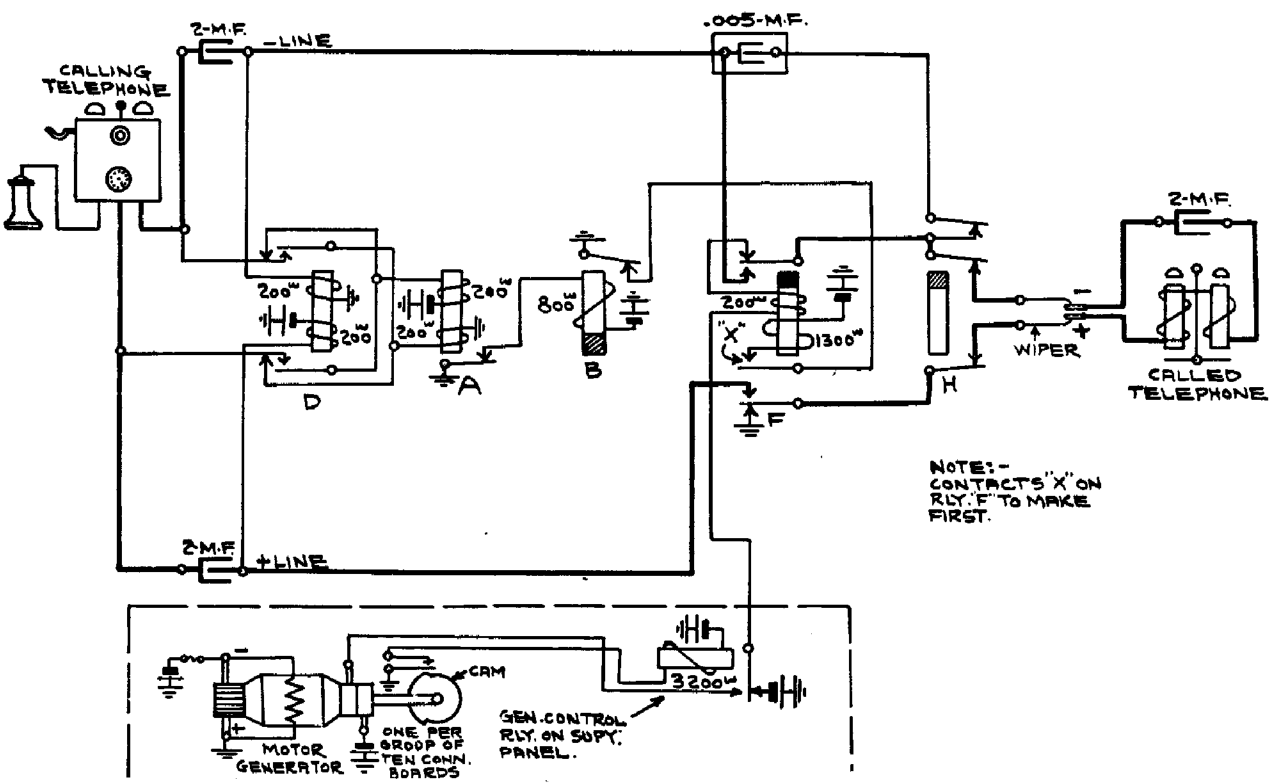


Fig. 16. Ringing and ring-cut-off circuits using battery connected generator

generator control relay, which furnishes alternating current from a ringing generator to the connector switch, through a resistance lamp, contacts of relays F and H, thence over the wiper to one side of the line, through the bell of the called telephone, back over the other side of the line and wiper, through contacts of relays H and F, 200 ohm winding of relay F to (—) battery, thus completing the circuit and ringing the bell of the called telephone.

The generator control relay is operated intermittently by a cam on the generator shaft or other form of interrupting device.

During the period that the control relay is not operated, it falls away, thus disconnecting the ringing current from the connector. During this period the telephone bell will not ring. This is known as the "silent period." In the silent period the generator lead to the connector is connected direct to (+) battery through the back contact of the control relay, so that in the event the party answers during the silent period, the F relay will operate.

Ringing tone

The party making the call knows that the bell of the called party's telephone is ringing, because of the ringing induction tone heard in the receiver each time the control relay sends ringing current out over the line. Because the return path of the ringing current is through the 200 ohm winding of relay F, a certain amount of current is induced in the 1300 ohm winding, through the winding of relay D to the (+) side of line and thence through the calling telephone and over the (—) side of line to (—) battery at relay A. A portion of this induced current will be lost through the path to (+) battery at relay A before passing out on the line, but enough current takes the route through the telephone to give the desired tone.

The copper sleeve and slug over the core of relay F give it a greater range of adjustment. This prevents its operation when the ringing current passes through its 200 ohm winding. The copper sleeve and slug reduce the impedance to the ringing current.

When the called party answers, the removal of receiver places the transmitter and receiver across the line (See Fig. 3) which allows the 200 ohm winding of relay F to receive direct current from the battery in series with the generator. This operates the armature of relay F far enough to bring the pair of springs marked "X" into contact, which closes the circuit of the 1300 ohm winding of relay F from (—) battery to (+) battery at the springs of relay B, thus operating the armature of relay F its full stroke, opening the generator and interrupter start circuits, and connecting the lines of the called telephone through to the windings of relay D, which operates.

The ringing circuit shown in Fig. 16 is the same as that described in Fig. 15 except for the following. The machine which furnishes the ringing current is in continuous operation; the generator is connected to the line through the 200 ohm winding of relay F instead of direct. The ringing induction tone is obtained by bridging a .005 M. F. condenser across the open line spring contacts on relay F so that a small amount of the generator current will pass back to the calling telephone direct instead of by induction. Since in order to obtain the ringing induction tone it is not necessary to utilize relay D, its windings are permanently connected to (—) and (+) battery respectively.

Cutting off the ring, reversal of battery, etc., is exactly the same in this method of ringing as described under Fig. 15.

Current reversal

Relay D, operating reverses the battery current supply on the lines to the calling telephone.

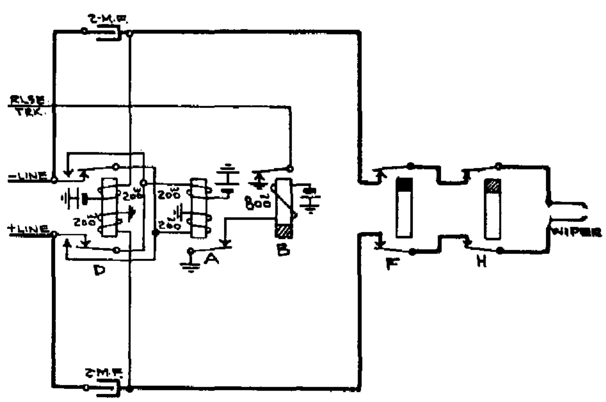


Fig. 17. Transmission circuit with battery to calling line reversed

This reversal is accomplished by the springs on relay D which are of the "make before break" type and therefore operate without opening the line circuit. Opening of either one of the lines would de-energize relay A and might cause the connector to release.

Transmission circuit

The transmission circuit of the connector is shown in Fig. 17. Battery to the transmitter of the calling telephone is fed through relay A while battery to the called telephone is fed through relay D. These two circuits are separated by condensers which provide a path for the voice currents to pass between the two telephones. The spring contacts of the connector through which the conversation passes are shown in this figure.

The battery is reversed to the calling party for the purpose of operating a service meter or to give supervision in case the call originated at a manual board.

Disconnect supervision

Following a conversation, as shown by the circuit in Fig. 17, should the calling party place the receiver on the hook before the called party does, the A relay will fall away and by the (+) battery on its spring contacts, relayed through the contacts of relays B and D, cause the supervisory lamp to glow. It will be noted that the connector release magnet circuit remains open at the springs of relay D.

Should the called party replace receiver before the calling party does, relay D will fall away connecting the (+) battery from springs of relay H, contacts of relays F and D to the supervisory lamp, causing the lamp to glow. Under these conditions, the release magnet circuit of the connector is open at the springs of both relays A and B.

This method of supervision is similar to that employed on cord circuits of common battery manual switchboards, and assures that any connection being held by either the called or calling party will be instantly observed by the attendant.

Battery to the supervisory lamp may be disconnected by means of the switch, in those offices where it is desired to supervise for held connections at certain times throughout the day.

Release magnet circuit

Normally the release magnet circuit of the connector is open at the off normal springs. When the connector is seized, the release magnet circuit is also open at the springs of relay B. The first vertical step of shaft operates the off normal springs closing the release magnet circuit at that point, and makes the release of the connector dependent upon the replacement of the receiver by both parties.

The 500 ohm N.I. resistance wound on top of and in multiple with the winding of the release magnet prevents undue sparking at the off normal springs when the release circuit is opened.

As previously explained, the connector is not released until both parties have replaced the receivers, although the remainder of the switches release immediately following the replacement of the receiver by the calling party.

Assume that the calling party is first to replace the receiver. Relay A will fall back, but relay B, being slow acting, remains operated long enough to close a circuit from (+) battery at the back con-

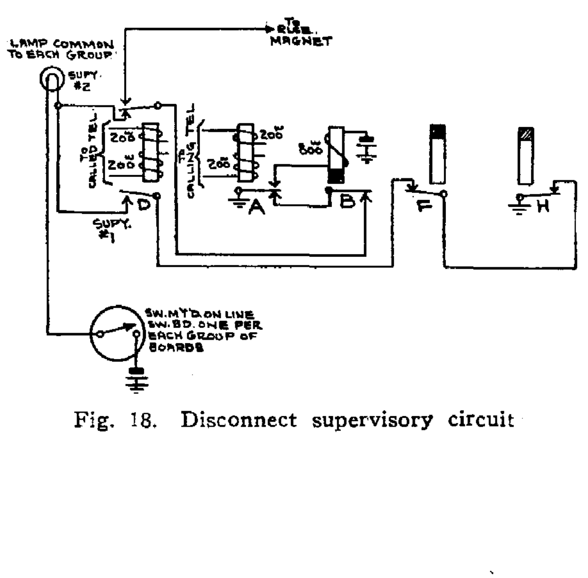


Fig. 18. Disconnect supervisory circuit

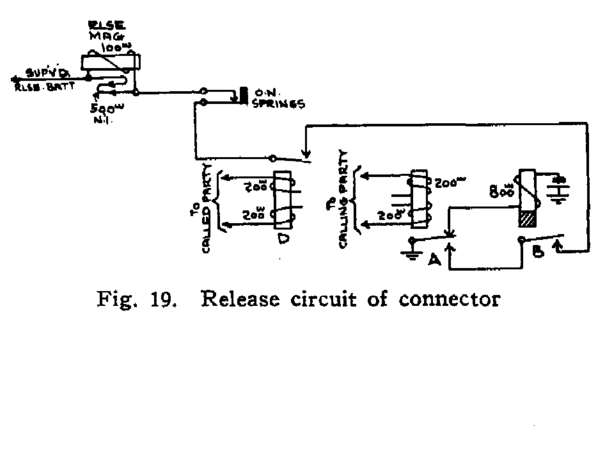


Fig. 19. Release circuit of connector

tact of relay A, make contact relay B, off normal springs, winding relay E to (—) battery, thus operating relay E and disconnecting (+) battery from the release trunk. Removal of (+) battery from the release trunk permits all switches associated with the connector to release. Relay E restores to normal and places (+) battery on the release trunk again from the springs of relay H. This (+) battery protects the connector against being selected for another call while it is held in this manner by the called party.

Replacement of the receiver by the called party allows relay D to fall back, closing the release magnet circuit allowing the connector to release.

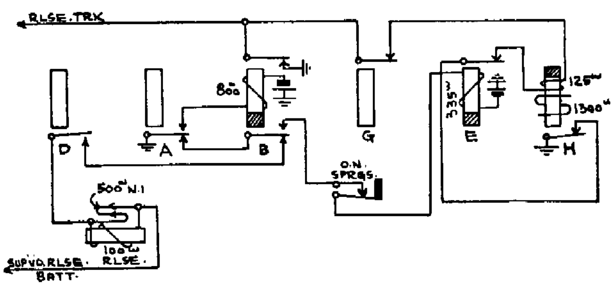


Fig. 20. Protection of connector during interval between hanging up of calling and called subscribers

Review

Fig. 12

1. Why are slow acting relays used?
2. Why are slugs sometimes placed on the heel end of the core and other times on the armature end?

Fig. 13

3. What relay on the connector is energized when the receiver is removed from the hook?
4. What are impulses?
5. What relay vibrates in response to the impulses sent from telephone?
6. Trace the vertical impulse circuit.
7. Trace the rotary impulse circuit.
8. Why is the C relay called the "series" relay?
9. At what point is the impulse circuit switched from the vertical to the rotary magnet?
10. Will the resistance of the rotary magnets increase or decrease if they become heated from continued operation?

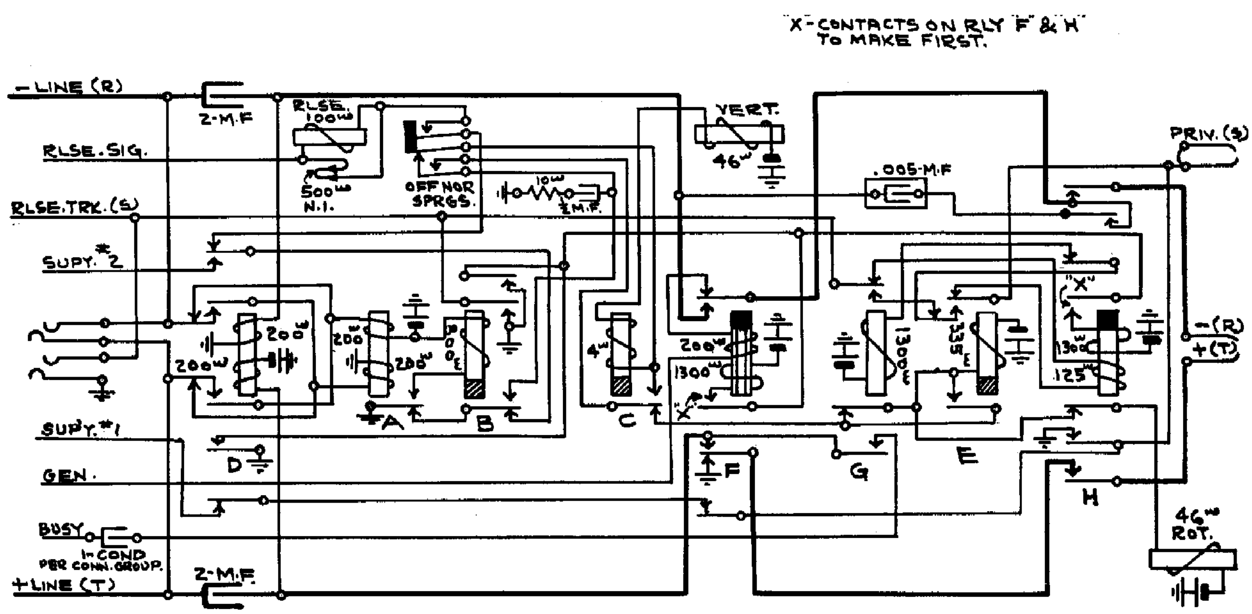


Fig. 21. Complete connector circuit

Fig. 14

11. Give the letter and the resistance of busy relay.

12. What part does relay E play in giving the busy tone?

13. What condition does the private wiper find on the private contact of a busy line?

14. Why is the rotary magnet circuit opened when busy relay is operated?

15. What is the procedure for a party who receives the busy tone?

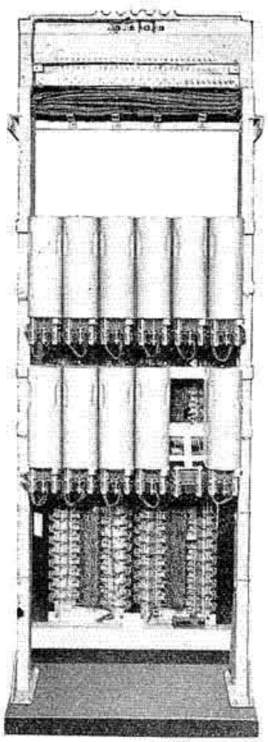


Fig. 22. Connector side of 100 line unit

Fig. 15

16. How is the ringing interrupter equipment started?

17. How is the ringing induction tone furnished to the calling party?

18. Describe how the "ring cut-off" is accomplished.

19. How is the ringing interrupter stopped?

20. Can ringing be stopped during silent period?

21. Describe the purpose of the two windings on ring cut-off relay F.

Fig. 16

22. How is the ringing induction tone furnished to the calling party?

23. How does the ringing circuit in this figure differ from the ringing circuit shown in Fig. 15?

Fig. 17

24. To which telephone is the current supply reversed?

25. Why are make before break springs used on relay "D"?

26. Which relay feeds battery to calling party's telephone? To the called party's telephone?

27. Give the resistance of the battery feed relays.

Fig. 18

28. Describe the conditions when supervisory No. 1 causes pilot lamp to glow.

29. Describe the conditions when supervisory No. 2 causes pilot lamp to glow.

30. How does this compare with manual cord supervision?

Fig. 19

31. Where is the release magnet circuit open, when the switch shaft is at normal?

32. How can the called party hold the release magnet circuit open? Which relay remains operated?

33. Which party controls the release of the connector?

34. Why is relay B made slow acting?

Fig. 20

35. Which relay connects (+) battery to the release trunk after relay B falls back?

CHAPTER 5

The Selector Switch

THE mechanism of the selector as shown in Fig. 23 is practically the same as that of the connector; it employs the same type of shaft, wipers, banks, release mechanism, etc.

The selector differs from the connector, in that only the vertical movement is controlled by the dial, which means that only one digit is required to operate it. The rotary movement is entirely automatic and serves to select an idle trunk from the level to which the wipers are stepped by the vertical movement of the shaft.

The selector functions are as follows:

1. Elevate the shaft by means of impulses from the dial.
2. Find and connect with an idle trunk.
   (a) Rotate shaft automatically.
   (b) Keep circuit to line wipers open while wipers are rotating over bank contacts.
   (c) Test each trunk.
   (d) Stop rotary movement at first idle trunk found.
   (e) Protect the trunk selected.
   (f) Extend lines through to next switch and disconnect attachments.

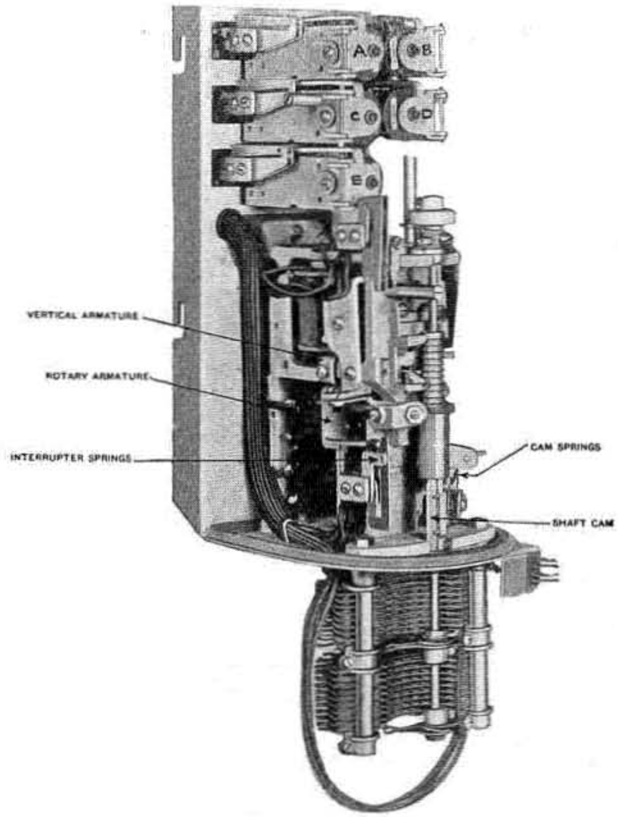


Fig. 23. Selector switch

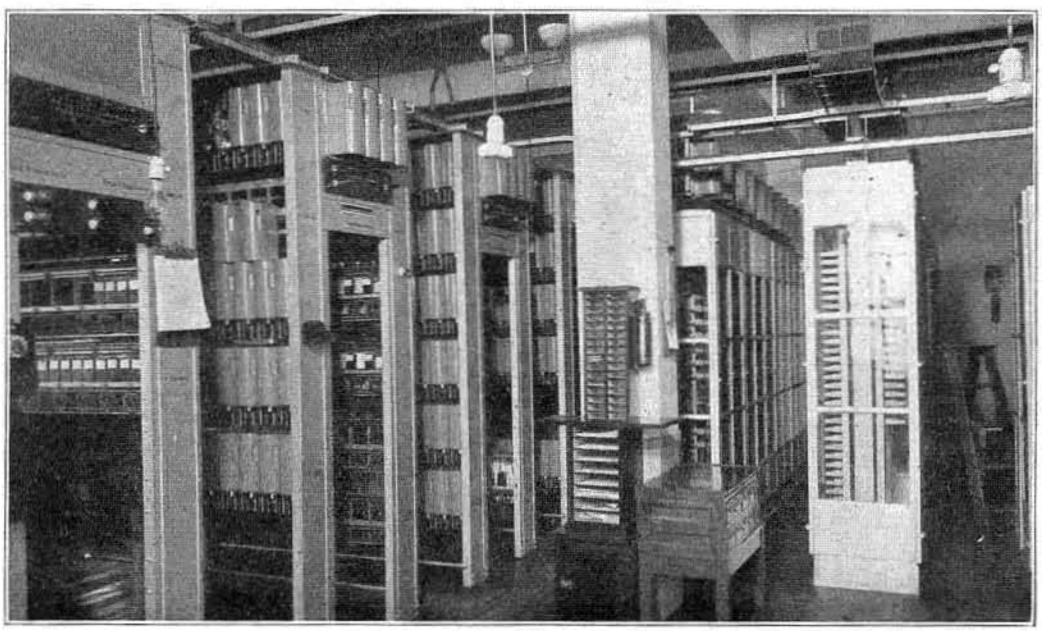


Fig. 23A. Switchroom view showing selectors

3. Release itself before or after it has cut through to succeeding switch.
4. Release itself without interfering with other trunks.
5. Give busy tone to the subscriber if all trunks of the level called are engaged.

Transfer Trunks

By the enlargement of the system from 100 to 1000 lines, it is obvious that some means of trunking must be provided to select a connector in the proper 100 group.

Early development in manual telephony made use of the transfer trunk to secure connection between two subscribers in different groups. A number of such trunks were provided between operators' positions. An operator receiving a call for a subscriber whose line terminated in an adjacent position would extend the call to that position over one of the transfer trunks and the connection would be completed to the subscriber's line by the operator in that position.

It was soon discovered, however, that this was not the most efficient method. Consequently it was abandoned, and the plan of providing a full multiple of all subscribers' lines accessible to each operator was adopted.

Development of the trunking for the automatic system was just the reverse to that of the manual. The first plans tried in automatic were based on the principle of the full multiple, but were later abandoned in favor of the transfer trunk principle. This method is still employed in automatic trunking.

1000 line system

The trunking arrangement of a 1000 line system is shown in Fig. 24. Instead of each tele-

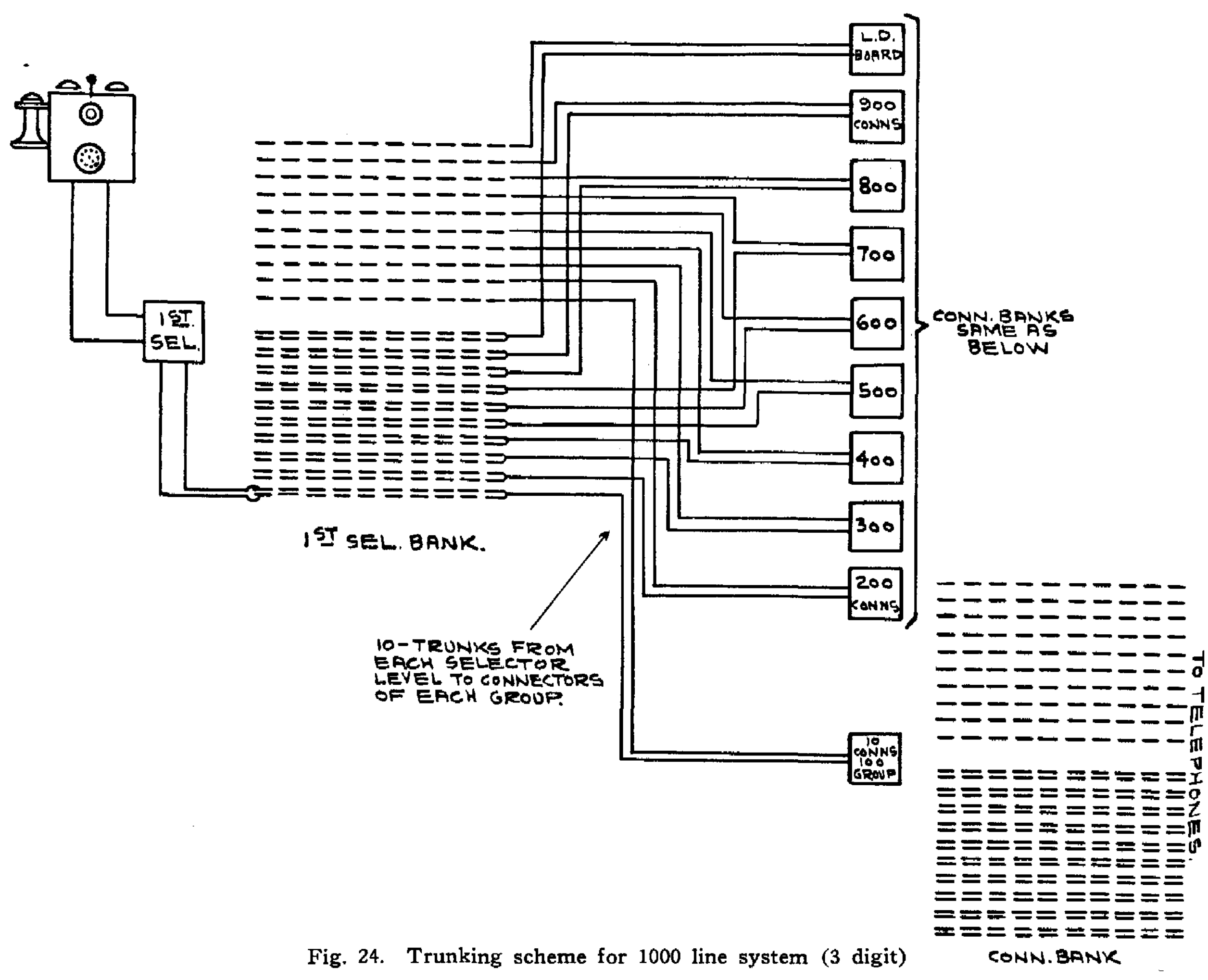


Fig. 24. Trunking scheme for 1000 line system (3 digit)

phone being connected to a connector switch as in the 100 line system, the telephones are now connected to selector switches. The selector selects a connector in the proper hundreds group and the connector the tens and units as before. This makes possible the enlargement of the system from 100 to 1000 lines.

In a 1000 line system of this kind, there would be 1000 first selectors. The bank contacts of these selectors would be multipled together, and from each row or level of contacts, there would be trunks to the connectors of each 100 group of subscribers' lines.

For convenience we will consider these trunks to be on a straight 10 per cent basis, that is, 10 trunks from each level of contacts of the first selector banks to 10 connectors in each 100 line group.

Each telephone number of a 1000 line system has 3 digits. It will be observed that to change a 100 into a 1000 line system it is only necessary to terminate the lines on selectors instead of connectors and to provide the additional connector groups.

When telephone number 125 is dialed, the connection is completed as follows: Dialing the digit "1" elevates the wipers of the calling subscriber's first selector up to the first level. The selector then automatically rotates its wipers over the contacts of that level until a trunk to an idle connector of the 100 group is found. Dialing the digit "2" elevates the wipers of the connector to the second level. The digit 5 is now dialed. This extends the connector wipers to the fifth set of contacts of the second row (or No. 25). This connects the calling party's telephone with the called party's telephone No. 125.

10000 Line System

To increase the number of telephones from 1000 to 10,000 it is only necessary to introduce

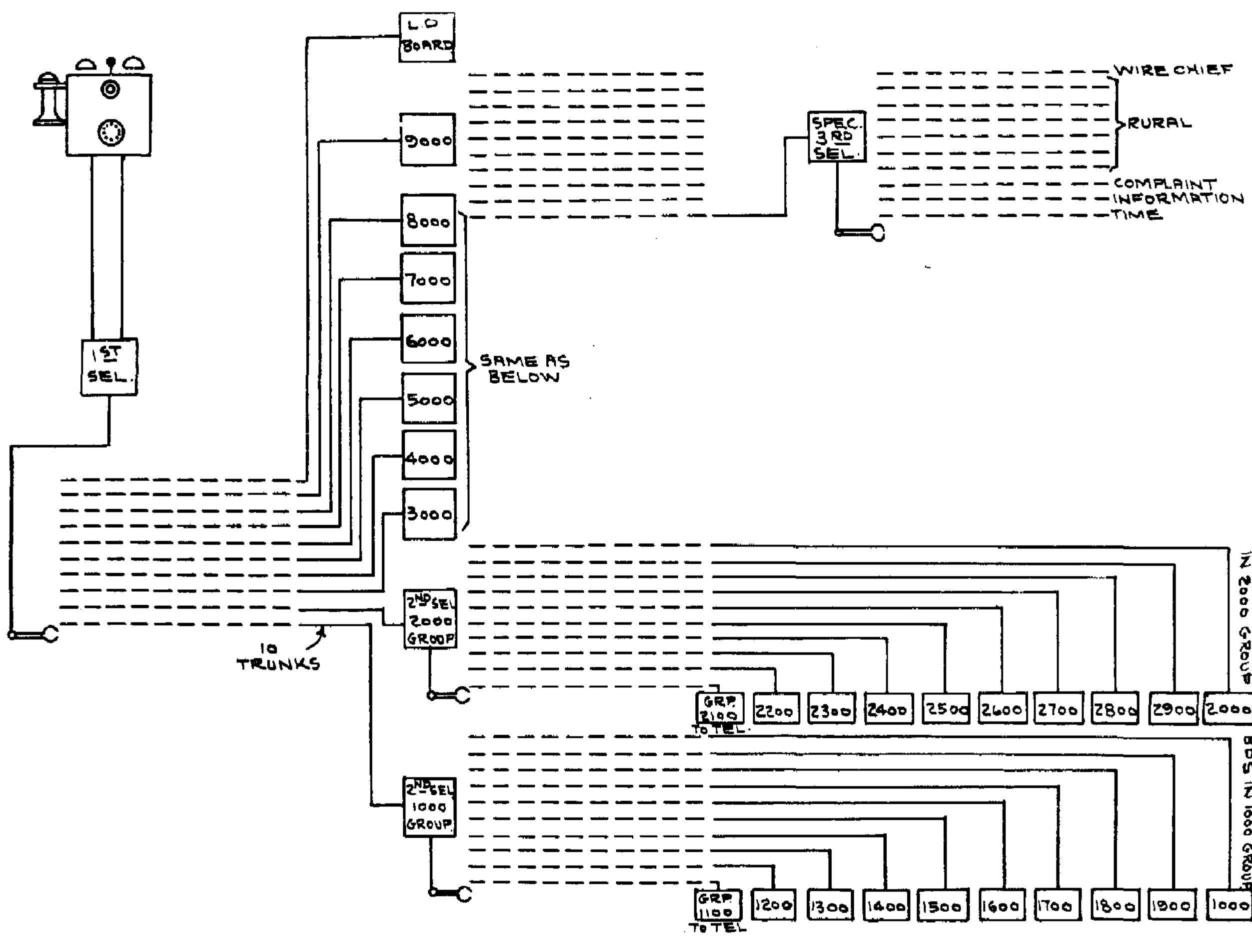


Fig. 25. Trunking scheme for 10,000 line system (4 digit)

2nd selectors between the 1st selectors and connectors. A diagram of the trunking arrangement of a 10,000 line system is shown in Fig. 25.

In a system of this size the first selector selects the desired thousand, the second selector the desired hundred, and the connector the tens and units or in other words the desired line itself.

Instead of the trunks from the levels of the first selectors being connected direct to connectors as was the case in the 1000 line system, they are, in the 10,000 line system, connected to second selectors. The bank contacts of the second selectors are connected to the connectors. Each level of the first selectors represents a capacity of 1000 lines. In the 1000 line system each first selector level represents a capacity of 100 lines. In other words, for each group of selectors (firsts, seconds, etc.), added, the capacity of the exchange (in lines) is multiplied by ten. Each telephone number in a 10,000 line system has 4 digits.

Special service numbers

Each exchange is provided with special services such as Long Distance, Information, Complaint, Wire Chief, etc. Where an operator is in attendance, means for connecting to these is shown in Fig. 25. Dialing "O" connects to Long Distance; 912, Information; 913, Complaint, etc.

Selector Circuit

Impulse circuits

The vertical impulse circuit of the selector is very similar to that of the connector and is

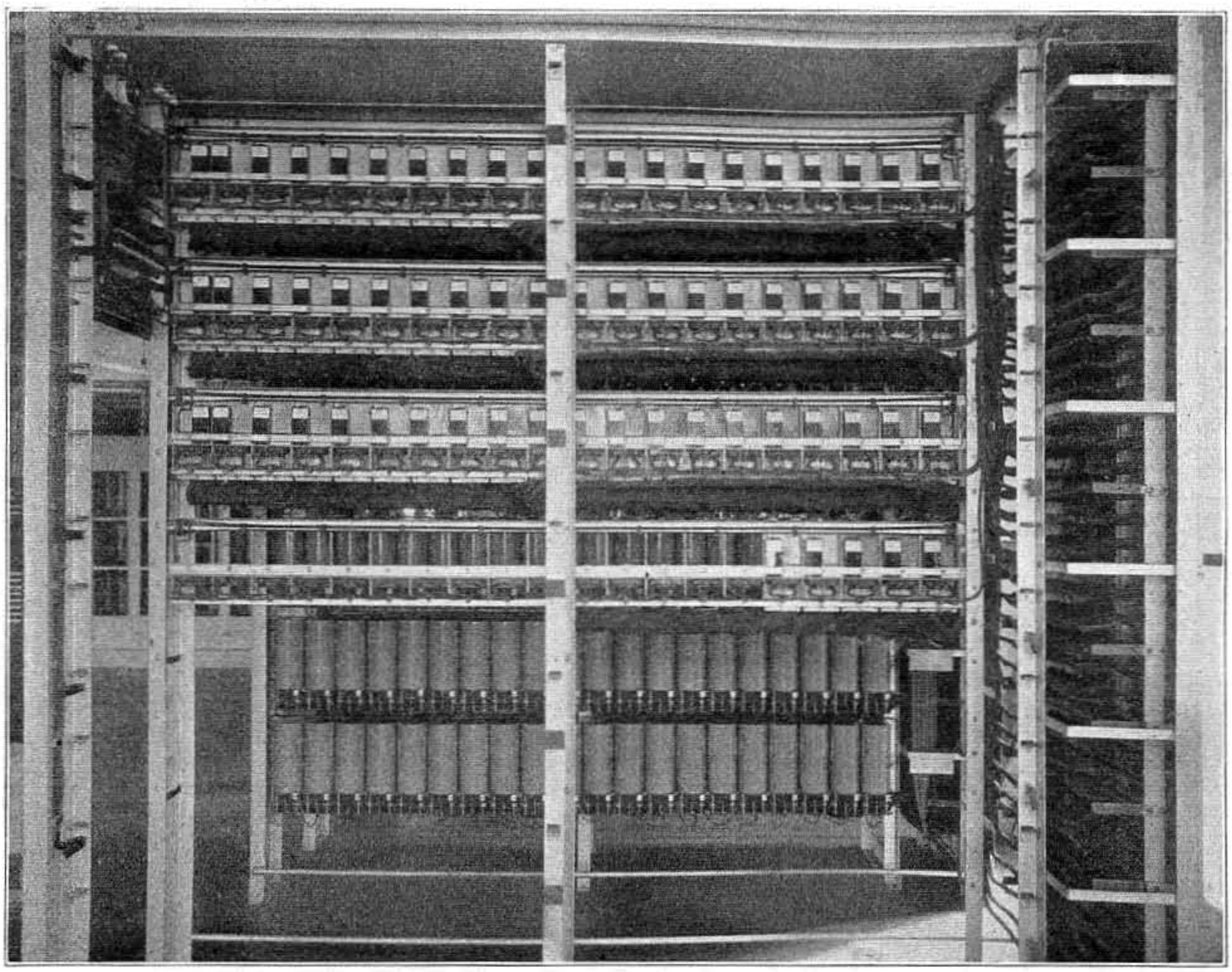


Fig. 26. Interior of selector board

shown in Fig. 27. When the switch has been selected by a subscriber in establishing a connection, relay A is energized by (+) battery flowing through secondary of the dial tone induction coil, bottom winding of relay A over + line, through the telephone, back over — line, top winding to (—) battery. Relay A by the operation of its spring contacts energizes relays B and M. Relay B prepares the vertical magnet circuit to A causes it to fall back, connecting (+) battery through back contact relay D, back contact A, make contact B through series relay C, vertical magnet to (—) battery. This elevates the shaft one step.

The first vertical step of the shaft allows the off normal springs to make contact, thus operating relay E from (—) battery through its winding, off normal springs, contact relay C to (+)

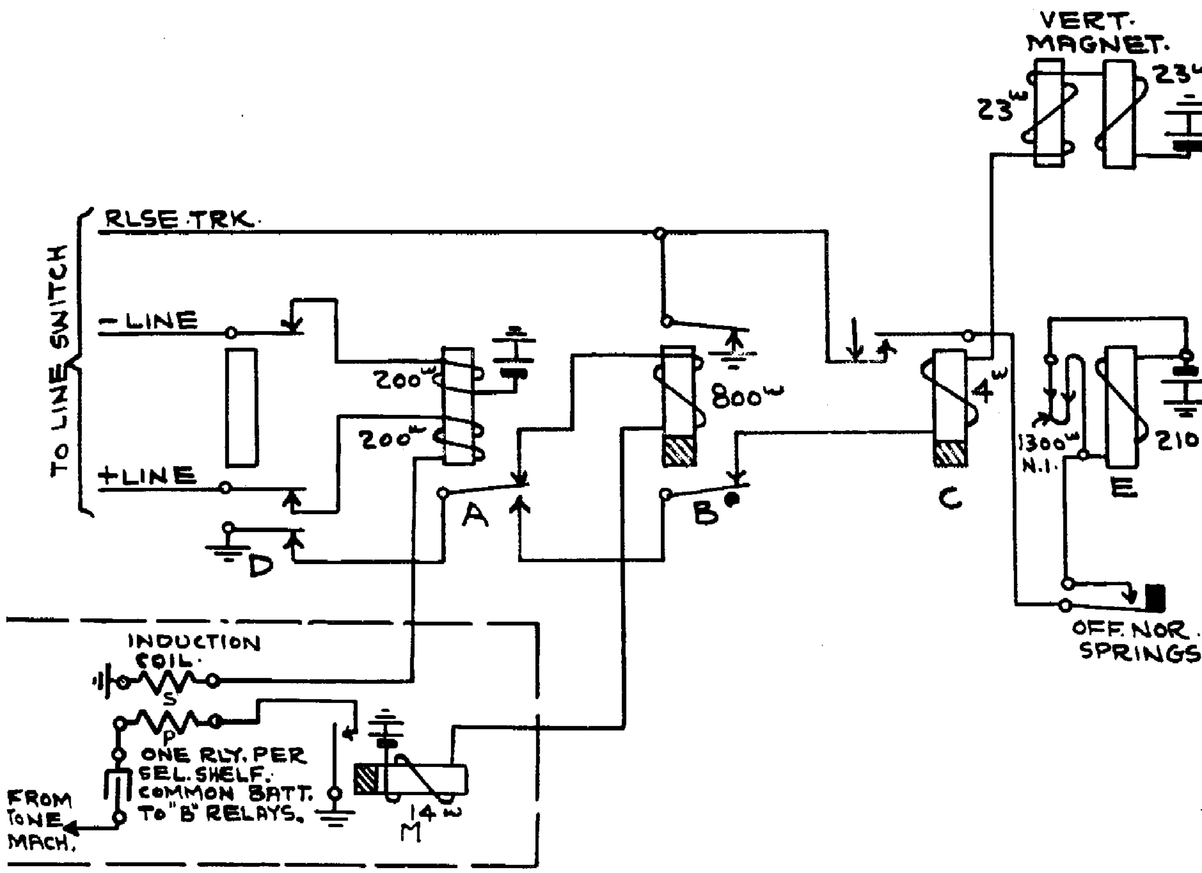


Fig. 27. Impulse circuit of selector

receive the impulses from the dial, and relay M closes the dial tone circuit through the primary of the induction coil. The dial tone is induced into the secondary winding of the induction coil and is heard by the calling party, indicating that connection has been made to a first selector and that the subscriber can now dial. The dial is turned and impulses are sent from the telephone causing relay A to fall back each time the line circuit is interrupted at the telephone. Relay B, being slow acting, holds up during these impulses. The first impulse delivered to relay battery at the springs of relay B.

Relay M furnishes battery to all B relays of one selector shelf or twenty selector switches.

Rotary action

Fig. 28 shows the rotary "cut in" circuit. After the vertical impulses have ceased, the series relay de-energizes, closing a circuit from (+) battery at the springs of relay B, through the contact relay E and winding of rotary magnet to (—) battery, energizing the rotary magnet. This rotates the shaft and its wipers on to the

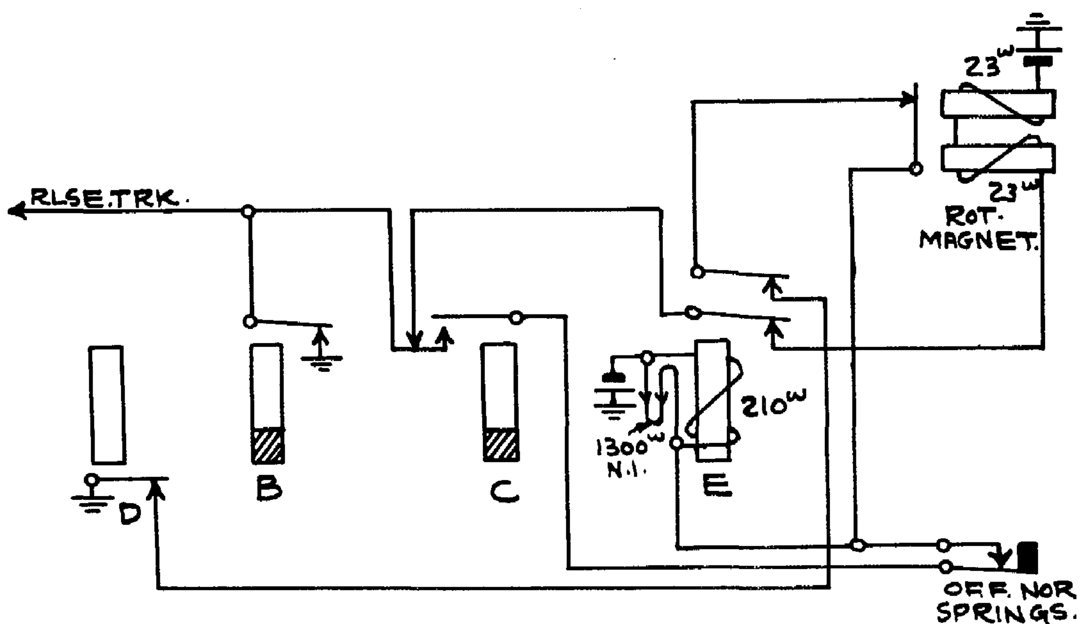


Fig. 28. Rotary "cut-in" circuit of selector

first set of contacts. After relay C falls away, relay E remains energized by means of its locking circuit from (+) battery at the contacts of relays D and E, rotary magnet, through the 210 ohm winding of relay E to (—) battery.

Switching through

The rotary armature operating, opens the rotary springs and opens the locking circuit of relay E allowing it to fall away.

Continuing with the description given in Fig. 28, should the private wiper (Fig. 29) now be resting on a grounded contact (which would indicate a busy trunk), a circuit would be closed from (+) battery on the private wiper through back contact on relay D, rotary magnet springs,

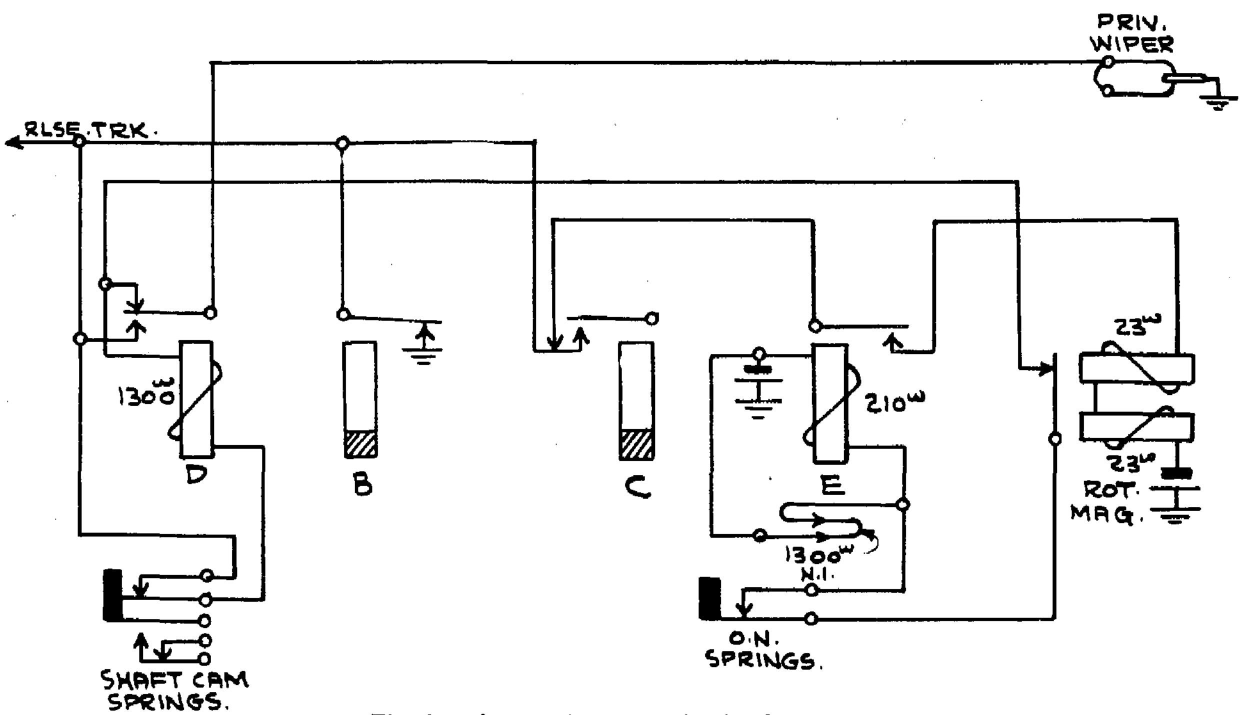


Fig. 29. Automatic rotary circuit of selector

off normal springs, through relay E to (—) battery, energizing relay E. This closes a circuit from (+) battery from the springs of B through the rotary magnet to (—) battery rotating the shaft another step. The circuit of E is again unlocked (as shown in Fig. 28) by the rotary armature opening its springs.

Should the next private contact be found grounded this same operation will be repeated, until an idle trunk is found.

While the private wiper rests on a grounded contact, both sides of the winding of relay D are grounded. Relay D is therefore shunted out and

When relay D operates, it switches the lines to the wipers thus connecting the telephone through to the switch ahead, energizing its A and B relays the latter of which will ground the release trunk of that switch, and therefore the private wiper of the switch we are considering.

This keeps relay D operated in series with relay E from ground at the release trunk to battery at relay E, even after relays A and B fall back. It will be noticed that relay D opens the circuit of relay A, but relay B does not fall back until after relays A and B of the next switch have operated.

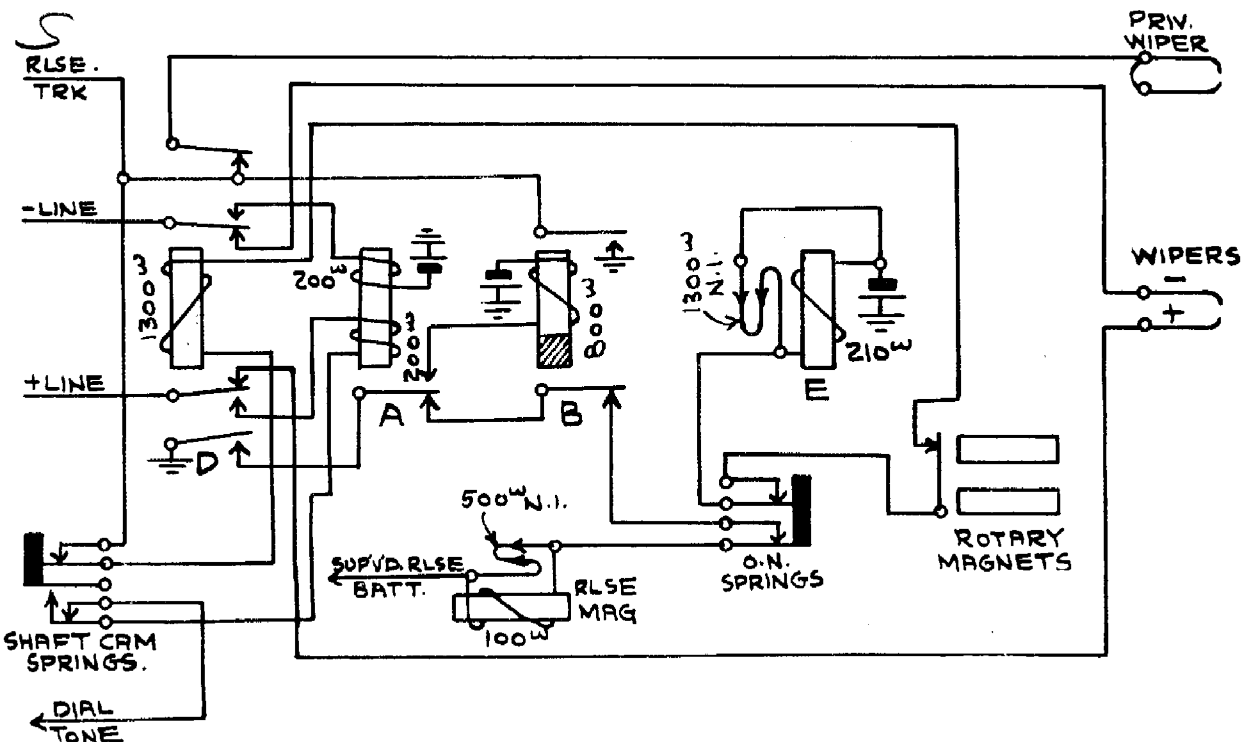


Fig. 30. Selector circuit showing lines switched through

cannot operate until the private wiper reaches an ungrounded contact, indicating an idle trunk, thus removing the shunt from relay D.

When this happens, relay D, with shunt removed, operates from (+) battery at relay B, through the shaft cam springs, winding of relay D, contacts rotary magnet springs, off normal springs, through relay E to (—) battery. This circuit is shown in Fig. 30.

Relay D will operate in series with relay E but relay E will not operate in series with relay D because of its small number of ampere turns and stiff spring tension.

When relay D is operated, switching the lines through, the release magnet circuit is opened.

Release magnet circuit

The calling party, placing the receiver on the hook causes relays A and B on the connector switch to fall away, removing the (+) battery from the release trunk and allowing relay D on the selector to restore and close its release magnet circuit from (+) battery at springs of relay D, contacts relays A and B, off normal springs, winding of release magnet, winding relay X to (—) battery. This circuit is shown in Fig. 31. The

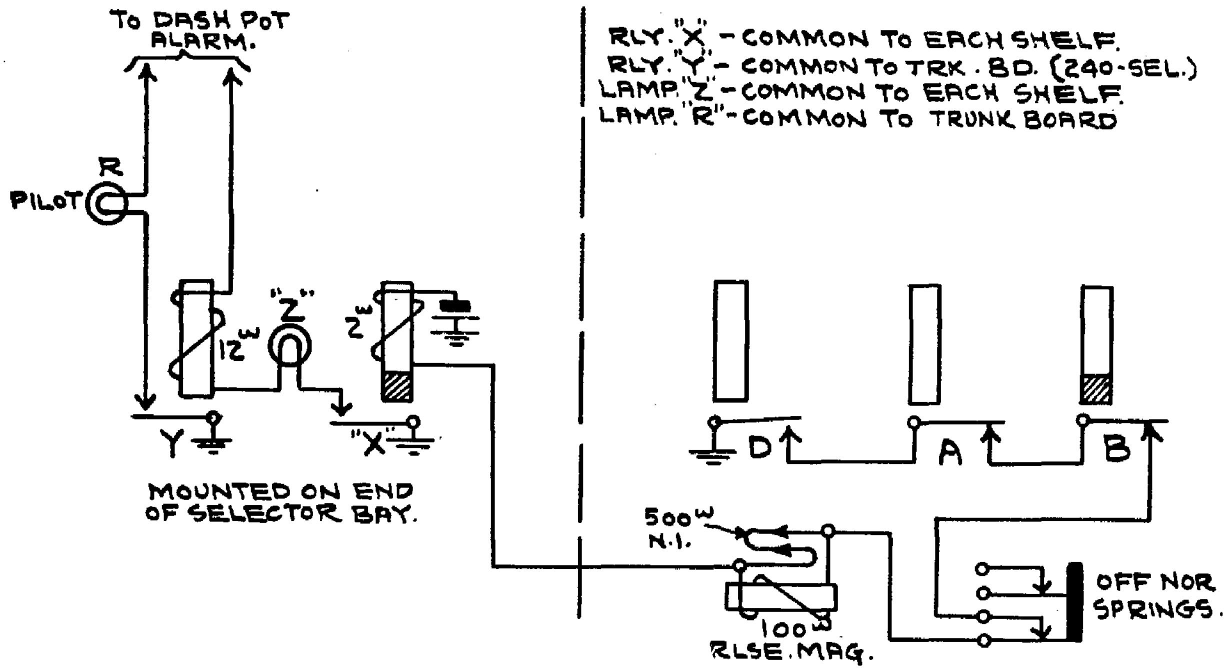


Fig. 31. Release circuit of selector

release magnet armature operates, causing the switch to restore to normal.

All trunks busy

A selector, seeking an idle trunk on a level where all the trunks are at that moment engaged, will have its shaft automatically rotated to the 11th position (its wipers are entirely free of the bank contacts) and give the calling party the busy tone.

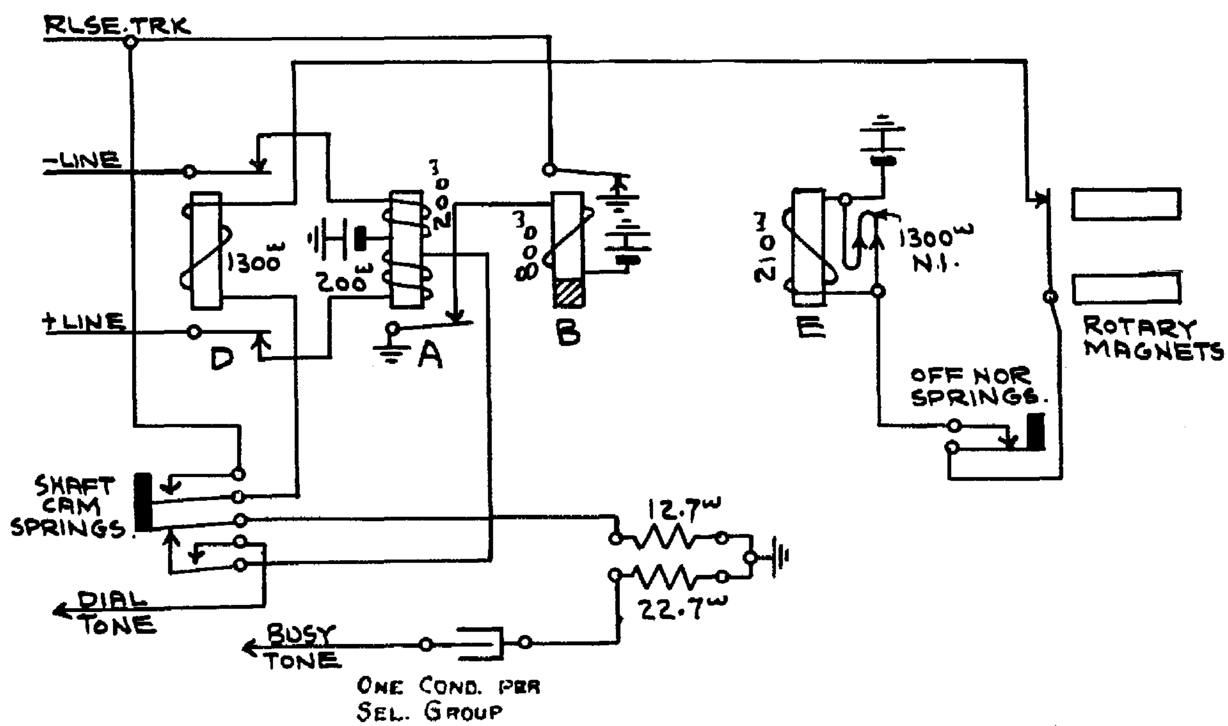


Fig. 32. Selector circuit, showing "all trunks busy" condition

While the shaft is in the 11th rotary position, it operates a set of cam springs, opening the circuit of relay D, preventing that relay from operating. It also disconnects the dial tone from the winding of line relay A and substitutes (+) battery on which the busy tone is induced.

Review

Fig. 24

1. What equipment is necessary for a 1000 line system?
2. How many digits are there in each telephone number of a 1000 line system?

7. What would be the effect if the springs on relay C failed to make when it restores to normal?

Fig. 28

8. Describe how the rotary cut-in is accomplished.
9. How is the circuit to relay E opened?
10. When do the off normal springs make contact?

Fig. 29

11. What takes place after the rotary cut-in, providing the private wiper rests on a grounded contact?

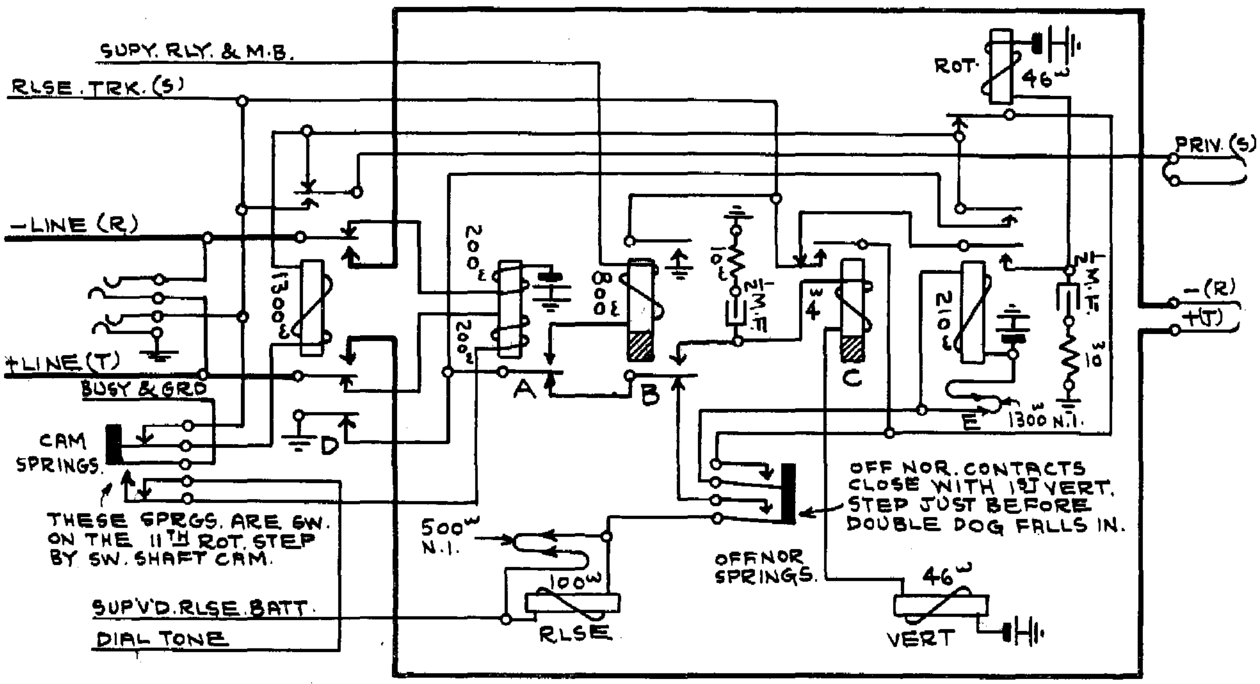


Fig. 33. Complete selector circuit

Fig. 25

3. What equipment is necessary for a 10,000 line system? 100,000 line system? 1,000,000 line system?

Fig. 27

4. What relays on the selector energize when the receiver is removed from the telephone?
5. What would be the effect on the operation of the switch if relay B was not slow acting?
6. What circuit does relay C prepare during the vertical impulses?

12. Why is relay D shunted (ground on both sides) during the rotary motion?

Fig. 30

13. Trace the circuit showing how relay D is first energized.
14. How is relay D held energized after it has switched the lines through to the next switch?
15. What relays are energized on the selector during the talking period?

Fig. 31

16. Where is the release magnet circuit open when the selector is at normal?
17. Where is the release magnet circuit open after the selector has switched through to the next switch?
18. What controls the release of the selector after it has switched through to the next switch?

Fig. 32

19. What happens when the shaft operates the cam springs on the 11th rotary step?
20. Why is the circuit of relay D opened?
21. Trace the release magnet circuit of the selector when releasing from the 11th position (Fig. 33).

CHAPTER 6

Line Switches

PREVIOUS to the invention of the lineswitch it was common practice to terminate each subscriber's line on a selector switch. The lineswitch is a non-numerical switch attached to each subscriber's line, and serves to connect the line to a trunk leading to an idle connector in a 100 line system or an idle first selector in a larger system.

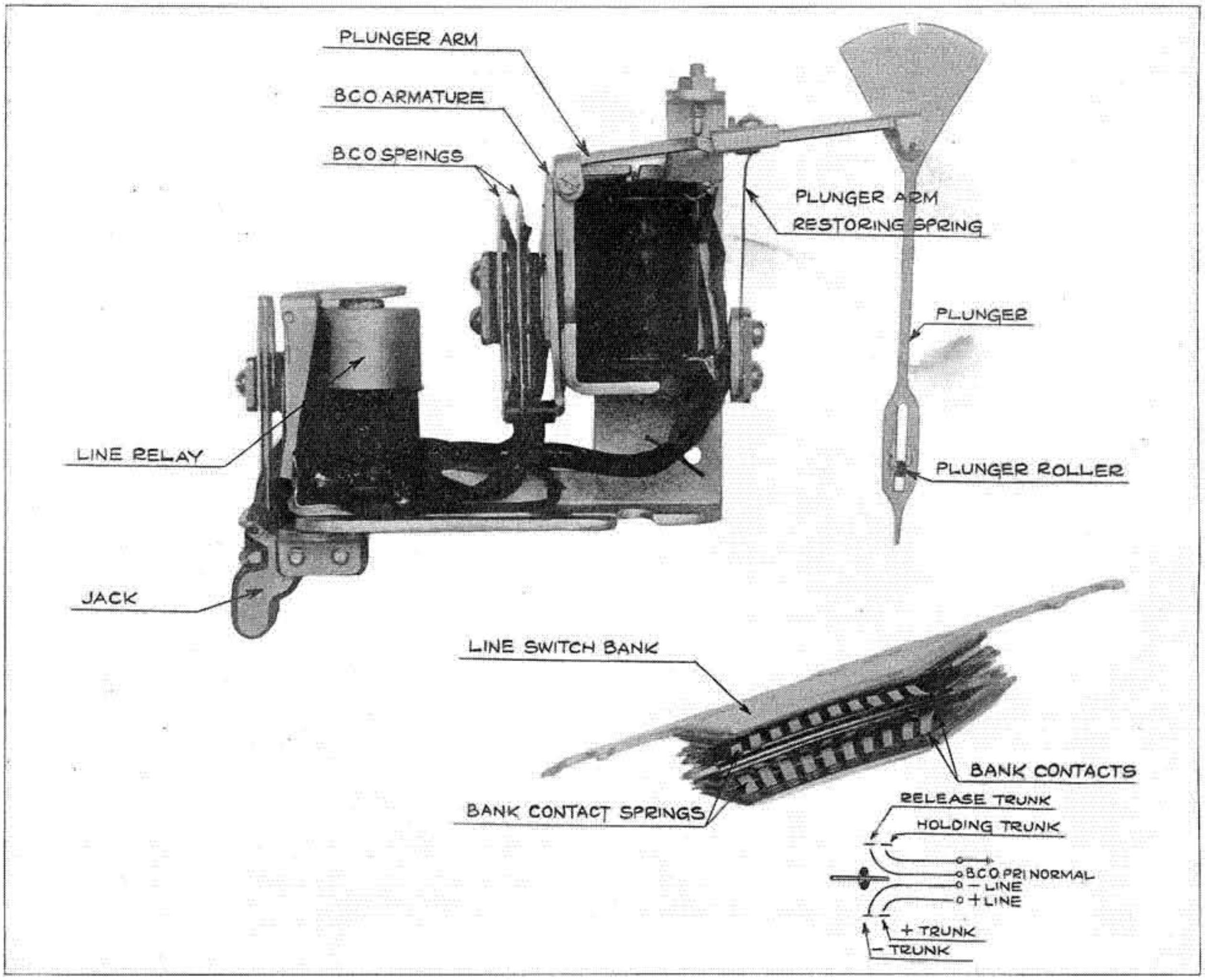


Fig. 34. Plunger type line switch and bank

Plunger Line Switch

The lineswitch consists of a line relay and a cut-off relay, such as is used in common battery manual practice, and a plunger which can be drawn into a set of bank contacts, operating them and thus connecting the subscriber's line to a trunk leading to a selector switch. In other words, it makes possible the use of a small group of trunks by a larger group of subscribers' lines.

The lineswitch bank differs in construction from the connector bank, as can be seen by the photograph in Fig. 34.

100 line system, using line switches

In Fig. 36 is shown a 100 line system using line switches. The line switch shown is standing with its plunger pointing opposite the third

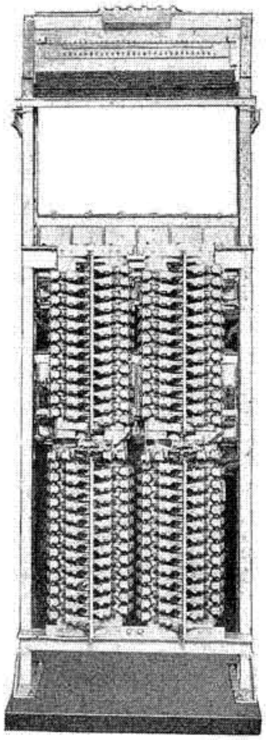


Fig. 35. Group of 100 plunger line switches

trunk. When the receiver is removed from the hook the lineswitch plunger operates the set of contacts associated with trunk No. 3, extending the connection from telephone through the lineswitch bank to the connector switch associated with trunk No. 3. The fan tail of the lineswitch plunger is disengaged from the guide shaft when the lineswitch is plunged into the bank. The instant that any lineswitch of a group plunges, disengaging itself from guide shaft, the remaining plungers seated on the shaft are stepped opposite the contacts of an idle trunk.

The entire 100 lines are served by ten connectors (more or less can be used as the traffic requires) and each lineswitch in the group has access to any one of the ten connectors.

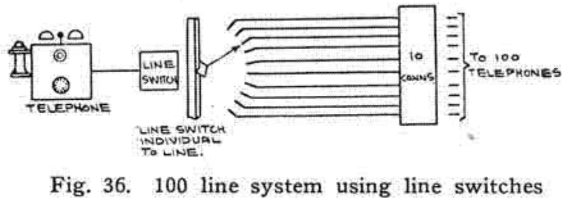


Fig. 36. 100 line system using line switches

The student is asked to compare the above system with the one described in connection with Fig. 9 where a connector is used for each line. For the purpose of this comparison, assume the cost of a lineswitch to be only one-third that of a connector.

1,000 line system, using line switches

Fig. 37 shows the trunking arrangement of a 1000 line system using a lineswitch for each telephone. This is the same as Fig. 36 except the size of system has been increased to 1000 lines.

It will be observed that the first digit from the dial operates the first selector, just as it did

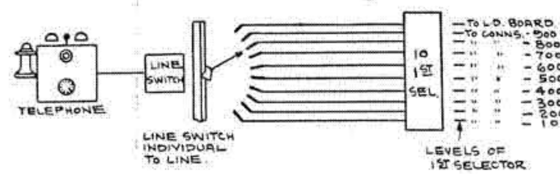


Fig. 37. 1,000 line system using line switches

before the lineswitch was introduced in the system. (See Fig. 24.)

10,000 line system, using line switches

In Fig. 39 the trunking arrangement of a 10,000 line system is shown, using a lineswitch for each telephone.

The first selectors select the thousands groups, the second selectors the hundreds, and the connectors as usual the tens and units.

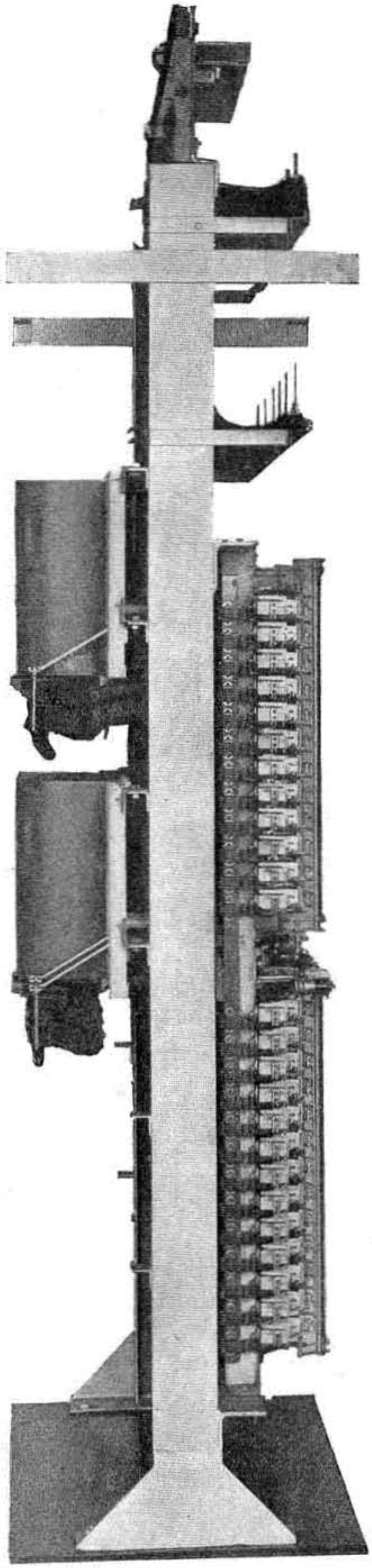


Fig. 38. Side view of 100 line unit

Fig. 40 shows the trunking arrangement of a 10,000 line system and the method of multiplying or connecting together, the banks of the lineswitches. Lineswitch No. 03 is shown plunged on trunk No. 4 while the remainder of the lineswitches, seated on the shaft guide have been stepped opposite the next idle trunk, which in this case is No. 3.

Talking circuit

Fig. 41 shows the talking circuit between two telephones. While this illustrates a connection between two telephones of a 100 line system, yet this condition will be identical on systems of any size. On larger systems, the lines merely pass through the switching relay contacts of the various selector switches.

The plunger of the lineswitch associated with telephone No. 90, is shown plunged into its bank, which extends the lines from the telephone to relay A of the connector switch. The wipers of the connector switch connect the D relay to the called telephone. The cut-off relays of both lineswitches are shown operated, thus clearing both lines of attachments and leaving them free for ringing and talking.

Current to the transmitter of the calling telephone is fed through relay A while current to the called telephone is fed through relay D.

Mechanics of the lineswitch

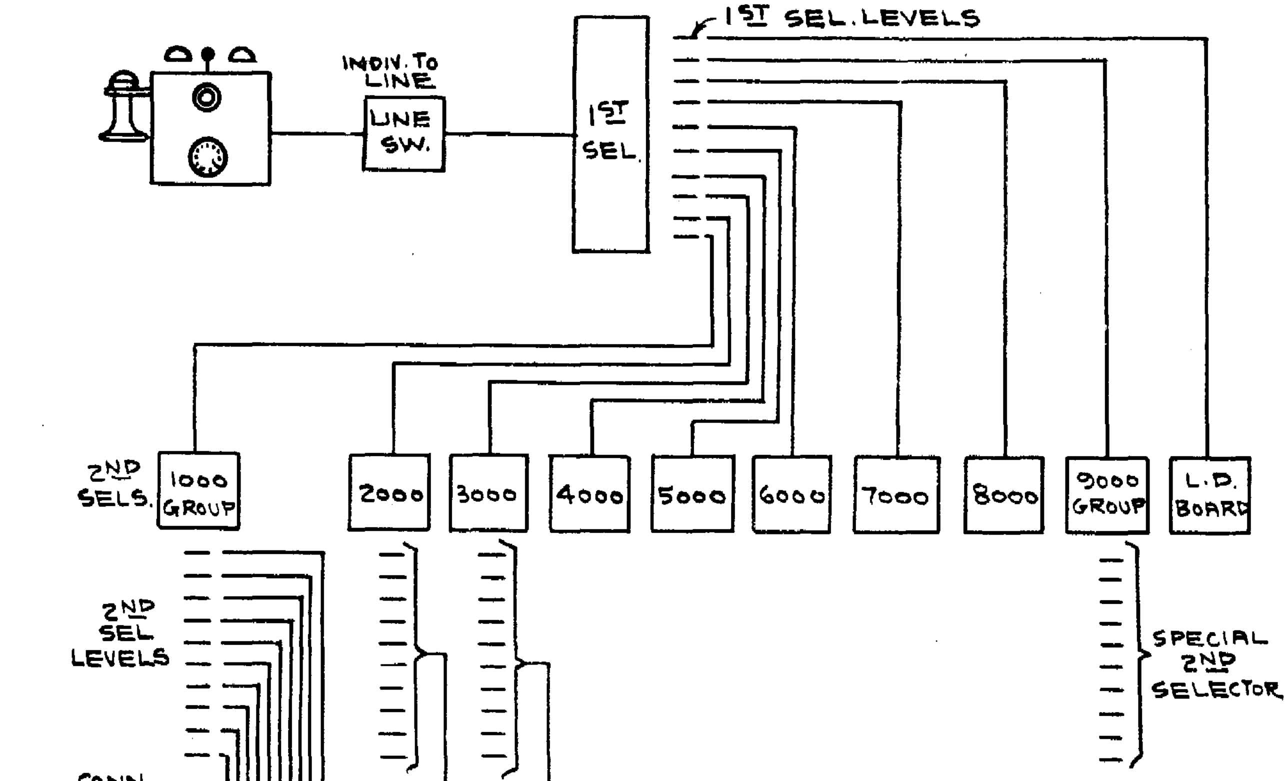
The lineswitch is the central office equipment upon which the subscribers' lines terminate.

Each lineswitch consists of a line relay, pull down coil, and bridge cut-off relay. The circuit of these is shown in Fig. 44.

The line relay has a resistance of 500 ohms and is mounted on the outside edge of the frame. The pull down and bridge cut-off coils are both wound on the same core and have a resistance of 45 and 1200 ohms respectively.

The functions of the lineswitch are as follows:

1. Operate the plunger, causing it to enter the bank and extend the lines to the selector or connector switch.
2. Disconnect the line relay and (+) battery from the line.



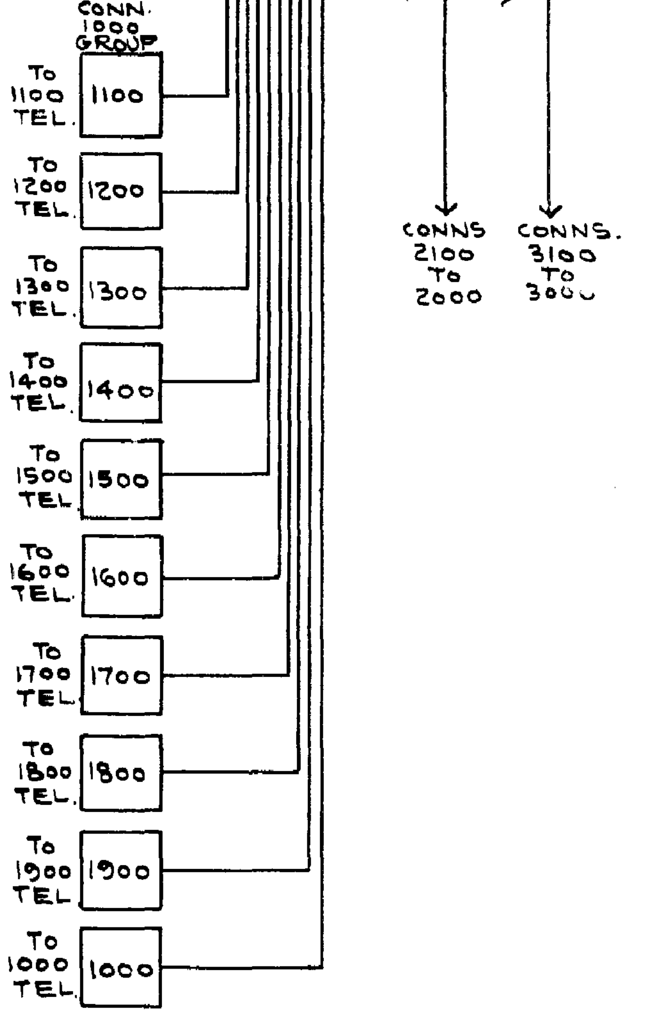


Fig. 39. 10,000 line system using line switches

3. Cause master switch to drive away other plungers so that privacy of the trunk is assured.
4. When in use it connects ground from the selector to the connector bank so as to prevent the connectors from connecting to this line while it is engaged.

The circuit of the lineswitch is similar to that of a manual line circuit using a cut-off relay. The removal of receiver energizes the line relay A, which in turn energizes the pull down winding causing the plunger to enter the bank. The bank contacts brought into connection by the plunger, connect the calling party's line to a trunk leading to a first selector. After the connection to the first selector is complete, the line relay falls away, opening the circuit to the pull down coil. The plunger is held in the banks by the B.C.O. winding.

On an incoming call, the connector switch establishes a guarding (+) potential on the private bank contact of the called party's number. This, by means of the private normal wire, energizes the B.C.O. winding on the called party's lineswitch, and operates the bridge cut-off armature, which opens the circuit to the line relay and prevents the lineswitch from entering the bank when the called party answers.

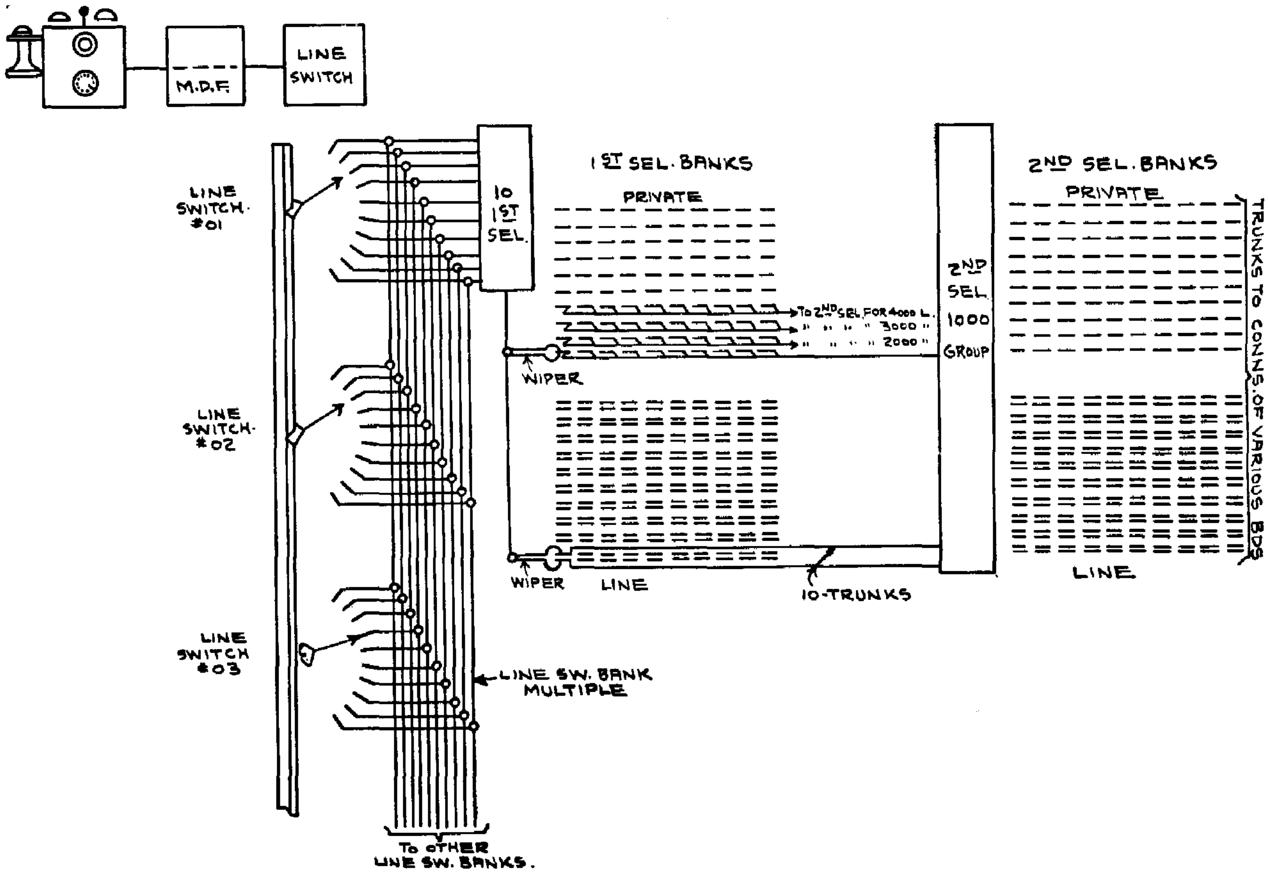


Fig. 40. 10,000 line system showing line switch multiple

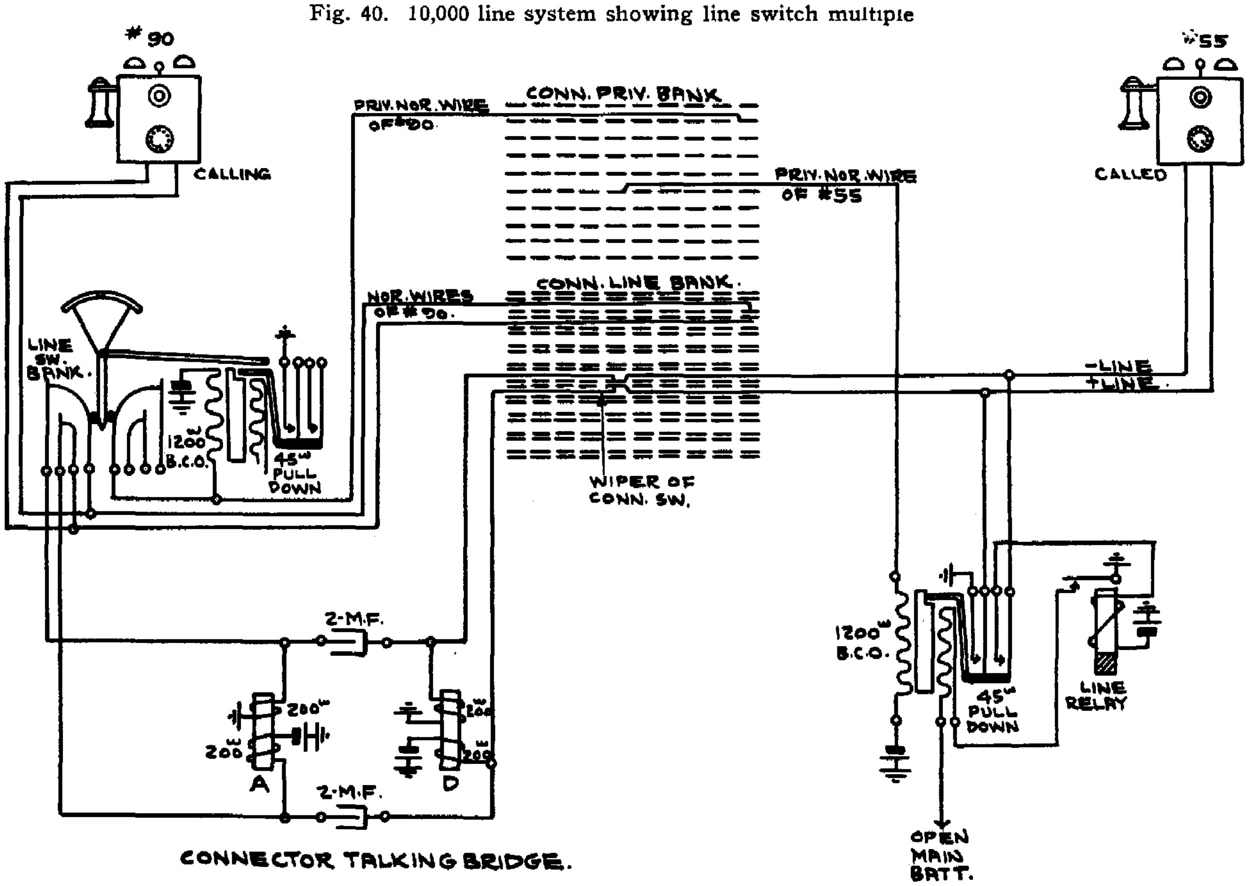


Fig. 41. Transmission circuit of 100 line system

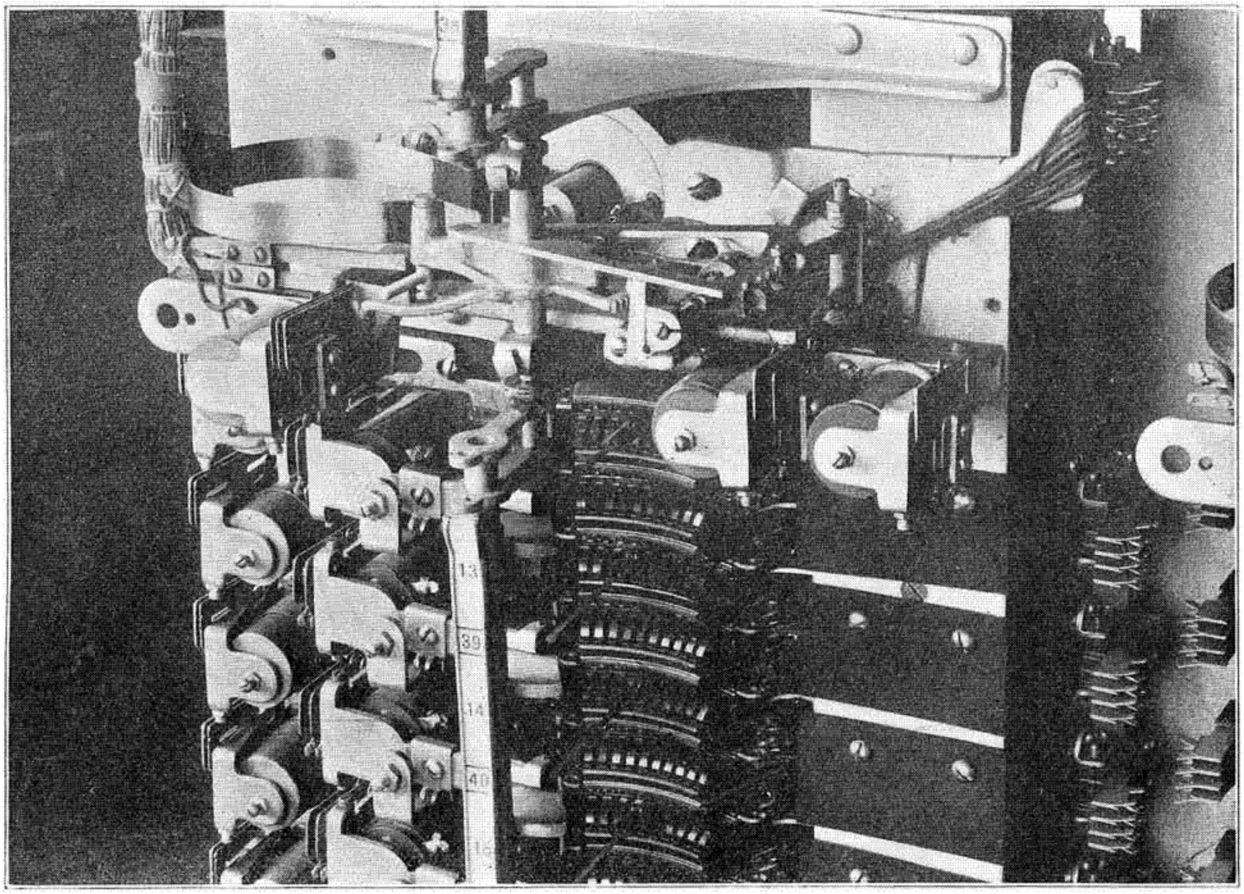


Fig. 42. Master switch and plunger guide shaft mechanism

It is common practice to mount 100 lineswitches on one side of a frame and the associated connectors on the other side.

Mechanics of the Master Switch

The functions of the master switch (see Fig. 42) are as follows:

1. Keep the shaft with plungers engaged in such a position that all the plungers will be pointed toward the contacts of an idle trunk.
2. Prevent any lineswitch from operating during the time that the master switch is hunting an idle trunk.

The power for moving the master switch from trunks one to ten is supplied by the solenoid. Its movement from trunks ten to one is the period during which it selects trunks. The "U" spring furnishes the power for movement during the trunk selecting period. The speed with which the master switch and lineswitch plungers move is controlled by the master switch governor and is between the limits of 105 and 110 cycles per minute.

When the trip relay A operates it locks mechanically and remains operated until the mechanical lock is released by arm No. 10.

The master switch bank wiper is locked mechanically to the locking segment and lineswitch shaft so that when the lineswitches are standing opposite the 10th trunk, the master switch bank wiper is resting on the 10th master switch bank contact, etc.

Line and master switch circuits

Fig. 44 shows the circuit of the line and master switches together. The removal of the receiver of the calling telephone closes the circuit from (—) battery through the winding of line relay A, contact B.C.O. springs, — line, through telephone, + line, B.C.O. springs, to supv'd (+) battery. This causes line relay A

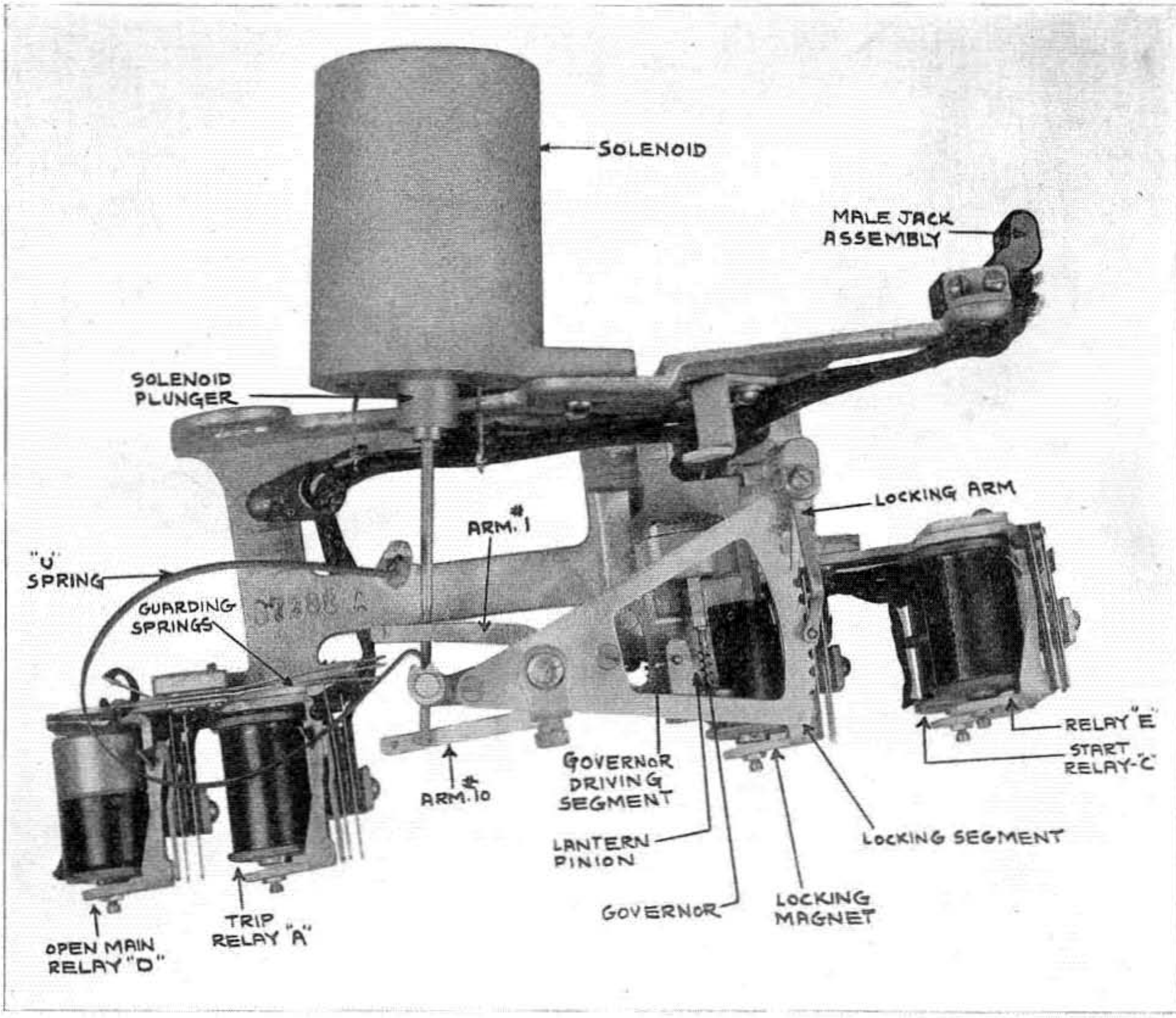


Fig. 43. Master switch

to operate and close the circuit from supv'd (+) battery contact relay A, pull down winding, contact of relay D to open main (—) battery.

The foregoing energizes the pull down coil and also operates the B.C.O. armature which disconnects line relay A from the line, but relay A will remain operated temporarily due to its slow acting feature. Following the quick action of the cut-off armature the pull down coil attracts the plunger armature and thrusts the plunger into the bank.

The plunger entering the bank closes the circuit from the telephone through the lineswitch bank contacts to relay A of the selector. Relay A on the selector, by the operation of its spring contacts energizes relay B which grounds the private or release trunk. This closes a circuit through the lineswitch bank, B.C.O. winding to (—) battery, and energizes the B.C.O. coil, which holds the bridge cut-off and plunger armature in an operated position after the line relay A has fallen away and opened the circuit to the pull down coil. This same circuit is also connected to the private normal of the lineswitch, protecting the line from seizure by a connector switch during the time the line is engaged.

The release of the lineswitch is affected by the removal of the (+) battery on the release trunk or private by the switch ahead. When the (+) battery is removed, the bridge cut-off coil of the lineswitch being de-energized, will allow the plunger to restore to a position against the guide shaft.

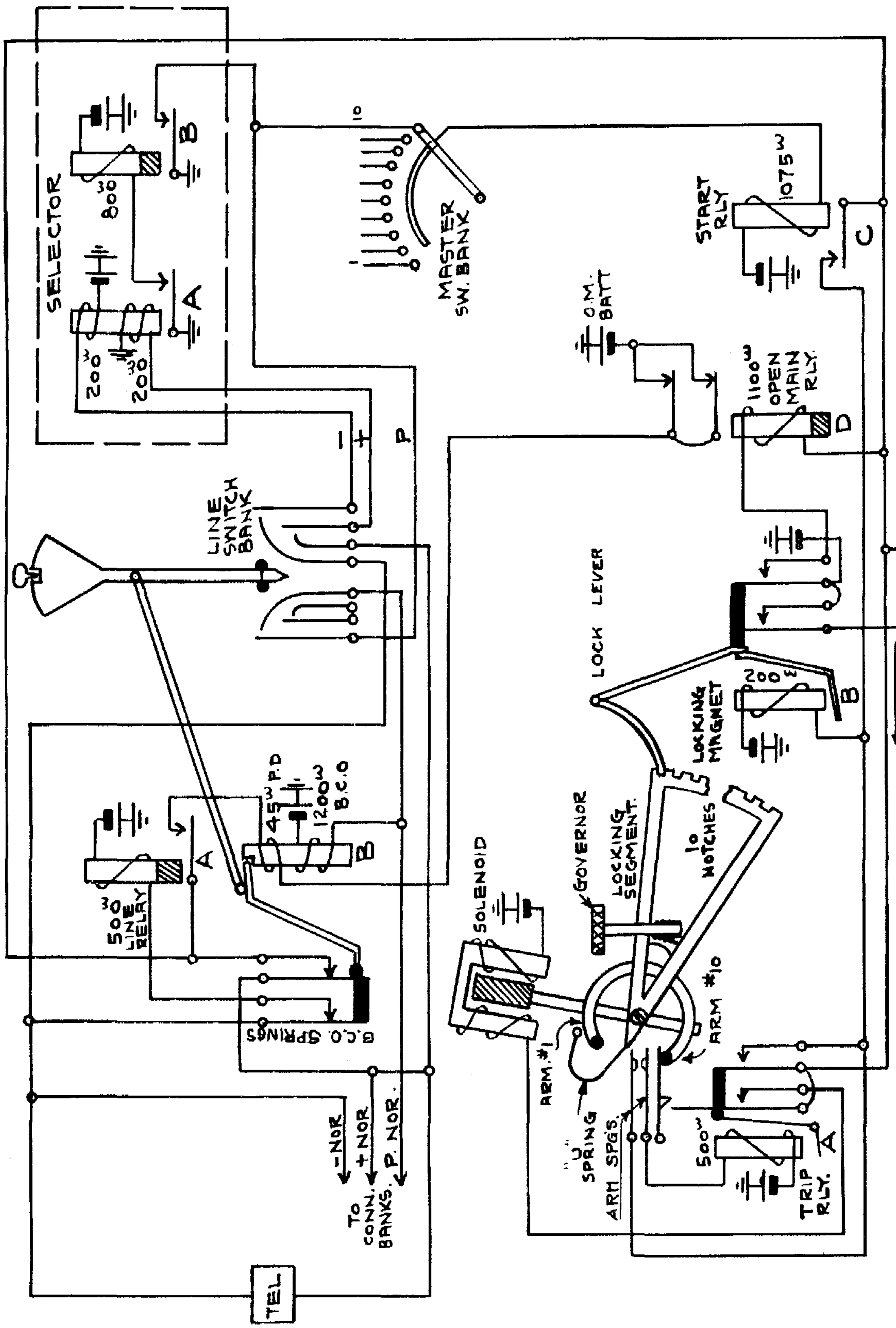


Fig. 44. Line switch and master switch circuits

The (+) battery on the release trunk is also connected through the master switch bank and wiper to relay C of the master switch, thus putting the master switch in motion. Relay C operating, closes a circuit from supv'd (+) battery through contact relay C, winding relay B to (—) battery, thus operating relay B which dis-engages the lock lever from the locking segment notches. This allows the locking segment to step from the trunk No. 10 to No. 9 under the power of the "U" spring.

During the period that the master switch is seeking an idle trunk, relay B closes a circuit from (—) battery through its spring contacts, winding of relay D, to supv'd (+) battery, thus operating relay D, opening the open main (—) battery to the pull down coils of all lineswitches under control of this master switch, until such time as an idle trunk is found. Disconnecting the battery to the lineswitches prevents them from plunging should a receiver be removed while the master switch is passing an engaged trunk.

When the master switch wiper reaches an ungrounded contact, which indicates an idle trunk, the starting relay C falls away and releases the locking magnet. Instantly the lock lever drops into a notch in the locking segment stopping the guide shaft with the idle plungers standing opposite this idle trunk.

When the guide shaft is opposite trunk No. 1, arm No. 1 is causing the two arm springs to make contact. On the next call the starting relay C operates causing the trip relay A to energize which in turn energizes the locking relay B. The springs of the trip relay A are held together by the mechanical locking spring and keep relay B energized even though starting relay C may fall away. They also energize the solenoid which pulls the guide shaft to trunk No. 10, where arm No. 10 opens the mechanical lock placed on trip relay A. During the time the guide shaft is stepping from trunk No. 1 to

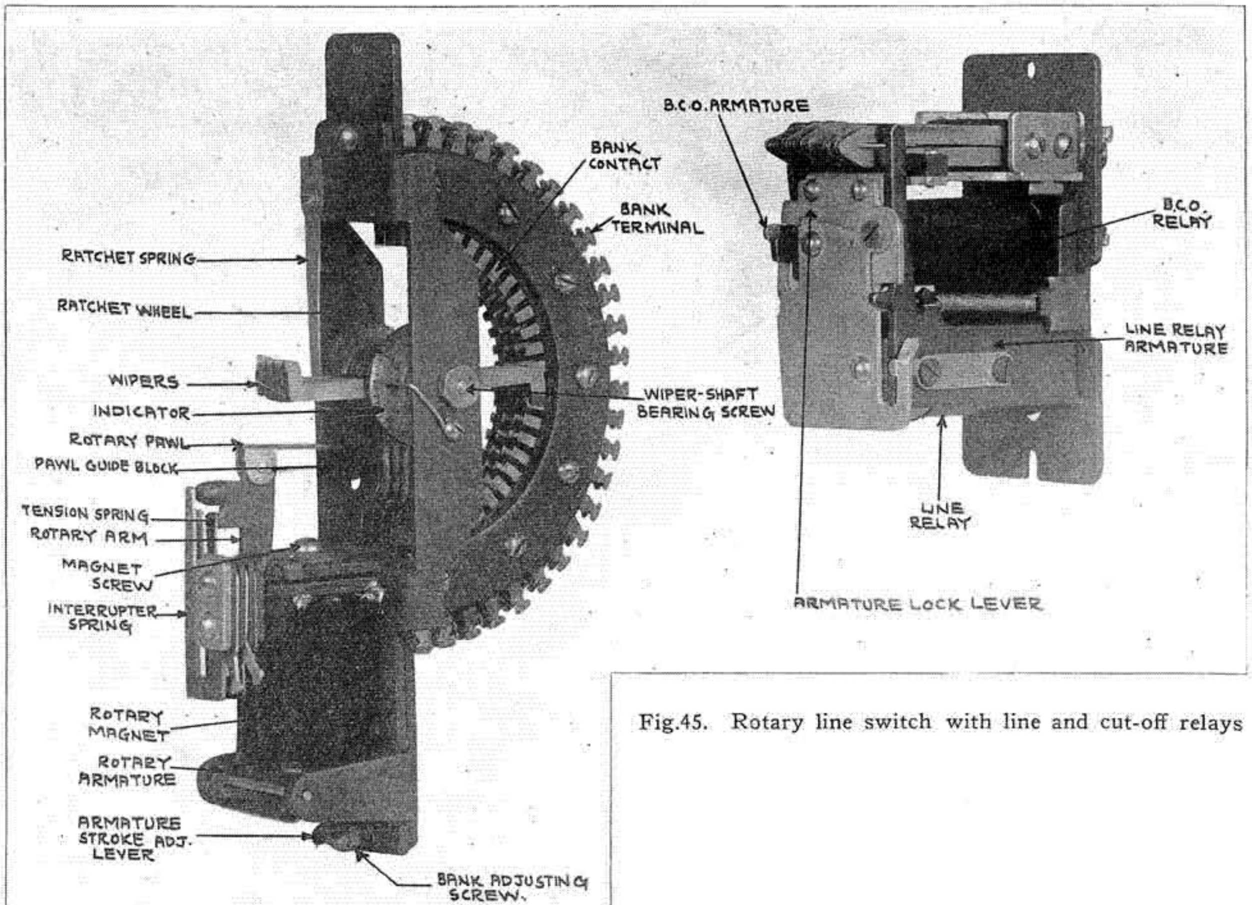


Fig.45. Rotary line switch with line and cut-off relays

No. 10 relay D remains operated thus opening the open main battery feed to the pull down coils. When trip relay A restores, the circuit to the solenoid, relays B, D and sup'vd grd. are opened and the locking relay B is returned to the control of the starting relay C. If the 10th trunk is busy the shaft will continue under the power of the "U" spring to the first idle trunk.

Rotary Line Switch

The rotary lineswitch is a more recent development. It eliminates the master switch and permits larger trunk groups and a more flexible arrangement. The banks of rotary lineswitches are made with both 25 and 50 sets of contacts. At present the 25 contact bank is the most commonly used.

The rotary lineswitch, circuit of which is shown in Fig. 46 and mechanism in Fig. 45 has a bank and four double ended wipers and by traveling a half cycle steps the wipers over all contacts. The electrical circuit is made to the wiper by two spring contacts at the hub of each wiper. The private wiper, by means of which the trunks are selected, has a longer or flatter wiping surface than the others.

The pawl rests normally between the ratchet wheel and stationary stop, locking the wipers in position. The wipers do not move unless it is necessary to hunt an idle trunk, which is determined after the call is originated. The rotary magnet armature and pawl move the wipers on its return stroke from the power received from the rotary magnet spring.

There is a line and cut-off relay with each lineswitch. The line relay is slow acting and the B.C.O. is quick acting. Associated with them is a mechanical interlocking device, which permits the cut-off relay to move its armature sufficiently to separate all back contacts but does not close any make, or front contacts if the line relay is normal. If the line relay is energized the cut-off relay can move its armature a full stroke.

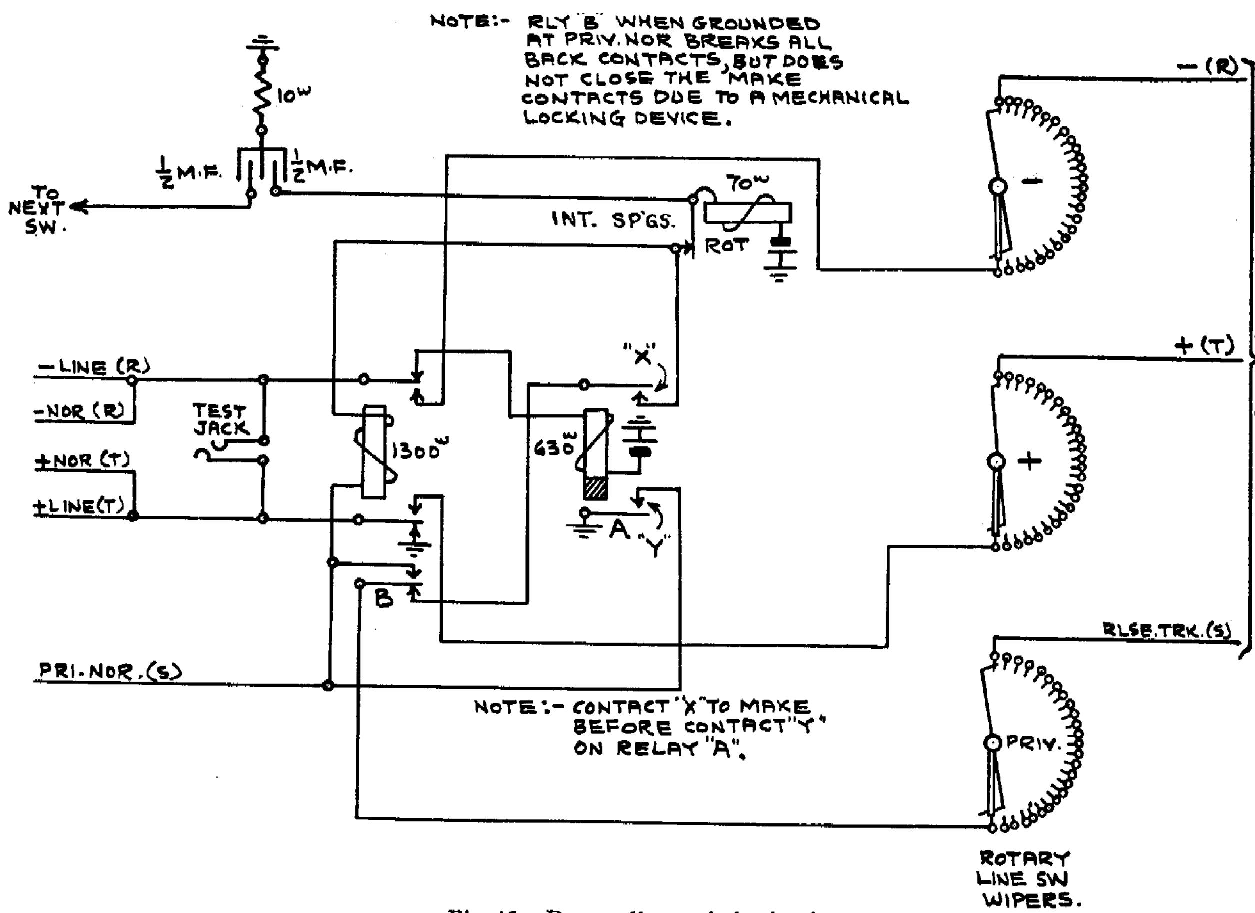


Fig. 46. Rotary line switch circuit

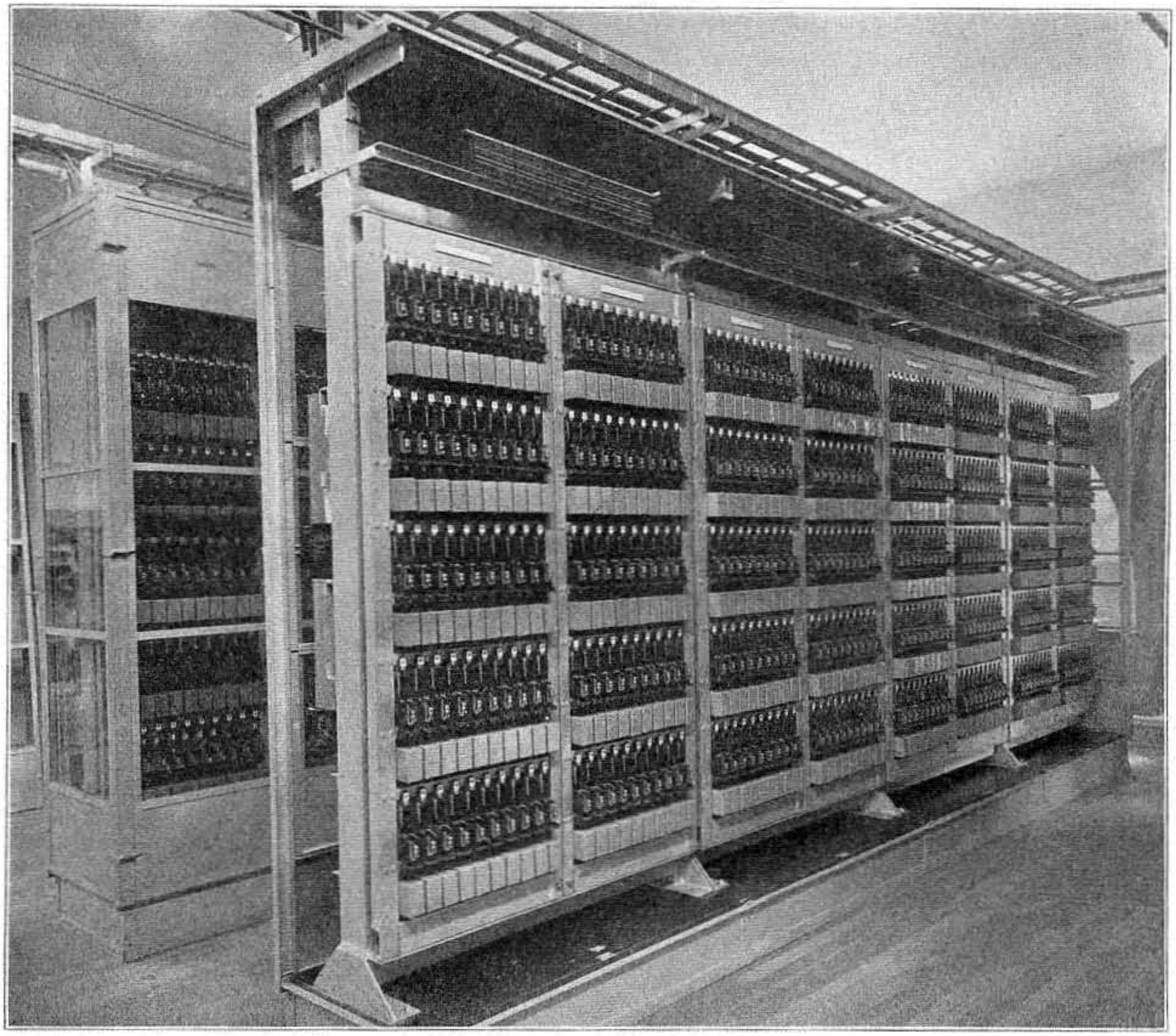


Fig. 47. Switchroom view, showing rotary line switches installed

Rotary line switch circuit

The removal of the receiver by the calling party causes the line relay A to energize from (+) battery, contact relay B, + line, telephone, — line, contact relay B, through winding of relay A to (—) battery. Relay A operating makes the "X" contacts first. If the trunk the wipers are resting on is busy, (+) battery will be connected through the private wiper, back contact relay B, "X" contacts relay A, contact rotary magnet, winding rotary magnet to (—) battery. Relay B does not operate as it is shunted by (+) battery being connected to both terminals of its winding. The rotary magnet operating opens its own circuit at the interrupter springs, upon completion of its stroke. The rotary pawl and armature restoring to normal under the control of the rotary magnet restoring spring, steps the wipers to the next trunk. If the next trunk is not busy the private wiper does not encounter (+) battery, therefore relay B operates from (+) battery, "Y" contacts, relay A, winding relay B, contact rotary magnet, winding of rotary magnet to (—) battery. The rotary magnet will not operate in series with relay B. Relay B, operating connects the — trunk, + trunk, and release trunk through to the first selector.

Relay B is energized from the holding (+) battery placed on release trunk at the first selector after relay A has fallen away.

On incoming calls Relay B is operated sufficiently to open all back contacts from the (+)

battery placed on the private normal at the connector bank.

The ½ M.F. condenser and 10 ohm resistance connected to the rotary magnet prevents undue sparking at the interrupter contacts.

Review

1. Why was the lineswitch developed?

Fig. 44

2. What relay on the lineswitch operates when its line is called by a connector?
3. What is the purpose of the supervised ground relay?
4. In which direction does the master switch select trunks?

Fig. 46

5. What equipment is eliminated by the use of the rotary lineswitch?
6. Are the wipers of the rotary lineswitch stepped during the energization or de-energization of the rotary magnet?
7. Why is the shunt placed around relay D while the wipers are rotating over busy trunks?

CHAPTER 7

Secondary Line Switches

THE object of the secondary lineswitch is to reduce the number of trunks and trunking apparatus by taking advantage of the economy offered by large trunk groups. It has been proven by experience that small trunk groups can not handle as many calls per trunk as can large trunk groups.

Secondary lineswitches are used in two places: first, (local) between primary lineswitches and first selectors to reduce the number of first selectors required; and second, (outgoing) between selector banks and repeaters (connected to trunks to other offices) to reduce the number of trunks between offices.

Both the plunger and rotary type lineswitches are used as secondaries.

It is common practice to mount secondary lineswitches on both sides of the mounting frame; that is, 200 lineswitches to one frame or upright.

Each plunger type secondary unit is usually divided into four sub-groups of 25 lineswitches or less, and in some cases two sub-groups of 50 lineswitches or less.

Each rotary type secondary unit is divided into two sub-groups of 50 lineswitches or less.

Ten sub-groups constitute a complete or "regular group."

Assume each of ten primary lineswitch units each equipped with 100 lineswitches and ten outgoing trunks, each terminated on a first selector. This would be referred to as 10% trunking and would require 100 first selectors for outgoing service for the 1000 lines. On this basis each 100 lines would have access to only ten individual first selectors.

It frequently occurs that the telephones of some lineswitch units originate a greater number of calls than do the telephones of other units, therefore, by terminating the primary lineswitch trunks on secondary line switches a flexibility is secured which makes all of the first selectors available to any of the primary lineswitch trunks. This method actually provides more outgoing trunks to each lineswitch unit and reduces the number of first selectors due to the increased efficiency of the large trunk group.

Plunger Primary Line Switch with Plunger Secondary

Fig. 49 is a schematic circuit showing the Primary Lineswitch, Primary Master Switch, Metering relays, Plunger Secondary Lineswitch, Secondary Master Switch and trunk connections to first selectors.

The removal of the receiver by the calling party closes the circuit from (—) battery through winding of relay A, contacts B.C.O. springs, — line, calling telephone, + line, contacts of B.C.O. springs to supv'd (+) battery. This causes the line relay A to operate and close the circuit from supv'd (+) battery through the pull down winding, winding of relay G, contact relay D1 to

(—) battery, thus energizing the pull down coil which operates the B.C.O. armature and disconnects line relay A from the line. Relay A remains operated temporarily due to its slow acting feature. Following the quick action of the cut-off armature the pull down coil attracts the plunger armature and thrusts the plunger into the bank.

The plunger entering the bank closes the circuit from (+) battery through meter relay M, (Relay M will not operate in series with the 2700 ohm winding of relay C), primary lineswitch bank contacts, winding relay C to (—) battery. Relay C operates and connects (+) battery through its make contacts, 85 ohm pull down winding of the secondary lineswitch, B.C.O. springs, through winding of relay A2, contact relay D2, both windings of relay A4, contacts relays D3 and C2 through winding of relay E1 to (—) battery. The secondary lineswitch is retarded in plunging until relay A4 operates and shunts its 3400 ohm winding, thus giving the start relay C1 sufficient time to operate before the secondary lineswitch plunges into the bank.

The 3400 ohm winding of relay A4 is sufficient resistance in the (—) battery circuit to the secondary line switches to prevent a shunt and its consequent effect of retarding the release of start relay C1 when the primary master switch steps to an idle trunk.

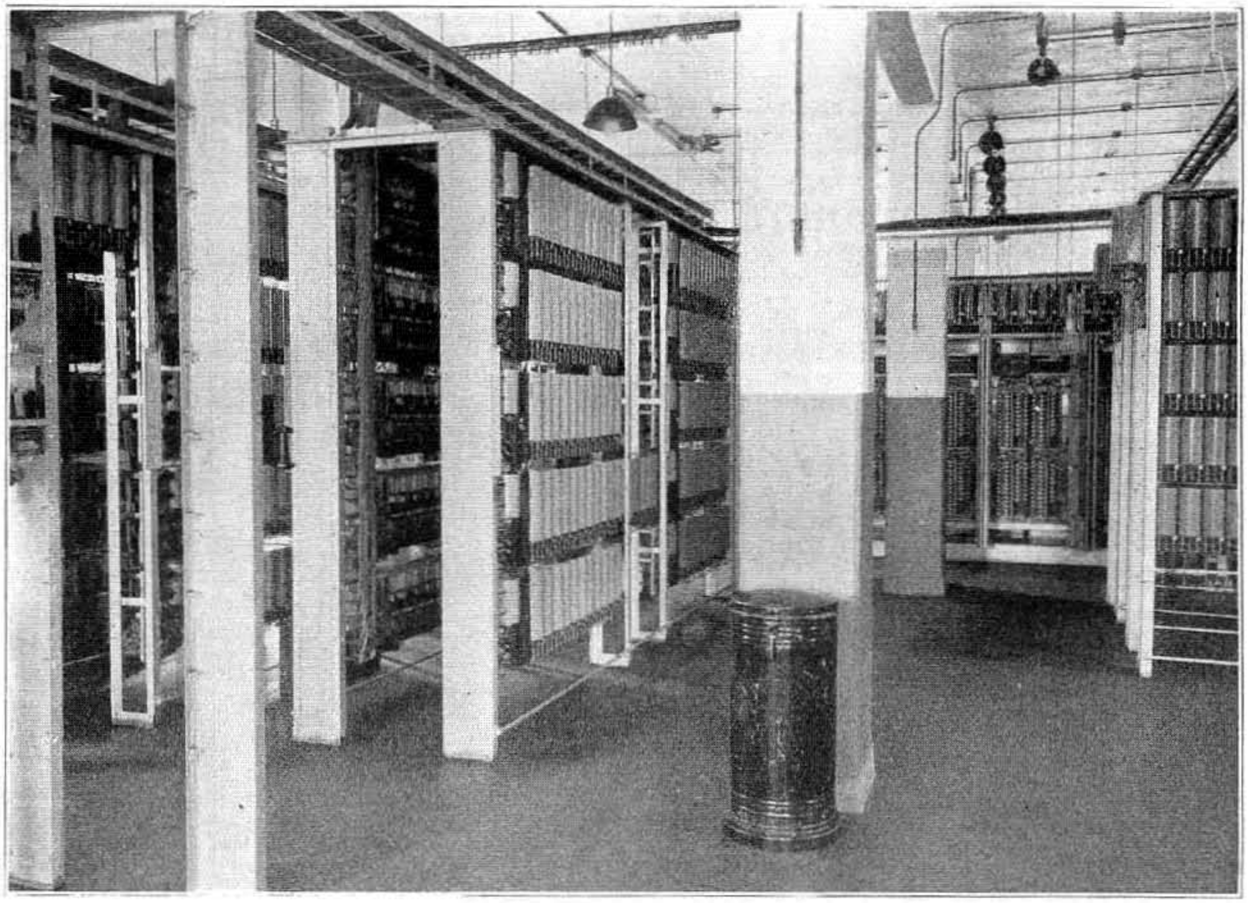


Fig. 48. Switchroom view, showing connectors and secondary line switches installed

The (+) battery from the contact of relay C is also furnished to the primary master switch bank, starting relay C1 to (—) battery. Start relay C1, operating closes a circuit to relay B1 thus operating it and disengaging the lock lever from the locking segment notches. This allows the master switch to step from trunk No. 10 to No. 9 under the power of the "U" spring.

During the period that the master switch is seeking an idle trunk, relay D1 is operated, thus opening the "open main" battery to the pull

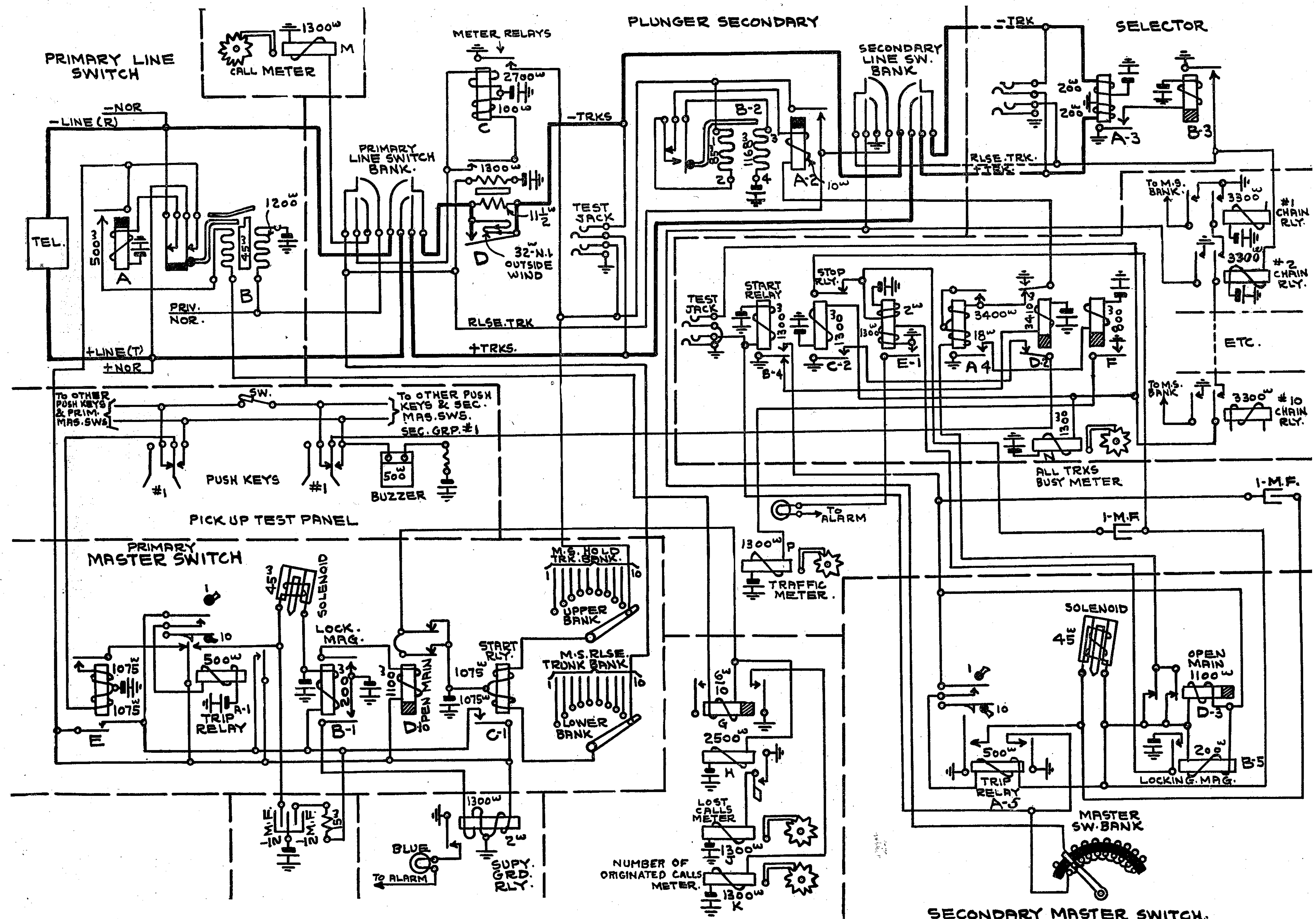


Fig. 49. Circuit showing plunger type primary and secondary line switches, with metered service

down windings of all lineswitches under the control of this master switch, until such time as an idle trunk is found.

Relay C also connects (+) battery through its make contact, contact relay A2, primary lineswitch bank, B.C.O. winding to (—) battery, energizing the B.C.O. winding, and holding the plunger in the bank, after relay A has fallen away.

A portion of the (+) battery from contact of relay C is furnished, via the contact of relay A2 to the 1300 ohm winding of relay D to (—) battery. The 1300 ohm winding does not have sufficient power to operate the relay. The current from relay A3 of the first selector flows through the 11½ ohm winding of relay D in the reverse direction to that flowing in the 1300 ohm winding, thus poling relay D to prevent its operation. When the called party answers, the connector reverses the current supply to the calling party, causing the current to flow through the 11½ ohm winding of meter relay D in the same direction as the current flow in the 1300 ohm winding, thus operating relay D, and through its contacts placing a shunt on the 2700 ohm winding of relay C. The call meter "M" now operates from (—) battery through the 100 ohm winding of relay C and registers the completed call. The 11½ ohm and 32 ohm N.I. resistances in the — trunk is shunted by the operation of relay D.

The secondary lineswitch plunger entering the bank closes its own holding circuit from (+) battery contact relay C through 85 ohm winding relay B2, B.C.O. springs through 1168 ohm winding relay B2 to (—) battery.

The secondary lineswitch plunger entering the bank closes a circuit from (+) battery through the secondary lineswitch bank contacts, master switch bank, winding of start relay B4 to (—) battery. Relay B4 operating, connects (+) battery through its make contact, through relays D3 and D5 in multiple, contact relay C2, winding relay E1 to (—) battery, thus operating the locking magnet B5, which disengages the lock lever from the locking segment notches. This allows the master switch to step to the next idle trunk.

During the period that the secondary master switch is seeking an idle trunk, relay D3 is operated, thus opening the "open main" battery to the pull down windings of all idle secondary lineswitches until such time as an idle trunk is found.

With the secondary lineswitch plunged, the circuit is complete from (+) battery through winding of relay A3, trunk, secondary lineswitch bank contacts, + trunk, primary lineswitch bank contacts, + line, telephone, — line, primary lineswitch bank contacts, 11½ ohm and 32 ohm N.I. windings of relay D, — trunk, secondary lineswitch bank contacts, trunk, through winding of relay A3 to (—) battery. Relay A3 by the operation of its spring contacts energizes relay B3, which connects (+) battery through its spring contacts to the release trunk. This forms a holding circuit for the B.C.O. winding of primary lineswitch and 1300 ohm winding of relay D after relay A2 restores and opens the holding (+) battery which it had placed on the B.C.O. relay of the primary lineswitch. The chain relay associated with the selector is also energized from (+) battery at spring contacts of relay B3.

The foregoing explanation was of an originating call on trunk No. 10 of a primary lineswitch group. The following explanation, using the same trunk as an illustration, is based on the assumption that this particular trunk is not engaged at the time that all trunks leading from the secondary lineswitch sub-group to the first selector became engaged.

Assuming that all trunks leading from the secondary sub-group to first selectors are busy, the chain relays associated with each trunk will be operated, extending (+) battery from spring contacts of No. 1 chain relay through the contacts of each chain relay, through relay C2 to (—) battery. Relay C2 operating, opens the (—) battery feed to the secondary master switch, so that it does not continue to rotate when all of its outgoing trunks are busy. Should the master switch stop on No. 2 trunk, thus operating the start relay B4 from (—) battery, winding of relay B4, master switch bank, to (+) battery at contact of chain relay No. 2, thus opening the circuit to relay D2 but it remains operated a short period due to its slow acting feature.

Relay C2 operating extends (+) battery through its spring contacts, contacts relay D2, push keys on "Pick up test panel," winding relay E to (—) battery. Relay E operating closes its own locking

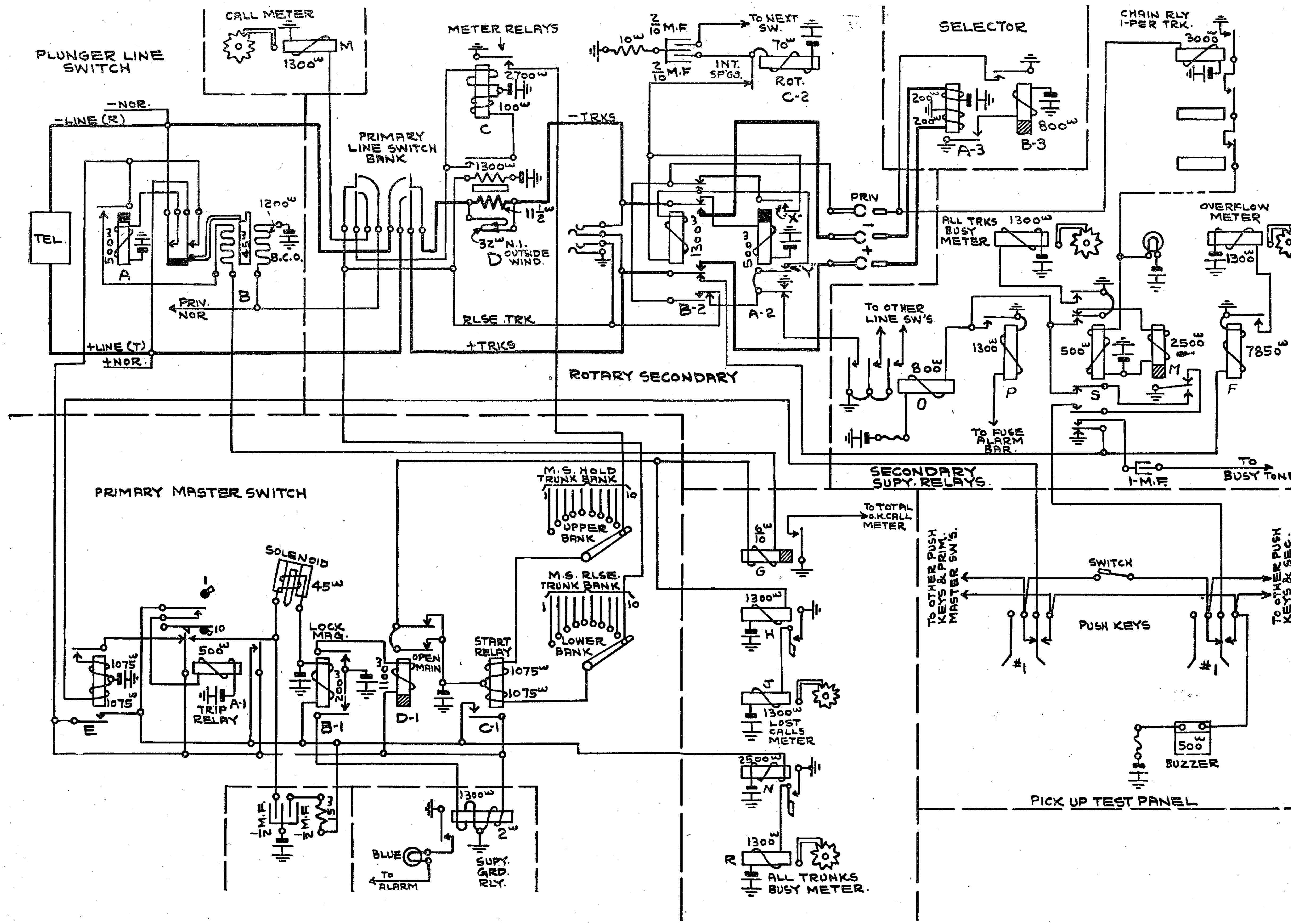


Fig. 50. Circuit showing plunger type primary and rotary secondary line switches, with metered service

circuit through its make contact, and the contact of relay A1 to supv'd (+) battery. Relay E also closes a circuit from supv'd (+) battery through its make contact, winding of locking magnet B1 to (—) battery. Relay B1 operating allows the primary master switch to make one complete cycle picking up all idle plungers that have released but have not been seated in the shaft to prevent their plunging into a secondary trunk which terminates in the busy sub-group. All other primary master switches having trunks terminating in the busy secondary sub-group will be moved one complete cycle. Relay E of each primary master switch is wired to an individual key on the "Pick up test panel." Each secondary sub-group, is also wired to an individual key on the "Pick up test panel." The reason for and details of the "Pick up" panel will be explained later.

Relay D2 being slow acting remains operated a sufficient length of time to rotate the primary master switches one complete cycle, then falling away it connects (+) battery through its back contact, winding relay A2, B.C.O. spring contacts, 85 ohm pull down winding, to trunk No. 10 of the master switch hold bank, thus guarding the trunk and preventing its selection by the master switch.

The (+) battery through the back contact of relay D2 is fed back to all the idle trunks in the various primary line switch units having trunks terminating in this busy secondary sub-group.

The "Pick up test panel" is for the purpose of testing to locate trouble should it occur on the common lead. This common lead, associated with each secondary sub-group is connected to the master switch of each primary lineswitch unit having trunks terminating therein. Therefore, should trouble, a ground for instance, occur on this lead the pick up panel with its keys affords a rapid means to determine in which one of the primary units or secondary sub-groups the trouble lies.

A ground on one of these common leads causes all the primary master switches associated therewith to rotate. Opening the knife switch separates the common between the primary and secondary equipment, and if the primary master switches cease to rotate, indicates that the common lead is grounded in one of the secondary sub-groups. Then by operating each secondary push key individually, the buzzer will sound when the sub-group causing the trouble is reached. If the primary master switches continue to rotate after the knife switch is opened, this indicates that the trouble is in the primary boards. The knife switch should be closed and each primary master switch push key operated individually until the buzzer sounds, indicating the trouble is in that unit.

The meter "J" records each call that is lost due to all primary trunks being engaged. The movable spring of relay "H" has a small weight attached to it which causes it to vibrate when the relay is first operated thus keeping the meter from recording during the time the master switch is moving from trunk No. 1 to No. 10 as relay H must cease vibrating before meter will operate.

The meter "K" records the total number of originated calls.

The meter "P" records the total calls passing through the secondary sub-group.

The meter "N" records the number of times all of the outgoing trunks from the secondary sub-groups are busy.

Relay E1 closes the slow-acting alarm circuit associated with the secondary line and master switches while the "supv'd grd." relay performs a similar function for the primary line and master switches.

The condenser associated with the primary master switch prevents undue sparking at the spring contacts of relays A1 and C1.

Plunger Primary Line Switch with Rotary Secondary

Fig. 50 is a schematic circuit showing a primary lineswitch, primary master switch, metering relays, rotary secondaries and trunk connections to first selectors. It is identical with that explained in connection with Fig. 49 except that in Fig. 50 the rotary type lineswitch is used as a secondary instead of the plunger type.

The removal of the receiver by the calling party causes the primary lineswitch to plunge and the primary master switch to step to an idle trunk as previously explained.

The plunger entering the bank closes the circuit to relay A2 from (—) battery, through the winding of relay A2, contacts relay B2, —

trunk, $11\frac{1}{2}$ ohm winding of relay D, contacts primary line switch bank, — line, telephone, + line, contacts primary line switch bank, + trunk, contacts relay B2, back contacts of relay S to (+) battery. Assume that the trunk on which the wipers of the secondary lineswitch are resting is busy, relay A2 operating tests the trunk for being engaged, from (+) battery at private contact of the busy trunk, private wiper, contacts relay B2, "X" contacts relay A2, contacts rotary magnet "C," winding rotary magnet to (—) battery. Relay B2 does not operate as it is shunted by (+) battery being connected to both terminals of its winding. The rotary magnet operating opens its own circuit at the interrupter springs upon completion of its stroke. The rotary pawl and armature restoring to normal under the control of the rotary magnet restoring spring steps the wipers to the next trunk. If this next trunk is not busy the private wiper does not encounter (+) battery. Therefore relay B2 operates from (+) battery, "Y" contacts relay A2, winding relay B2, contacts rotary magnet, winding rotary magnet to (—) battery. Relay B2 operating connects the calling party's line through to the first selector.

Relay B2 is held energized from (+) battery placed on the release trunk by relay B3 of the selector after relay A2 has fallen away. This same (+) battery also energizes the chain relay associated with the first selector.

Assuming that all trunks leading from a secondary sub-group to first selectors are busy, then the chain relays associated with each trunk will be operated and extend (+) battery from spring contacts of No. 1 chain relay, through the contacts of each chain relay, through relay S to (—) battery. Relay S operating connects (+) battery through contacts of relays M and S, pick up test panel push keys, winding relay E to (—) battery. Relay E operating closes its own locking circuit to supervised (+) battery, and also closes a circuit from supervised (+) battery to relays B1 and D1. Relay B1 operating allows the primary master switch to make one complete cycle picking up all idle plungers that have released but have not been seated on the shaft, to prevent their plunging into a secondary trunk which terminates in the busy sub-group. All primary master switches having trunks in the busy secondary sub-group will be moved one complete cycle.

Relay M being slow acting remains operated a sufficient length of time to assure the operation of relay E on all of the primary master switches trunking into the busy secondary group. Relay O operates from (+) battery at contacts of relay S and connects (+) battery through its fifty contacts to the respective master switch release banks, thus guarding all trunks and preventing their selection by the primary master switches.

In the event a primary lineswitch connects to a busy secondary sub-group before the operation of relay M the busy tone will be received and the overflow call meter will be operated.

In case a fuse blows relay P will operate and close a circuit through relay O which operates, and busies all trunks terminating in the secondary subgroup by placing (+) battery on the release trunk wire of all trunks entering this sub-group.

The "all trunks busy" meter operates each time all trunks of the secondary sub-group become busy.

Relay N also operates an "all trunks busy" meter each time all the trunks of a primary lineswitch group are busy.

The 2/10 M.F. condenser and 10 ohm resistance connected to the rotary magnet prevents undue sparking at the interrupter contacts.

Review

Fig. 49

1. What advantages are gained by the use of secondary lineswitches?
2. Why are chain relays used?
3. When does call meter M operate?
4. How is the primary lineswitch held in its bank before (+) battery is connected to the release trunk at relay B-3 of the first selector?
5. Does the primary master switch rotate with all trunks busy? Does the secondary master switch rotate?
6. What is the object of the "Pick up test panel"?
7. Explain how idle secondary lineswitches in a busy secondary sub-group are protected from selection at the various primary lineswitch units?

Fig. 50

8. Does the primary master switch rotate with all trunks busy?
9. Explain the primary master switch "pick up feature."
10. What equipment is eliminated by the use of the rotary lineswitch?

CHAPTER 8

The Impulse Repeater

THE impulse repeater shown in Fig. 51 is used in connection with automatic systems where more than one office is installed. It is connected in outgoing trunks from one office to another to eliminate the necessity of using a three wire trunk to hold the connection, as has been the case in the systems studied thus far.

Purpose of Repeaters

In addition to eliminating the third conductor the repeater provides current for the transmitter of the calling party. The advantage is that the efficiency of the transmission remains constant and does not vary as would be the case if the transmitter current was obtained from the connector at a distant office.

The functions of the impulse repeater are as follows:

1. Ground the release trunk to hold switches back of it.
2. Repeat impulses to operate switches in distant office.
3. Reverse current supply to calling party, when battery is reversed to it.
4. Supply transmitter current to the calling party, for conversation.

Circuit before impulsing

In Fig. 52 is shown the repeater circuit preparatory to repeating impulses to an incoming switch at a distant office.

Relay A is held operated from the loop through the telephone of the calling party. Relay A by the operation of its spring contacts energizes relay B, which connects (+) battery to the release trunk to hold the lineswitch and selectors preceding the repeater. It also connects (+) battery to the 1900 ohm winding of relay F to (—) battery. The 1900 ohm winding does not have sufficient power to operate its armature.

Relay B also closes the circuit of relay A of the incoming selector at the distant office from (+) battery through the winding relay A, + trunk, contact relay A, 250 ohm winding relay E, contact relay D, 60 ohm winding relay F, (relay F does not operate as the current flowing through the 60 ohm winding is in the reverse direction to that flowing in the 1900 ohm winding), contacts relays C and B, — trunk, winding relay A to (—) battery.

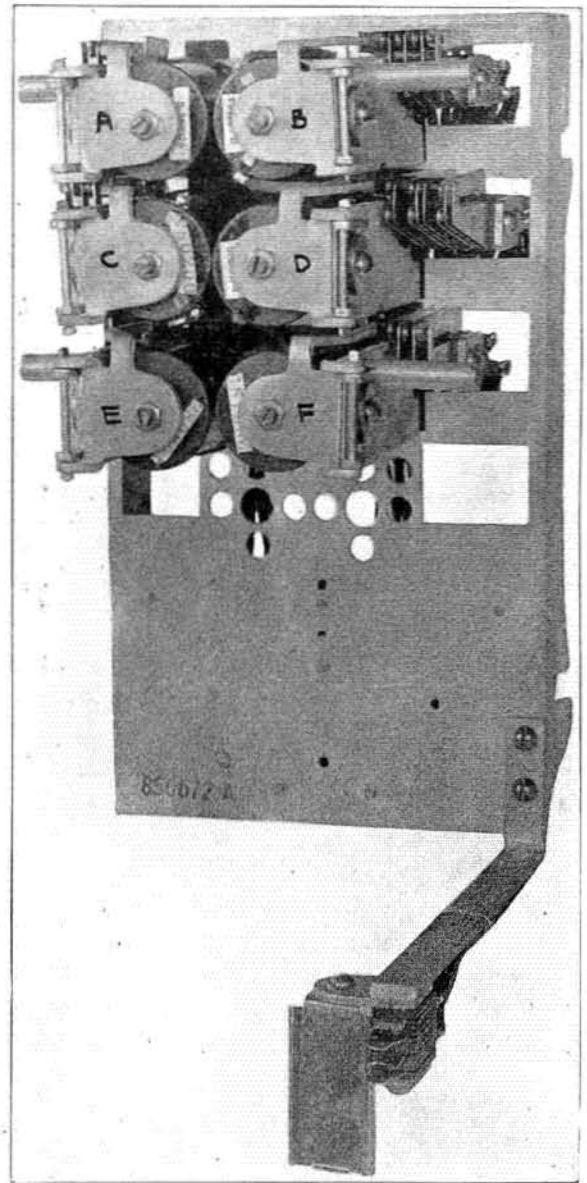


Fig. 51. Impulse repeater

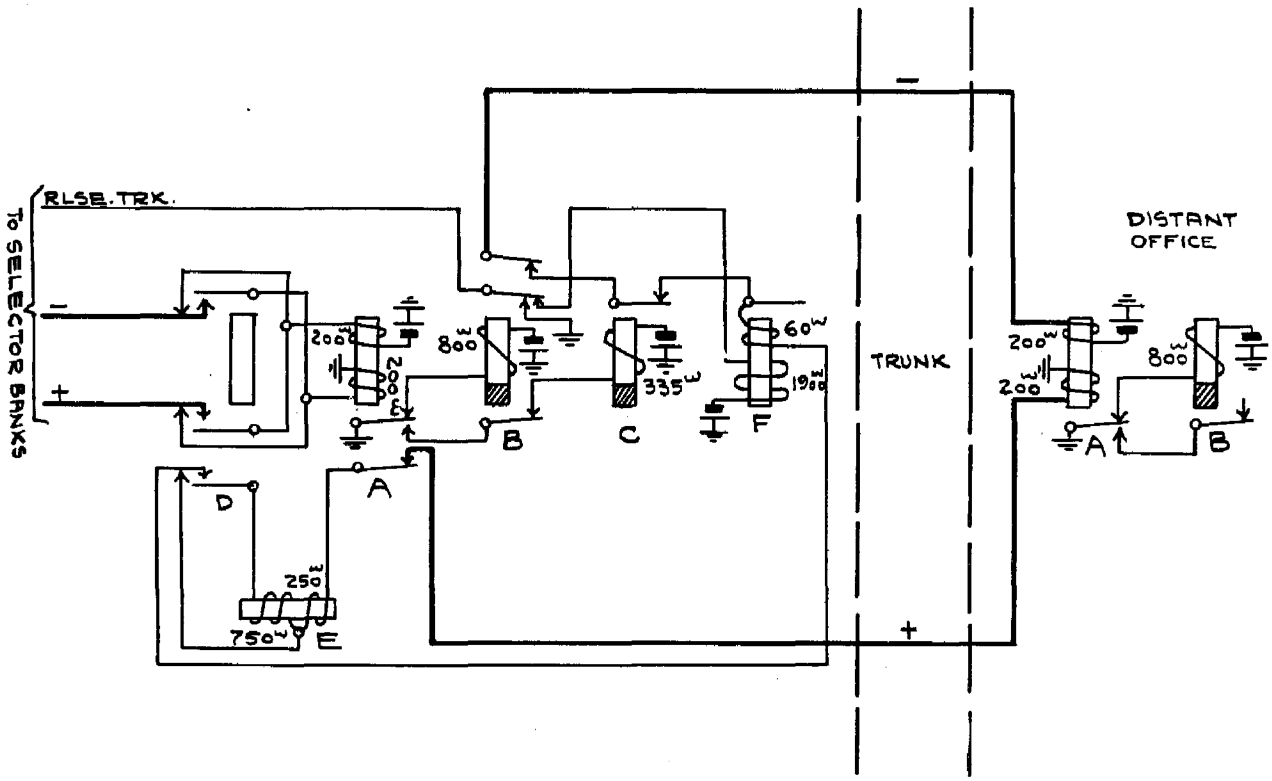


Fig. 52. Circuit of repeater ready for impulsing

Impulse circuit

Fig. 53 shows the repeater circuit during the impulsing period. On the first impulse received relay A falls away and causes relay C to operate from (+) battery, contacts relays A and B, through winding of relay C to (—) battery. Relay C operating shunts the 60 ohm winding of relay F and the 250 ohm winding of relay E during each series of impulses. Thus all resistance at the repeater is removed from the circuit to the incoming selector during impulsing.

Each time relay A of the repeater falls away in response to the interruptions received from the calling telephone, the circuit of relay A of the incoming selector at the distant office is opened at contact of relay A of the repeater, thus repeating the impulses to the incoming selector.

Talking circuit

When the called party removed the receiver to answer the call, current supply to the line from relay A is reversed (as shown in Fig. 17). In the event that the call comes from a distant office in which case there will be a repeater in the circuit at that distant office, reversal of the current supply from the A relay of the connector, reverses the battery flowing through the 60 ohm winding of relay F on the repeater. Reversing the direction of current in the 60 ohm winding causing it to flow in same direction as that of the 1900 ohm winding will operate relay F. (See Fig. 54.)

Relay F operating closes a circuit from (+) battery contact relay F, winding relay D to (—) battery. Relay D operating reverses the battery to the calling party for the purpose of operating a traffic meter or to give supervision in case the call originated at a manual board.

Relay D also connects the 750 ohm winding of relay E in series with the trunk holding bridge, thus making a total of 1060 ohms bridged across the trunk to hold the switches in the distant office. This additional impedance is added to the trunk holding circuit to improve the transmission.

During the period of conversation, relays D, A, B, E, and F of the repeater are operated.

The complete circuit of the repeater is shown in Fig. 55. Relay D operating places another condenser (when required on long trunks) in multiple with the regular condenser on each side of the trunk to improve transmission. These

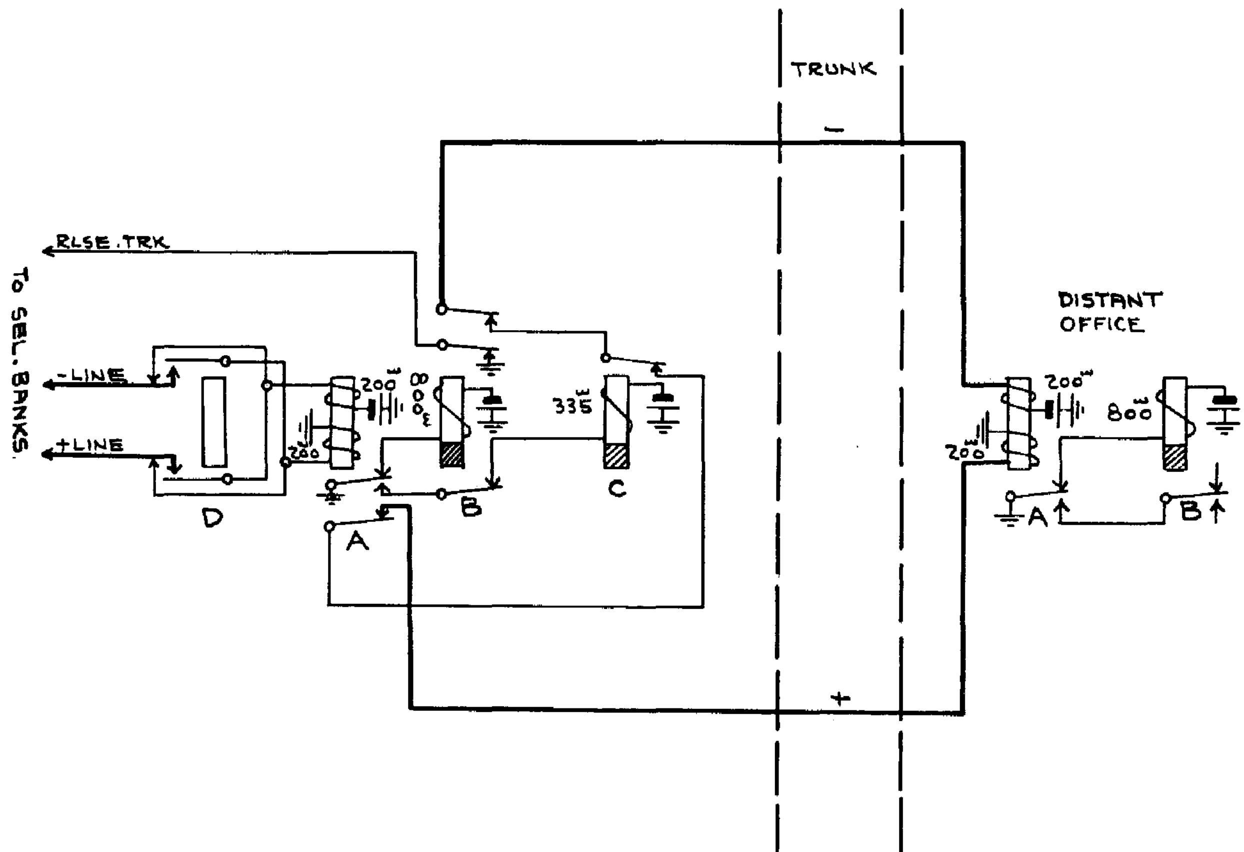


Fig. 53. Impulse circuit of repeater

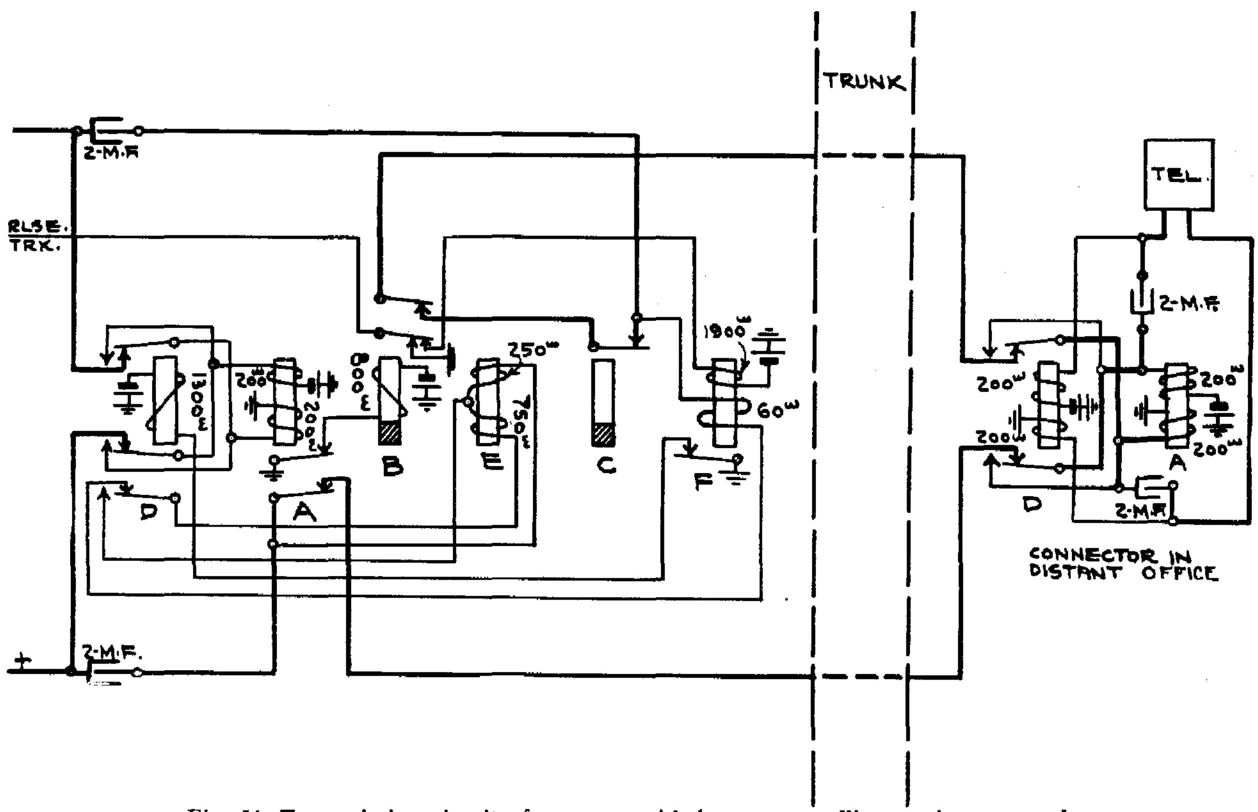


Fig. 54. Transmission circuit of repeater with battery to calling station reversed

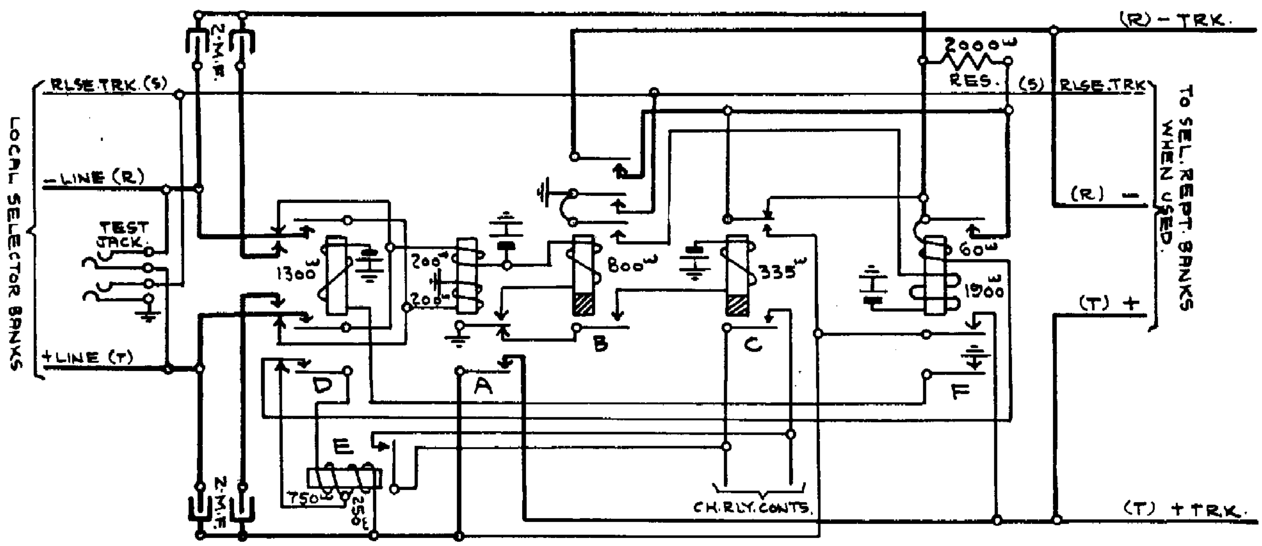
condensers are not permanently in multiple with the regular condensers but are connected only during conversation. Thus the increased capacity does not interfere with impulsing over the trunk

The 2000 ohm coil connected across the back contacts of relay C prevents the possibility of an extra impulse being sent to the incoming selectors as relay C removes the 310 ohm resistance from the trunk circuit during impulses. It also absorbs any "discharge" from the talking condensers that might interfere with impulsing.

Relays can be connected to the chain relay contacts of repeaters to operate a meter whenever all the repeaters in the group are engaged.

Review

1. Why are impulse repeaters used?
2. Does the repeater have both a vertical and rotary operation?
3. How much resistance is there across the trunk loop before impulsing?
4. How much resistance is there across the trunk loop during impulsing?
5. How much resistance is there across the trunk loop during conversation?
6. Explain the operation of relay F.
7. Why are the back contacts of relay C shunted through 2000 ohms resistance?
8. Why is a third wire not required between offices?
9. From where does the calling party receive transmitter current?



NOTE:- RELAY "F" MUST NOT PULL UP UNTIL BATT. IS REVERSED OVER THE TRUNK.

Fig. 55. Complete repeater circuit

CHAPTER 9

Power Equipment

Power Board

THE power board shown in Fig. 56 is typical of those used in automatic telephone offices. This board consists of five slate panels upon which is mounted the following equipment, counting the panels from left to right.

Panel No. 1. The commercial power switch, generator field rheostat, and circuit breakers of the generator used for charging the battery.

Panel No. 2. Voltmeter, ammeter, battery fuses, and counter cell switch.

Panel No. 3. Tone machines and alarm type fuses.

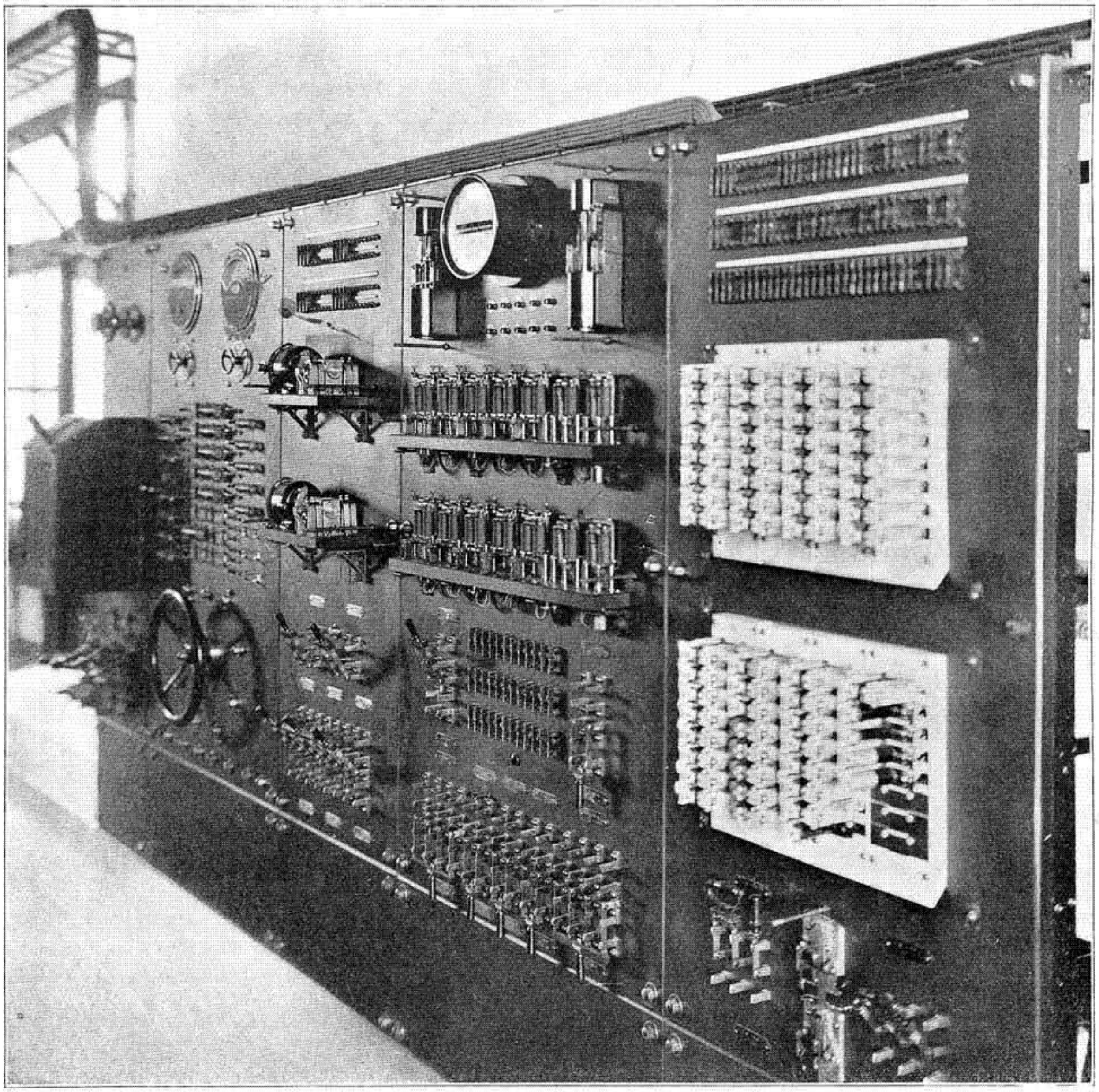


Fig. 56. Typical power board for automatic exchange

Panel No. 4. Frequency meter, ringing interrupters and duplicate sets of harmonic converters.

Panel No. 5. Supervisory and Dial tone equipment.

Storage Battery

The automatic switch equipment is designed to operate on a battery voltage ranging from 46 to 49 volts. The storage battery consists of 25 cells with 7 counter electromotive force cells connected to the negative end of the battery as shown in Fig. 57. The latter are used to keep the voltage on the discharge bus bars between the limits of 46 and 49 volts.

Counter electromotive force cells are composed of lead plates, placed in the same electrolyte as is used in the regular cells; they have no current capacity but set up an opposing E. M. F. of approximately 2 volts per cell when current is passed through them.

The electrolyte used in telephone storage batteries is of 1.210 specific gravity at a temperature of 70°F. The storage battery should be of sufficient size to carry the office load and allow some reserve for emergencies.

The unit of storage battery capacity is the ampere-hour; if a battery has a capacity of 240 ampere-hours, means that it will supply 240 amperes for one hour, or its total capacity. The charging rate of a battery is based on an 8-hour period, therefore, in the case of a battery of 240 ampere-hours capacity, it should be charged at the rate of 30 amperes continuously for 8 hours.

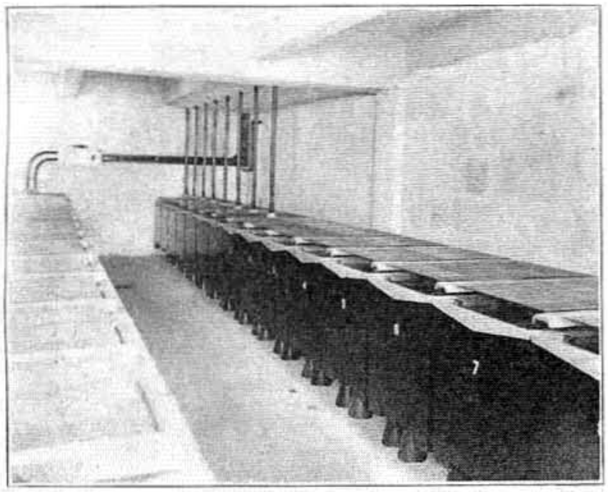


Fig. 57. Storage battery

Charging Equipment

Two charging machines are usually installed; one consisting of a motor-generator set, or rectifier, and a reserve or emergency set in the form of a charging generator connected direct to a gas or gasoline engine.

Mercury arc rectifiers are usually installed in offices where the ultimate charging rate does not exceed 50 amperes. Two mercury arc rectifiers can be operated in multiple to supply 100 amperes but it is common practice to use motor-generator charging machines for offices requiring a charging rate higher than the output of one rectifier.

Power Circuit

During the charging period the generator or rectifier is connected direct to the negative and positive terminals of the battery through the circuit breaker. The C.E.M.F. cell switch connects (—) battery to the (—) bus bar on the power board, and as the voltage of the battery increases, the C.E.M.F. switch is operated, cutting more counter cells in series with the battery circuit to the — bus bar. In some cases the C.E.M.F. cell switch is operated by hand and in others it is motor driven, so that it can be controlled from a remote or distant point. In the smaller offices the voltage regulation is entirely automatic.

At the beginning of a charge the field resistance of the generator is decreased until the proper output is secured, after which the circuit breaker is closed connecting the output of the generator to the battery.

The generator shown in Fig. 58 is shunt connected when floating or charging the battery and is run compound only in cases of emergency, when the battery is disabled and it becomes necessary to operate the switchboard on the generator direct without the use of the battery.

The negative battery lead is connected to the different groups of equipment from the (—) bus bar through fuses on the main distributing power panel. Each fuse is bridged by an alarm type fuse which blows and sounds a general alarm in case its associated large fuse blows or otherwise goes open.

The voltmeter is usually connected to a switch so wired, that the generator, charge and discharge voltages can be read. The ammeter is of the differential type and is connected to a switch whose contacts are wired to shunts in the discharge and charge leads so that the charge, discharge, and combination currents can be read.

Signal Equipment

The power and signal relays referred to in the preceding connector and lineswitch circuits are mounted on the power panels at the top of the connector or primary lineswitch units.

The purpose of the signal equipment is to give a general alarm in case of connector release failure, continuously rotating master switch or lineswitch trouble.

Connector and line switch signals

These troubles are indicated by both visual and audible signals. The visuals are variously colored

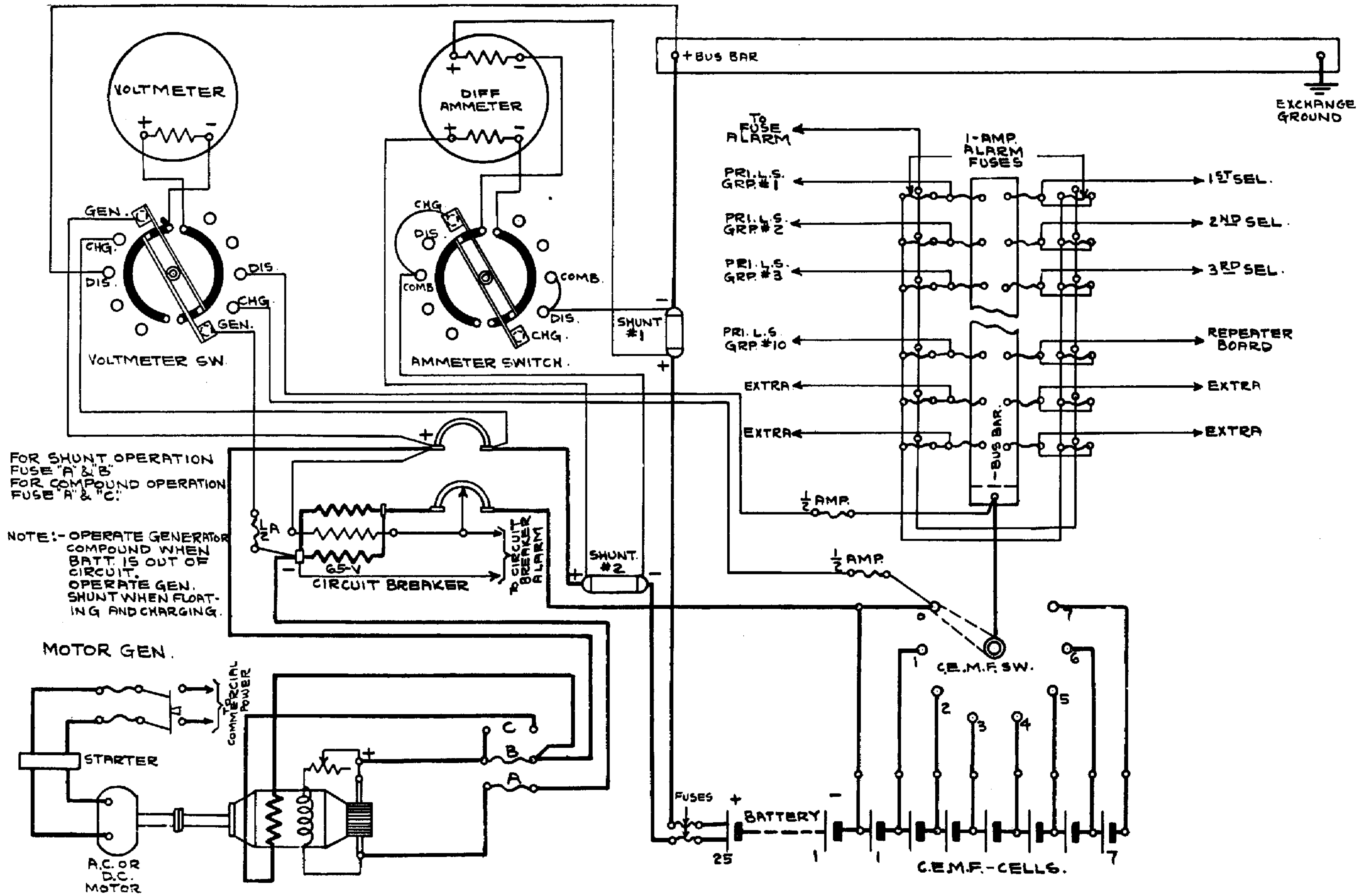


Fig. 58. Power s vitchboard circuit

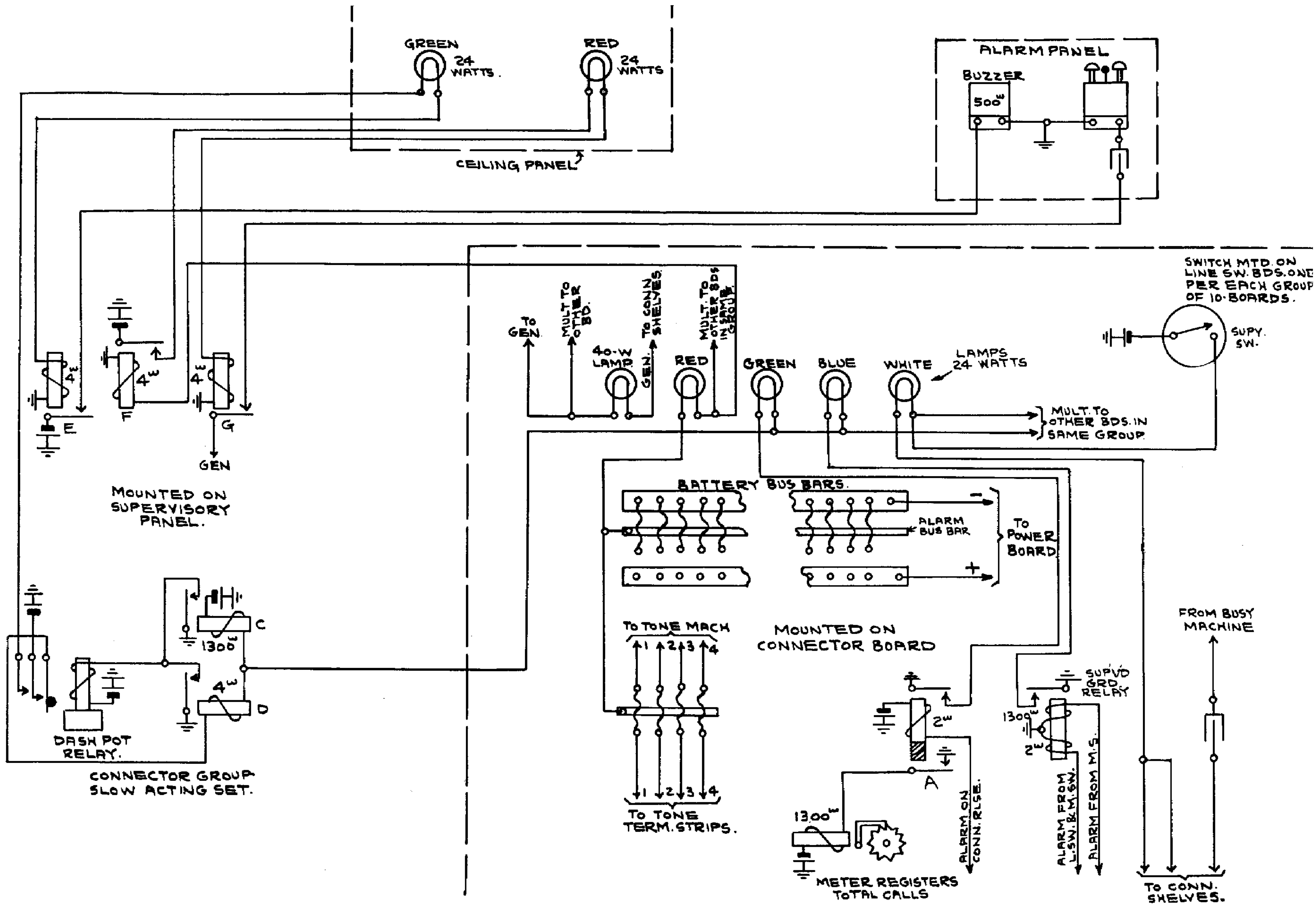


Fig. 59. Signal circuits for connector and line switch groups

lamps mounted on the connector or lineswitch units, to distinguish the particular units and also by pilot lamps located on the ceiling to distinguish the groups. The color scheme usually employed on the lamps mounted on the unit are as follows:

White — Connector supervisory. (See Fig. 18.)

Blue—Supv'd grd. to line and master switch. (See Fig. 44.)

Green—Supv'd battery to connector release. (See Fig. 19.)

Red—Fuse.

For instance, should a connector shaft fail to restore to normal and open its release magnet circuit at the off-normal springs (see Fig. 19), the release magnet will continue to draw supervised negative (or release battery) through the 2 ohm relay A. (Fig. 59.) Relay A operating connects (+) battery to total call meter, also through green lamp, winding of relay C to (—) battery. The green lamp does not glow due to the high resistance of relay C. Relay C operating closes the circuit to the slow acting dash pot relay which operates and connects (—) battery through relay D to the green lamp causing it to glow. Relay C is shunted and releases when the winding of relay D is connected in multiple with it. The dash pot relay also closes a circuit from (—) battery at its spring contacts through the green ceiling lamp, winding of relay E to (+) battery causing the ceiling lamp to glow and relay E to operate sounding the general alarm buzzer.

The green lamp on the ceiling panel as shown in Fig. 48 indicates the connector group, and the green lamp on the unit indicates that the connector in trouble is in that unit.

The "supv'd grd." relay shown in Fig. 44 is operated, either by the master switch continuing to rotate, battery crossed with (+) line, or a line relay on a line switch failing to restore to normal. The supv'd ground relay closes the circuit from (+) battery through its spring contacts, through the blue lamp, causing the connector group slow-acting set to operate and sound the general alarm, the same as explained under connector release, except that the blue lamp glows instead of the green.

When a fuse blows, the (—) battery from the bus bar is connected to the alarm bar, by the blown fuse, through the red lamp, relay F to (+) battery, causing the red lamp to glow. Relay F operating, connects (—) battery through its spring contacts, red ceiling lamp, through winding of relay G to (+) battery, causing ceiling lamp to glow and relay G to operate, furnishing ringing current to ring the "fuse alarm" bell, indicating a blown fuse.

The supervisory switch connects (—) battery through the white lamp on each connector unit to supervisory No. 1 and 2 as shown in Fig. 18.

The discriminating or "class of service" tones Nos. 1, 2, 3 and 4 are used to distinguish between subscribers whom it is necessary to supervise or restrict from certain services, etc. For instance, if a subscriber is denied the use of long distance service, the tone indicating this is connected to his lineswitch B.C.O., so that whenever the long distance recording operator is dialed from that station the tone becomes audible to the operator and the request for toll service is denied.

These tone circuits are wired in the terminal assemblies in such a manner that any tone can be connected to the bridge cut-off coil of any line by a slight change in soldering as shown in Fig. 63.

Selector signals

The selector power and signal equipment is similar to that explained in Fig. 59, except the dial tone, busy tone, and individual shelf lamps. The selector signal circuits are shown in Fig. 60.

The selectors are mounted twenty on a shelf as shown in Fig. 26. Six shelves, so mounted, constitute a selector bay and two bays associated together, a trunk board. Each trunk board as shown in Fig. 48 is equipped with colored signal lamps similar to those used on the lineswitch and connector units. These lamps are mounted on a slate panel on the front or power end of the trunk board.

The color scheme usually employed for the lamps on selector trunk boards are as follows:

White—Supervised battery to B relays. (See Fig. 27.)

Green—Supervised battery to selector, release magnets. (See Fig. 31.)

Red—Fuse.

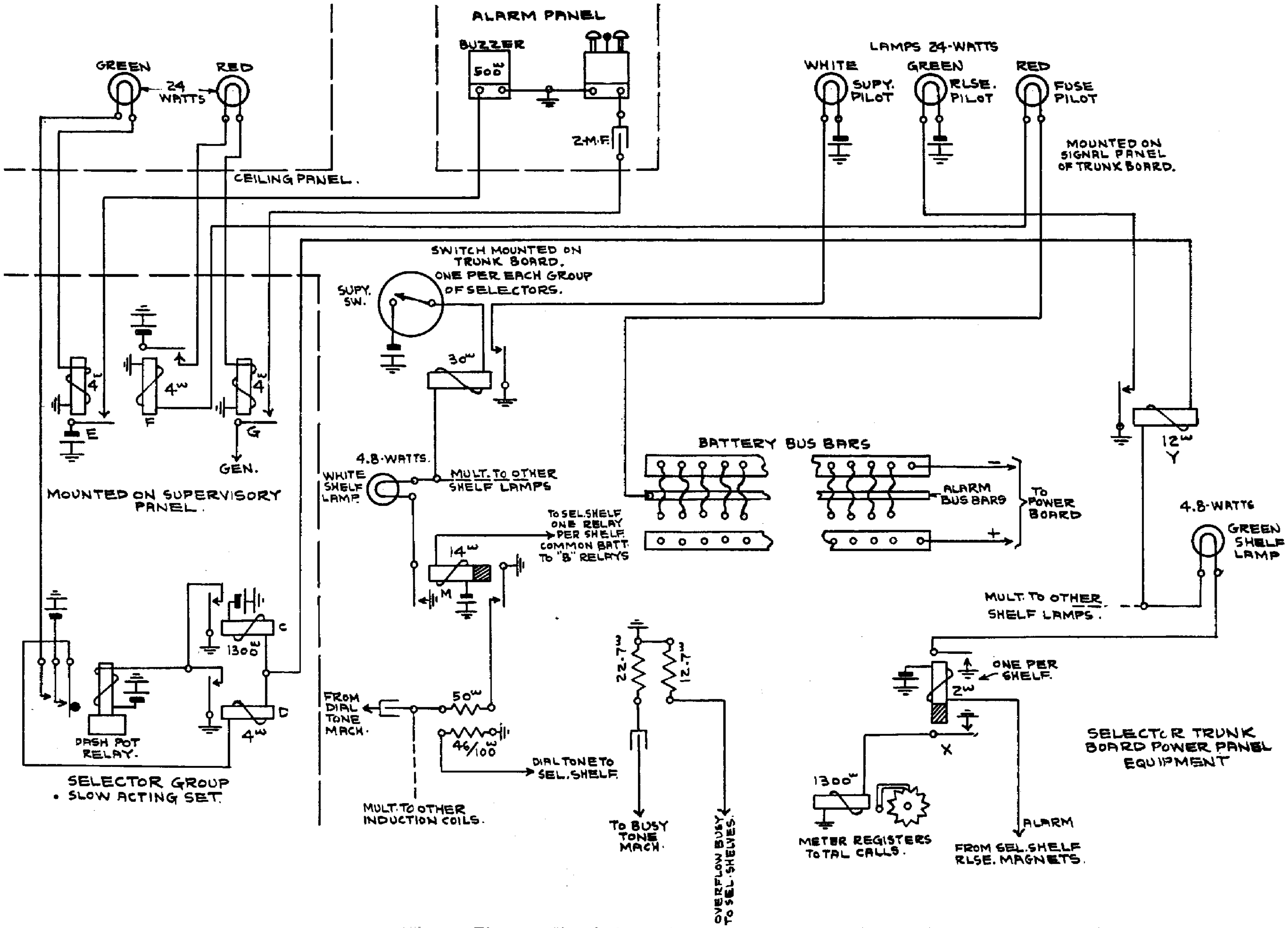


Fig. 60. Signal circuit for selector group

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The above lamps (except the fuse) serve as pilots to their respective shelf lamps, each shelf being equipped with an individual white and green lamp, in addition to the pilot, so that trouble can be instantly traced to the shelf affected.

The dial tone induction coils, one for each shelf, are mounted on the front of the trunk board and covered with connector type covers.

The busy tone induction coils are mounted on the rear of the supervisory panel of the power board, one coil for the first selector group, one for the second selector group, etc.

The supervisory switch is closed during the period that the selectors are routined for permanents.

Review

Fig. 58

1. Why are counter electromotive force cells used?
2. Describe a counter electromotive force cell.
3. When charging the battery, is the generator connected series, shunt, or compound?
4. Why is a compound generator furnished?

Fig. 59

5. Explain the procedure of locating trouble when the alarm buzzer sounds.
6. Explain the operation of the dash pot relay.
7. When is the alarm bell rung?

Fig. 60

8. Why is the dial tone used?
9. When is the dial tone connected to a selector shelf?
10. Explain the purpose of the ceiling lamp panel.
11. Which alarm sounds when the white supervisory lamps glow?

CHAPTER 10

Trunking

TRUNKING as it relates to systems of various sizes, contained in one office, has been discussed in the preceding chapters. In Fig. 61 is shown a diagrammatic trunking scheme of a multi-office area consisting of five main offices and one sub-office, together with the associated special services, such as toll recording, wire chief, complaint, time, fire, police, etc.

The system shown in Fig. 61 is of the 100,000 line capacity requiring telephone numbers of five digits. By reference to the dial in the upper left-hand corner, it will be seen that there is a letter associated with each of the digits 2 to 9; therefore all telephone numbers in this particular system, while they require five turns of the dial, are composed of a letter prefix and four figures. This is, of course, the same as five figures but it is sometimes considered that a letter prefix and four figures is more easily remembered than is a number composed of five figures.

This system is based on the use of plunger type lineswitches and rotary secondaries, the circuit for which is shown in Fig. 50. The trunks to the various offices go direct from the levels of the first selector, thence through repeaters to the various offices. In order not to complicate the sketch, connections are shown in one direction only. A call originating in any of the other offices would be just the same as that shown for office "C."

The special services, requiring operators in attendance, are located at the "F" office. Connection to these special services is obtained by dialing "F01" for wire chief, "F02" for information, etc.

Reverting call equipment, used when one party on a party line calls another on the same line, is furnished in each office, as shown for office "C."

Reports to fire or police are made by dialing "119" which connects to a rotary selector and selects an idle trunk to the information desk. After ascertaining that it is a legitimate report, the call is extended by the information operator, to the fire or police department, as desired. Connection to the "M" sub-office is obtained by dialing "MO." The incoming trunks in this office terminate on third selectors instead of second

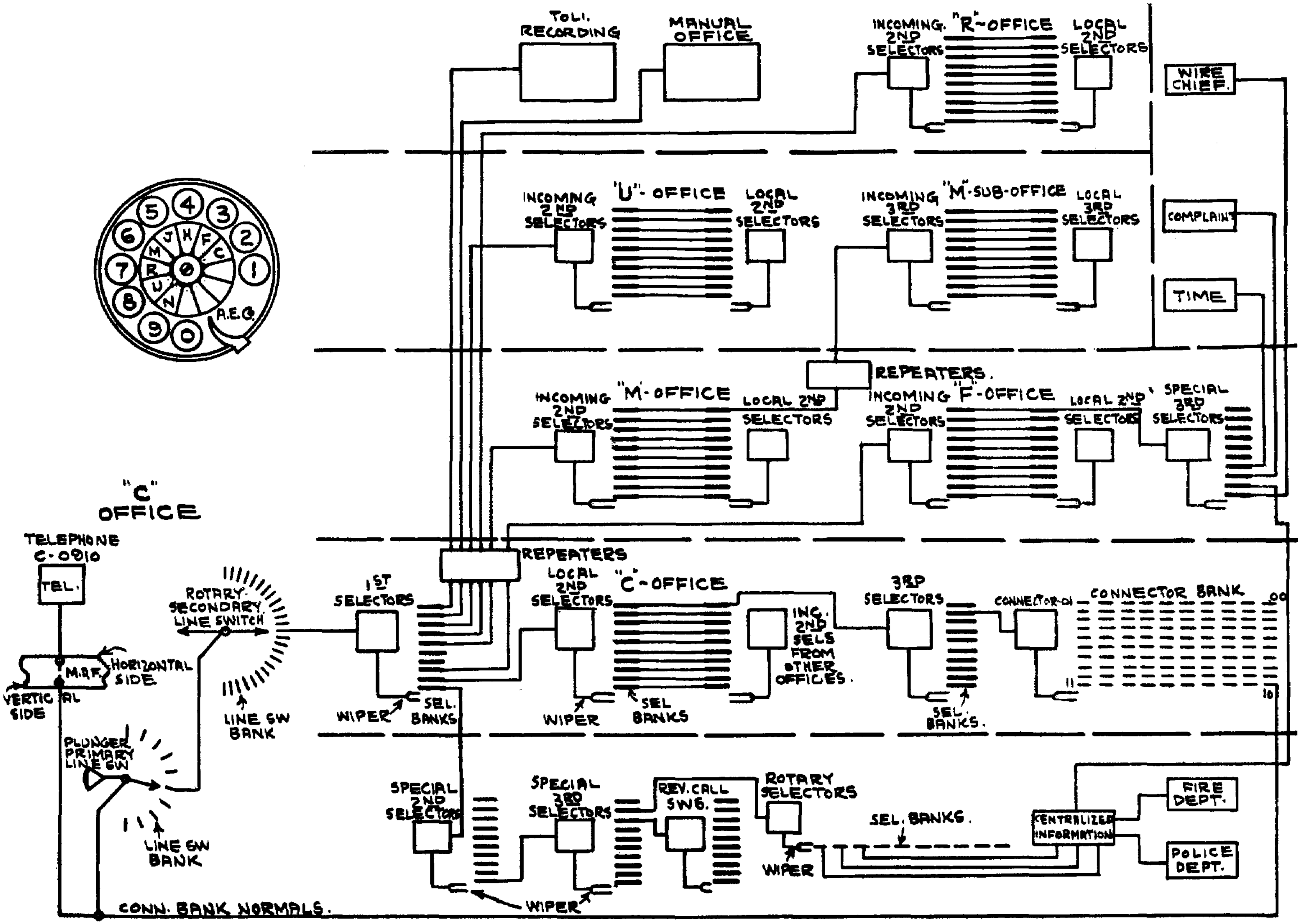


Fig. 61. Trunk layout for 100,000 line system

selectors, as is the case in all other offices shown in this system.

Line Switch Board Wiring and Terminals

In Fig. 35, which is a photograph of the line-switch and connector unit, the terminals for all cables associated with the board will be seen near the top on the line switch side. The purpose of this terminal assembly is to provide a means for terminating all cables and wiring which are made as a part of the installation in the factory, so that they can be connected to the cables running to the other switch groups associated with it in an automatic system.

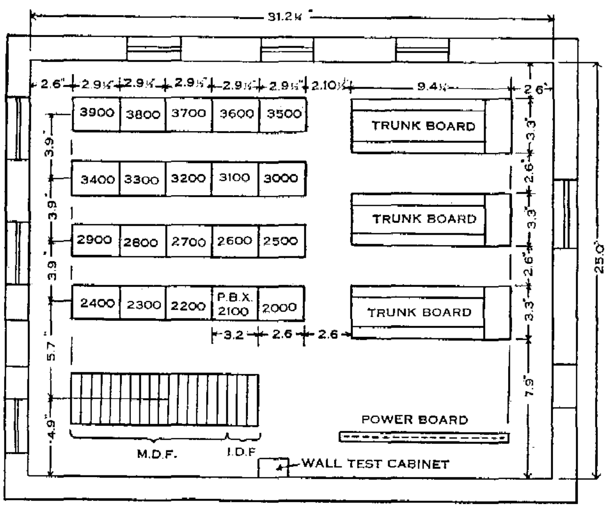


Fig. 62. Floor plan for typical 2,000 line office

In Fig. 63 is shown a section of a typical line-switch and connector unit terminal assembly. The lineswitch board, as shown in this sketch, is divided into four sections, known as divisions A, B, C, and D, so that various percentages of outgoing trunks may be employed. The outgoing trunks from the lineswitch banks are cabled individually to the terminal assembly and if the traffic or calling rate on the entire 100 lines is such that it can be handled by 10 first selectors, the outgoing trunks of these four divisions are multipled together at the terminal assembly. Should 10 trunks be insufficient to handle the traffic, the unit is divided into two groups of 50 lines each, the outgoing trunks from line-switch banks being separated at the terminal assembly into two groups of 10. Each group furnishes outgoing service to 50 lines. Each group of 50 lines is controlled by its own master switch, as shown at B & D in this sketch.

A further increase in the number of trunks can be made by dividing each group of 50 into two groups of 25 each which divides the 100 lines into four groups of 25 lines each. If necessary, each group of 25 lines can be furnished with 10 outgoing trunks.

The subscribers' lines are cabled from the main distributing frame and connected to their corresponding terminals. They are arranged in two rows, 01 to 50 and 51 to 100.

In the explanation of Fig. 59, it was stated that the discriminating, or class of service tones were connected to the lineswitch B.C.O. coils. Arrangement is provided in the bottom 8 strips of the lineswitch unit terminal assembly so that any one of these four tones can be connected to the B.C.O. coil of any telephone number in this unit. Whenever a lineswitch B.C.O. coil is connected to a tone it should be disconnected from the bottom terminal strip to which is connected (—) battery.

When a telephone is discontinued or a subscriber's number changed, all calls intended for this discontinued or changed number are routed to the information operator by means of the intercepting trunk. To connect a number to intercepting trunk, the connector bank terminals are unsoldered from the lineswitch and main frame cable terminals and soldered to the terminals of the intercepting trunk. The connector bank private terminal is unsoldered from the lineswitch B.C.O. coil terminal and soldered to the intercepting trunk terminal.

The terminals marked "hold trunk" of the line-switch bank are connected at this point to (+) battery, provided subscriber call meters are not used. This (+) battery is furnished to the bank contacts of each lineswitch to operate the secondary line and master switch in the event that meters and their associated relays C and D (Figs. 49 and 50) are not used. When meters and their associated relays are used, the hold trunks of the lineswitches are unsoldered from (+) battery terminal strip and soldered to the meter strip which is assembled above the hold trunk terminal strip.

The incoming trunks from the selector banks

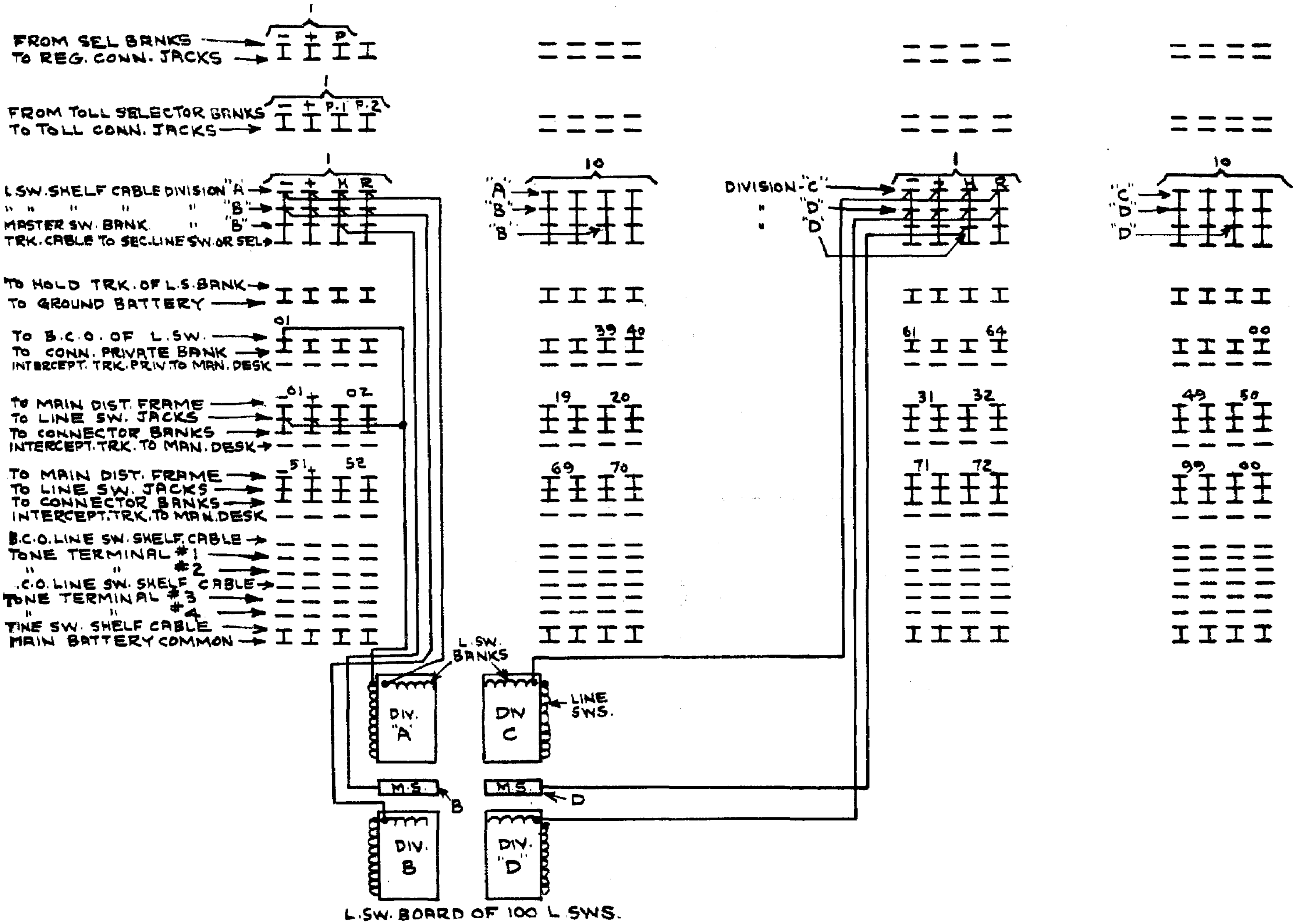


Fig. 63. Wiring and terminal assembly of line switch board

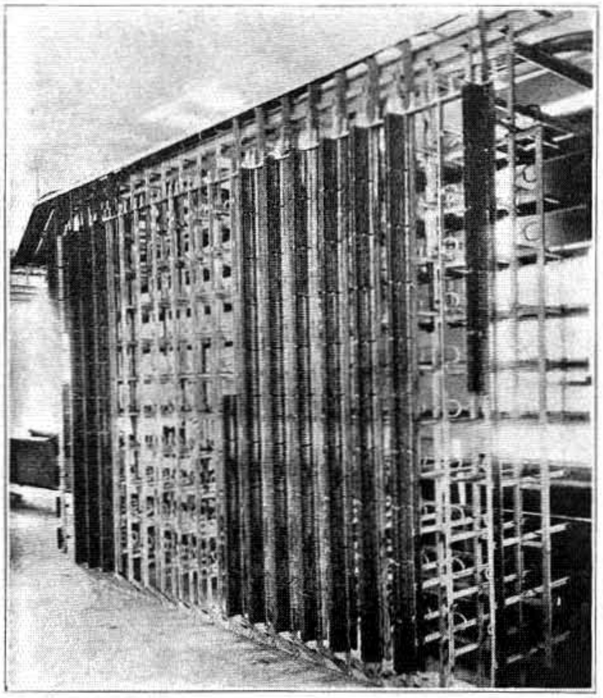


Fig. 64. Main distributing frame

to the connectors are terminated on the top terminal strip where they are soldered to the terminals of the unit cable leading to the connector jacks.

The incoming trunks from the toll selectors to the toll connectors are handled the same as are the trunks to the regular connectors, except that they are terminated on a special terminal strip.

Primary to Secondary Wiring

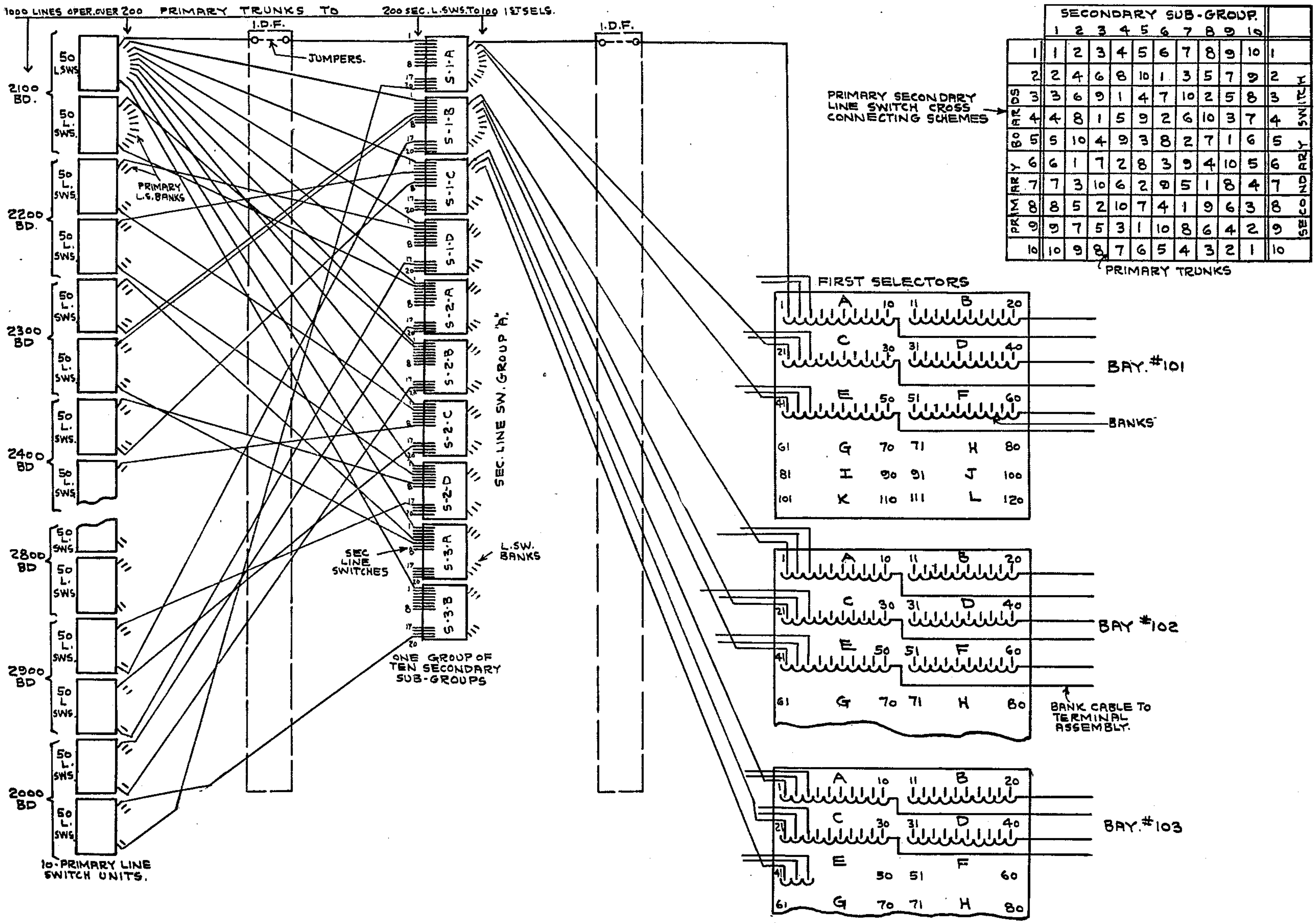
The purpose and general uses of the lineswitch were explained in connection with Figs. 49 and 50.

In Fig. 65, a trunking arrangement between primary lineswitches, secondary lineswitches and first selectors is shown. For the purpose of this explanation, a system composed of 1000 primary lineswitches is used, the outgoing trunks of which are terminated in a group of secondary lineswitches consisting of 10 sub-groups, 20 trunks in each sub-group. Each secondary lineswitch sub-group has 10 trunks to first selectors.

If secondary switches were not employed in this trunking scheme, and the originating calls could be handled on 10 outgoing trunks per 100 lines, the trunks would, of course, be connected direct to first selectors. Should the originating traffic on any group of 100 lines exceed, at any time, that which can be handled by 10 trunks, additional trunks could be added to take care of this increased calling, and if secondary switches were not employed, the only means for providing these increased facilities would be to divide the primary boards into two divisions of 50 lines each and give each an individual group of trunks to first selectors. This would not only increase the number of first selectors, but would, to a certain extent, be somewhat inflexible. In other words, one line unit may be taxed to its capacity at certain times during the day, while other units have comparatively few originating calls, or vice versa.

The secondary switch, placed between the primary lineswitch banks and the first selector, not only provides the additional outgoing trunks from the primary lineswitch units without increasing the first selectors in direct proportion, but also affords means whereby the primary trunks from any division of 50 lines are distrib-

Fig. 66. View of switchroom showing intermediate distributing frame



Primary boards	Secondary sub-group 1	2	3	4	5	6	7	8	9	10	Secondary switch
1	1	2	3	4	5	6	7	8	9	10	1
2	2	4	6	8	10	1	3	5	7	9	2
3	3	6	9	1	4	7	10	2	5	8	3
4	4	8	1	5	9	2	6	10	3	7	4
5	5	10	4	9	3	8	2	7	1	6	5
6	6	1	7	2	8	3	9	4	10	5	6
7	7	3	10	6	2	9	5	1	8	4	7
8	8	5	2	10	7	4	1	9	6	3	8
9	9	7	5	3	1	10	8	6	4	2	9
10	10	9	8	7	6	5	4	3	2	1	10

Fig. 65. Trunking plan, primary to secondary line switches

uted over the entire group of first selectors. This scheme is more flexible than if the trunks were connected from the primary lineswitch banks direct to first selectors. Should the number of originating calls warrant, the primary lineswitch units can be provided with a still higher percentage of outgoing trunks by dividing each division of 50 into 2 divisions of 25, each having a group of trunks to secondary lineswitches.

Several groups of secondary lineswitches may be used. This depends entirely upon the size of the office and traffic conditions to be met. For the purpose of this explanation, group "A" only is shown.

Plunger and rotary type lineswitches are both employed as secondary lineswitches. The circuit arrangement of each is shown in Figs. 49 and 50, respectively.

In order to distribute the originating or outgoing calls as uniformly as possible over the entire group of first selectors, a trunk from each secondary sub-group is connected to a first selector located on a different section of first selectors.

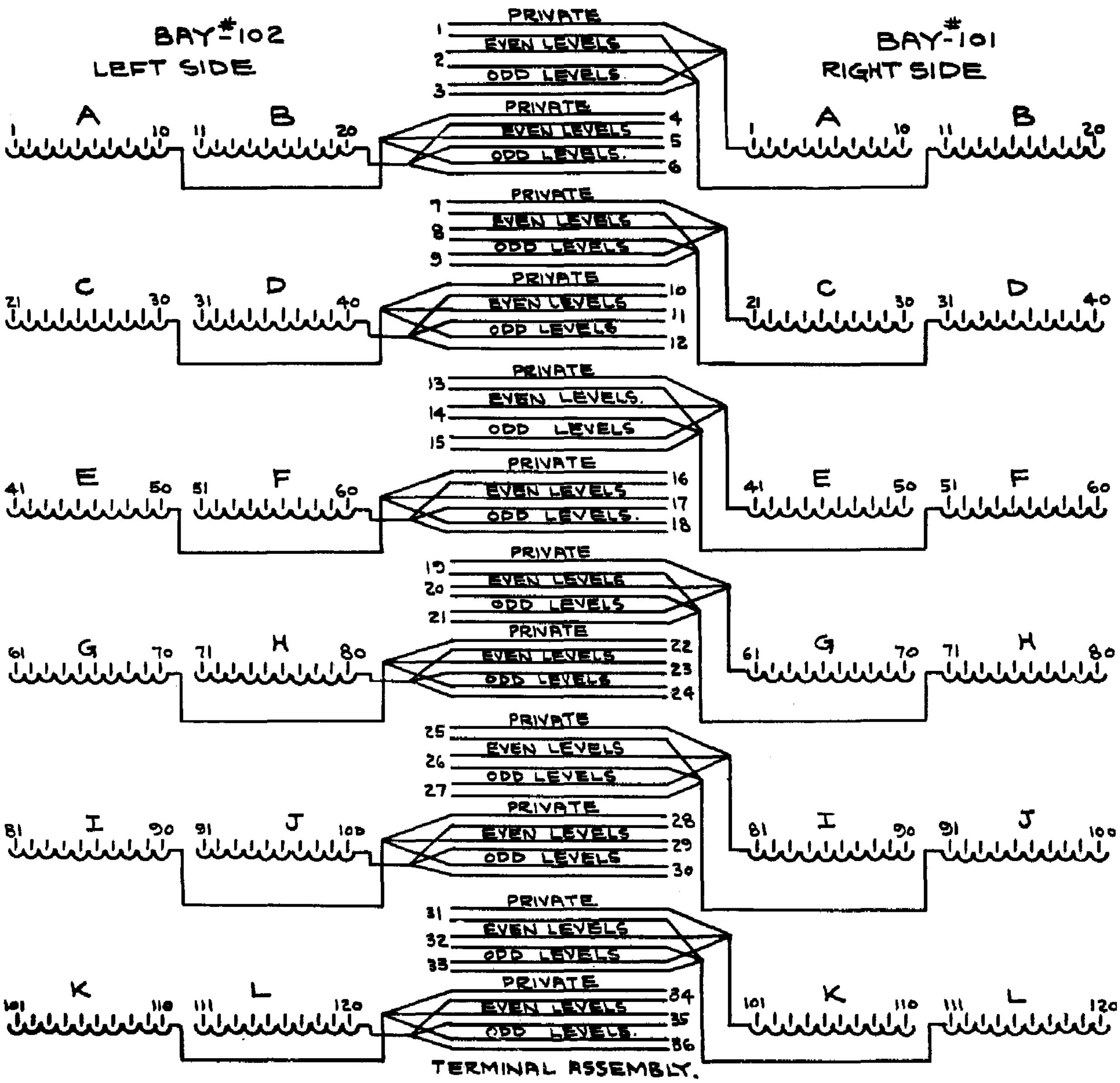


Fig. 67. Selector bank wiring scheme

The table in the upper right-hand corner of Fig. 65 shows the connections for the outgoing trunks of 1000 lines terminating on secondary lineswitches. These connections are made by means of a jumper on the I.D.F. In the left-hand column of this table is given the number of the primary unit. The numbers in the small squares as indicated by the arrow in the bottom row of figures are the numbers of the individual trunks from each primary unit, and the row of figures across the top indicates the secondary sub-group in which each particular primary trunk is terminated. The positions of the secondary switches in the sub-groups to which the trunks connect, are shown by the figures in the right-hand column.

Selector Banks and Wiring

Selectors are mounted twenty on a shelf, as shown in Fig. 26. Six shelves, so mounted, constitutes a selector bay and two bays associated together, a trunk board.

Figs. 67 and 68 show the terminal end of a trunk board. The terminal assembly is composed of 36 supports upon which the selector bank cables terminate, and connect to trunks leading to the next series of switches.

The terminals are enclosed by two doors. Details of the front or power and signal end of a trunk board were explained in connection with Fig. 60.

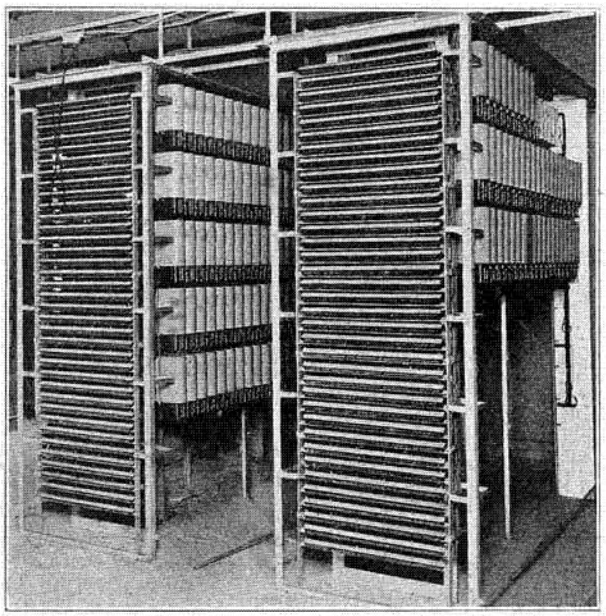


Fig. 68. Selector boards showing terminal assembly

The general wiring scheme of the selector banks is shown in Fig. 67. Each shelf of twenty selectors is divided into two sections, as shown in bay 101; that is, the top shelf is composed of sections A and B with selectors 1 to 10 mounted on section A, selectors 11 to 20 on section B, selectors 21 to 30 on section C, etc.

Selector Bank Terminals

The selector banks are wired to terminal strips of 100 contacts each (see Fig. 69) and assembled in three separate groups on the terminal assembly, namely, privates, even and odd levels. The privates of the A and B sections, as shown in bay 101, are assembled on support No. 1, even numbered line levels on support No. 2 and odd numbered line levels on support No. 3.

The bays in which the various selectors are mounted are usually designated in the hundred series which they represent, as first selectors, 101-102-103, etc.; second selectors, 201-202-203, etc.; third selectors, 301-302-303, etc.; fourth selectors, 401-402-403, etc.; toll selectors, 601-602-603, etc.

The banks of ten selectors of a section are multipled together and cabled to sets of terminals shown in Fig. 69. The 100 single wires from the private banks are fanned out and connected to the private terminal strip, but the 100 pairs of wires from the line banks require two terminal strips of 100 contacts each. The pairs of the even numbered line levels are wired to one strip and those of the odd numbered line levels to the other strip, as shown in the lower part of the sketch.

In order to make the necessary connections, to these three terminals strips, they are mounted on three separate supports; the private strip on the first or top support, the even numbered line level strip on the second support and the odd numbered line level strip on the third support.

Bank slips

In order to distribute the traffic over the various switches as uniformly as possible and also reduce the time necessary for a selector to find an idle trunk, the trunks are multipled so that

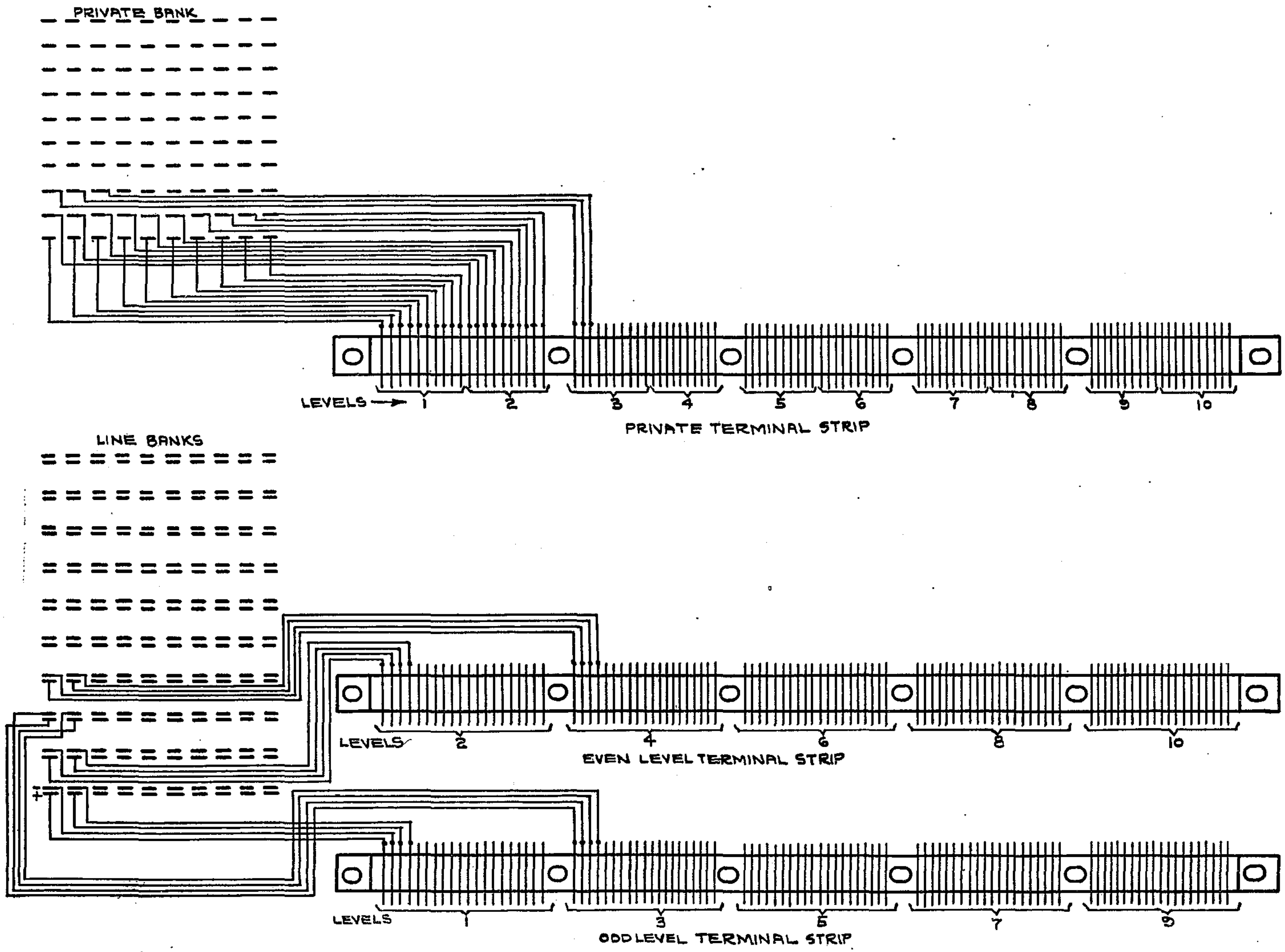


Fig. 69. Wiring of selector banks to terminal strips

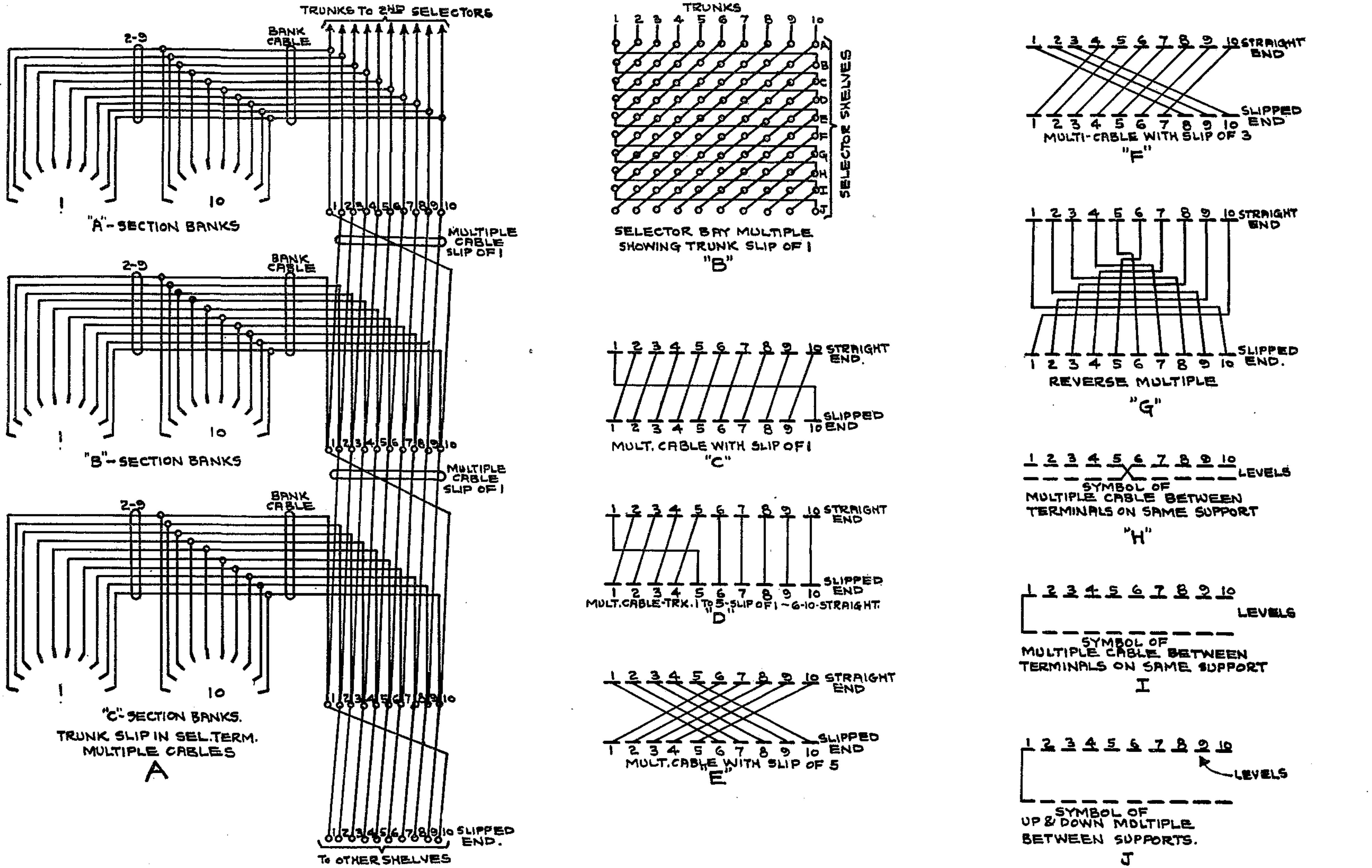


Fig. 70. Various "slips" used in selector bank multiple cables

the selectors of each section will not have the same trunk for first choice. This arrangement is referred to as a "slipped" multiple, which means that the trunks are slipped forward a certain number of contacts between sections.

Fig. 70, sketch "A," shows the banks of three first selector sections, A, B, and C, using the same ten outgoing trunks to second selectors. The terminals of these sections are connected by multiple cables, which have a slip of 1. The A section connects straight to the outgoing trunks, while section B connects through a cable having a slip of 1; that is, trunk No. 1 on B section connects to No. 2 outgoing trunk, which is first choice to selectors on section B, and trunk No. 10 connects to No. 1 outgoing trunk, which is first choice to selectors on section A. Trunk No. 1 on section C connects to No. 3 outgoing trunk, which is second choice to section B and third choice to section A.

The top row of terminals shown in Fig 70, sketch B, can represent any level of ten trunks on a certain "A" selector section; the next row below it represents the corresponding level on the B section, and so on, until the ten sections have been connected. A slip of 1 is employed throughout the ten sections. This sketch shows very clearly that the first choice trunks of the first five sections are last choice to the last five sections in the group.

In Fig. 70, sketch "C" shows a multiple cable with a slip of 1, which is used to connect terminals of sections whose banks are assembled on the same support; it is sometimes called jumper terminal or hair pin, but when used as a multiple between supports, it is referred to as such.

In Fig. 70, sketch "D," is shown a multiple cable with trunks 1 to 5 slipped 1, and trunks 6-10 straight; sketch "E," a multiple cable with a slip of 5; sketch "F," a multiple cable with a slip of 3; and sketch "G," a reverse multiple.

Sketches "H" and "I" show the symbols used to represent multiple cables connecting to the terminals of two sections on the same support.

Sketch "J" shows type of symbol used to represent the "up and down" multiple between supports.

Terminal assemblies

Fig. 71A shows a schematic terminal assembly for a trunk board, which is two bays associated together on one upright.

The banks of the six shelves (12 sections) of selectors are mounted, their banks terminateo and connected, as shown in Fig. 67.

As previously explained, the levels of the A and B sections of bay 101 terminate on supports No. 1, 2 and 3 and are connected together by a multiple cable having a slip of 1, the privates on support No. 1, even numbered line levels on support No. 2 and odd numbered line levels on support No. 3. The ten groups of terminals shown connected to each selector shelf represent the ten levels from that shelf. These levels number from left to right, as shown directly below supports No. 34, 35 and 36 in Fig. 71A.

The top terminal strips of the second and sixth levels on supports Nos. 19, 20 and 21 (Fig. 71A) represent the outgoing cable or trunks to the next series of switches. The second level has ten trunks cabled to switches 1 to 10 on F section, bay 201, and the sixth level has 5 trunks cabled to repeaters, whose trunks terminate at a manual office. All other levels on these supports do not connect direct to outgoing cables, but multiple to supports No. 1, 2 and 3, where connection to the outgoing cable is made.

The levels shown in Fig. 71A represent either privates, even or odd levels. When considering privates, each level represents a set of ten contacts (as shown in Fig. 69). When considering even and add numbered line levels, each level represents a double set of 10, or 20 contacts.

The 1st, 3rd, 4th, 5th, 7th, 8th and 9th levels are not used in this sketch and are referred to as "dead levels." Unused or dead levels are multipled together and trunked to the information board, so that in case a subscriber connects to them an operator will answer.

Fig. 71B shows the multiple between shelves of all contacts of the second level, as well as the soldering of each contact. The 2nd, 3rd, 4th, 5th and 6th trunk contacts of the multiple cable connecting to section A, bay 102, are left open or unsoldered at supports Nos. 1, 2 and 3. This gives sections A and B of bays 101 and 102 five individual trunks each and five trunks in common. This same trunking is used throughout the second level of other sections.

The trunks of the sixth level bays 101 and 102 (Fig. 71B) are connected to 15 trunks terminating at a manual office. At supports Nos. 16, 17 and 18 the sixth level is soldered, so that upper and lower half of the two bays have five individual trunks each and five in common.

The trunks from the tenth level connect to the toll recording board.

Second to third selector trunking

The second selector trunking in a 100,000 line system is somewhat different from the selector trunking explained thus far. In Fig. 72, the

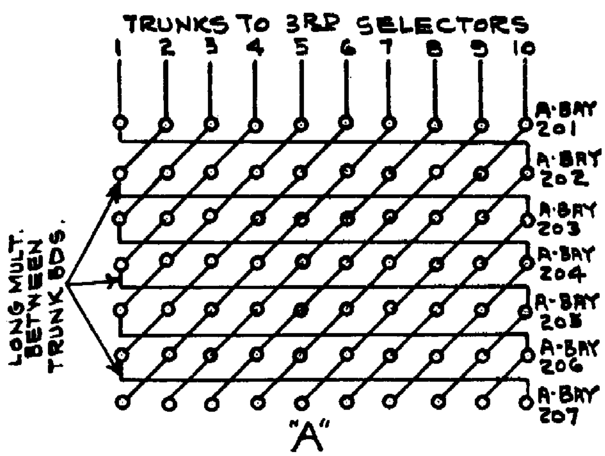


Fig. 72. Trunking scheme, second to third selectors

second selector bays number from 201 to 207, giving a total of seven selector bays. The terminals of like sections on each trunk board (two bays) are assembled on the same supports and connected together by multiple cables (see Fig. 67C). The terminals of the right side of the trunk board are assembled above those of the left side.

A long multiple cable connects the different trunk boards together and multiples all the like sections in each of the second selector trunk boards. The trunks to the third selectors are usually all connected at the terminals of the first bay of second selectors.

In a 100,000 line system, the second selectors of each 10,000 line group will be connected as explained above.

Selector to connector trunking

One third selector bay equipped with 100 to 120 selectors is usually sufficient to handle the calling to the average group of 1000 lines. The different classes of services; namely, flat rate, metered rate, party line, and P.B.X., are usually distributed throughout each 1000 line group.

Fig. 73 shows the trunking from the third selector banks to a connector unit. The unit is equipped with ten connectors, of which 1 to 4 are first choice selection to toll calls and last choice to local calls. Switches 10 to 5 are first choice to local calls. The cabling shown in this sketch between connector unit and the third selector banks, both toll and regular, is complete for a future growth of 5 regular and two combination toll and regular.

The first five contacts have a slip of 1 while the last five are multipled straight.

Review

Fig. 61

1. What number is called to connect to reverting call switches? To toll recording? To the manual office? To complaint?
2. Name the different switches used on a call from the C office to the "M" sub-office.

Fig. 63

3. How many outgoing trunks are provided from each group of 50 lines?
4. Explain the use of "class of service" tones.
5. Explain how to connect a line at the terminal assembly, so that the operator will receive the "class of service" tone when called from that line.
6. Explain how to connect a line to the intercepting trunk.
7. Describe 10%, 20% and 40% trunking on plunger type lineswitches.

Fig. 65

8. What advantages are derived from the installation of secondary line switches?

Fig. 67

9. What constitutes a trunk board?
10. How are the selectors in each bay grouped?
11. How are the selector bank cables connected and assembled?

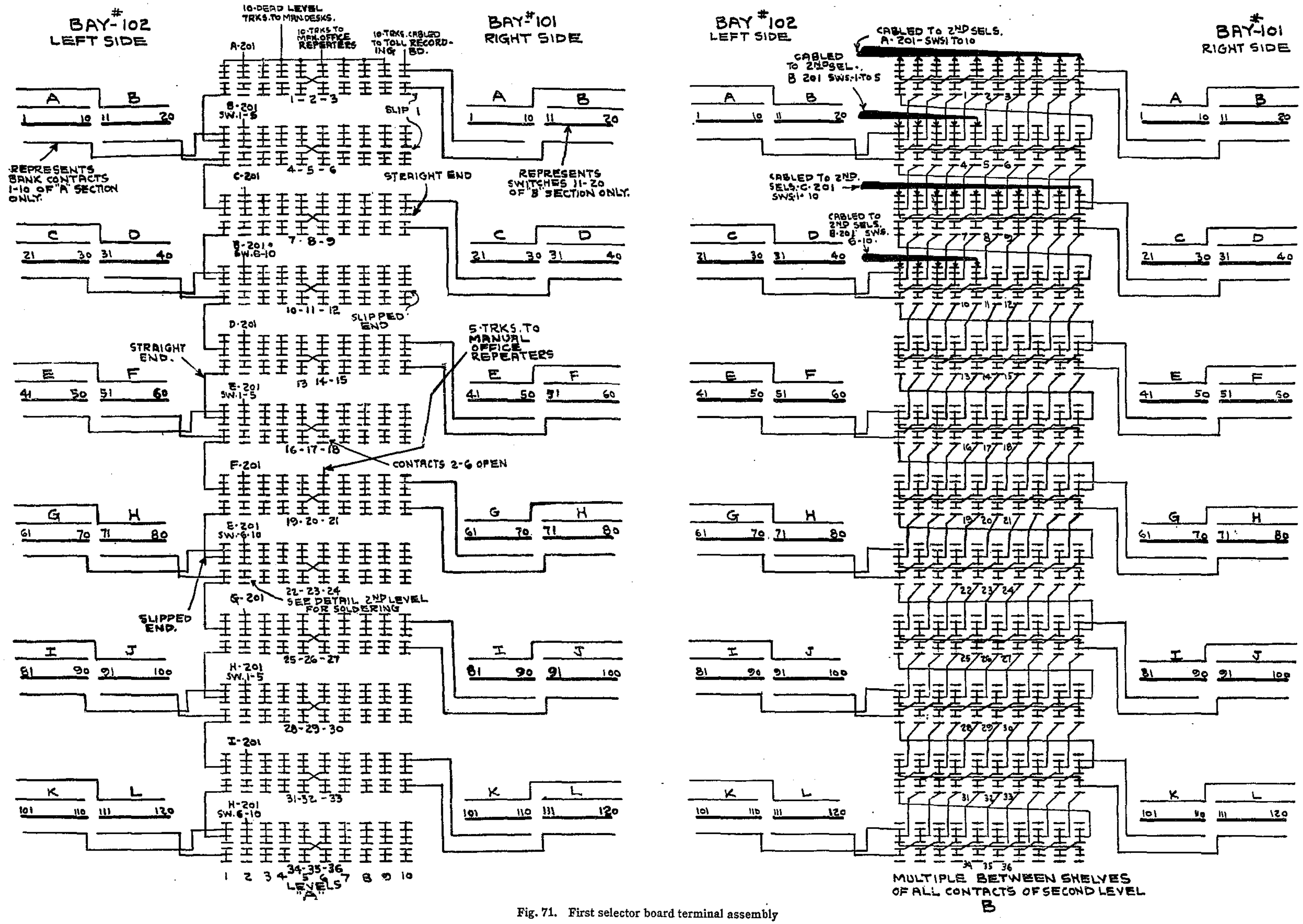


Fig. 71. First selector board terminal assembly

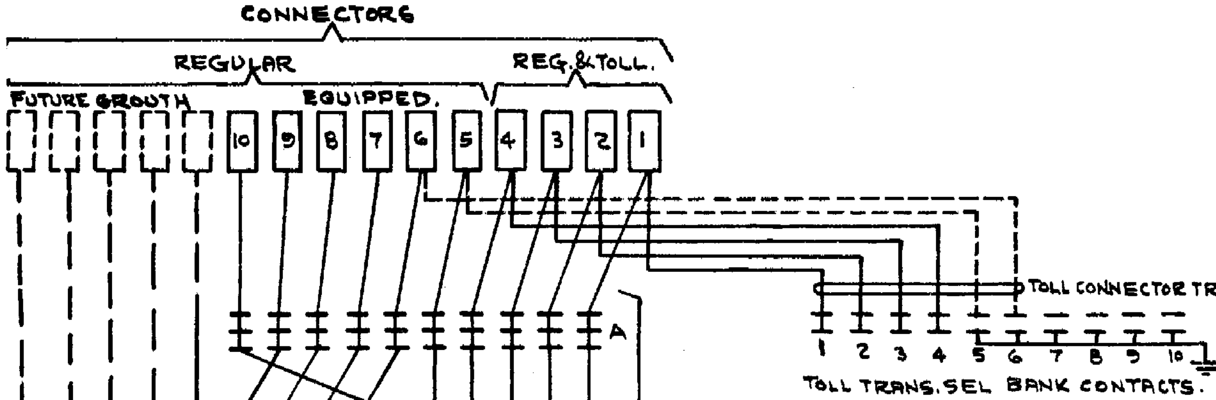
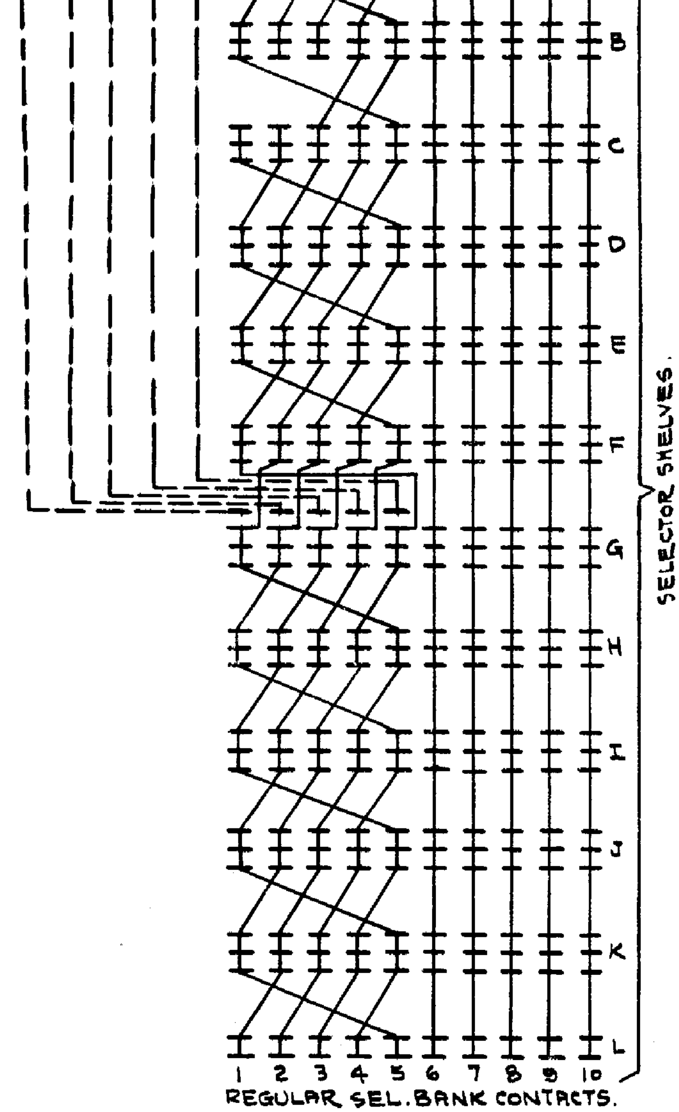



Fig. 73. **Trunking scheme, third selectors to toll and regular connectors**

Fig. 70

12. What is the purpose of trunk slips?

Fig. 71

13. How many first selectors have access to the A-201 sections of second selectors?
14. How many first selectors have access to the 10 dead level trunks?
15. How many first selectors have access to the 10 trunks of the sixth level connecting to the manual office repeaters as shown on supports Nos. 1, 2 and 3? To the five trunks of the sixth level as shown on supports Nos. 19, 20 and 21?
16. In case the trunks to the long distance or recording board are increased to twenty, to which support will the additional 10 trunks connect to provide an equal distribution throughout the two bays?
17. In Fig. 71B, show the second level trunking in detail on supports Nos. 13 to 36 similar to that shown on supports Nos. 1 to 12 by referring to the corresponding second selector outgoing cables shown in Fig. 71A.

Fig. 72

18. How does the trunking from the second selector terminals differ from that of the first selectors?
19. Where are long multiple cables used?
20. What slip is used in Fig. 72?

Fig. 73

21. What change in the terminal soldering is necessary to increase the number of connectors?
22. What slip is used in Fig. 73?
23. Which connector is first choice to the toll third selectors?

CHAPTER 11

Special Service Connectors

Frequency Selecting Connector

FIGURE 75 shows the circuit of the frequency selecting features of the 10 party connector. This connector is the same as the regular connector shown in Fig. 21, with the addition of the frequency selecting machinism represented by the minor switch. The circuit is so arranged that the frequency is selected by a digit dialed before the vertical and rotary operations, which was explained in connection with Fig. 13.

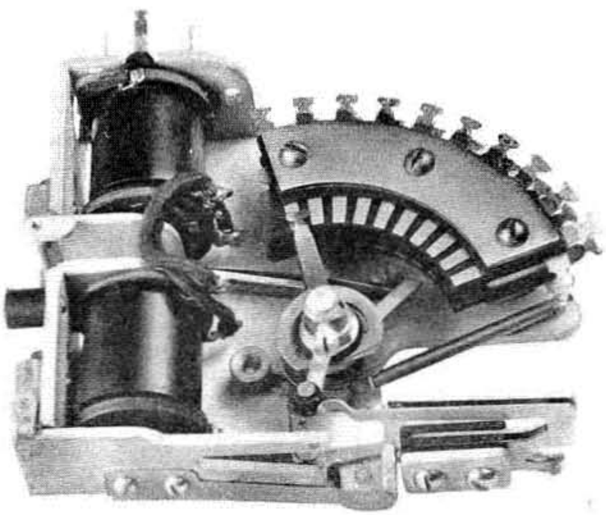


Fig. 74. Minor switch

The frequency selecting or minor switch has its own rotary and release magnets. It is also equipped with a double set of bank contacts and two sets of wipers which are attached to the same shaft. With the minor switch at normal, the bottom wiper rests on the first set of contacts on the lower bank while the top wiper rests opposite the first set of contacts on the upper bank.

Relay F operates as soon as the selector connects to the line relay of the connector by the following circuit, (+) battery through contact of relay B, 1300 ohm winding of relay F, bottom wiper of minor switch to (—) battery. Relay F operating closes the impulse circuit from (+) battery, contacts relays A and B, off normal springs, through the 4 ohm winding of relay C, contact relay F, minor switch rotary magnet to (—) battery, thus stepping the minor switch in a rotary direction each time the circuit of relay A is interrupted.

The instant the minor switch wipers are stepped one rotary step, the circuit to relay F is opened at the bottom minor switch wiper but relay F remains operated from (+) battery through the contact of relay B, 1300 ohm winding of relay F, contacts relays F and C through the rotary magnet to (—) battery. Upon the completion of the frequency selecting impulses relay C restores and opens the locking circuit to relay F, which releases and prepares the circuit to the vertical magnet through its back contacts.

The ringing circuit through the top minor switch wiper remains open, thus preventing ringing current from reaching the wipers until relay H operates and connects the connector shaft wipers through to the bank contacts of the called telephone.

Ringing current is connected to the — line when parties 1 to 5 are called and to the + line when parties 6 to 10 are called.

Rotary Connector

The rotary connector differs from the regular connector (as shown in Fig. 21), as it has two distinct rotary operations; the first is under the control of the dial as explained in connection with Fig. 13, and the second is an automatic rotary, such as used on the selector (Fig. 29). This automatic rotary feature functions upon the completion of the regular rotary motion.

The private bank on the rotary connector has a double set of contacts for each level, similar to the line bank. The top is termed P1, and bottom P2. The P2 privates correspond to the private contacts on the banks of regular connectors.

By the use of the rotary connector a subscriber may have several lines with only one call number listed in the directory. The number listed is the first of the group and the rotary connector will select the first idle one of the group. Should all the lines be engaged the rotary connector will

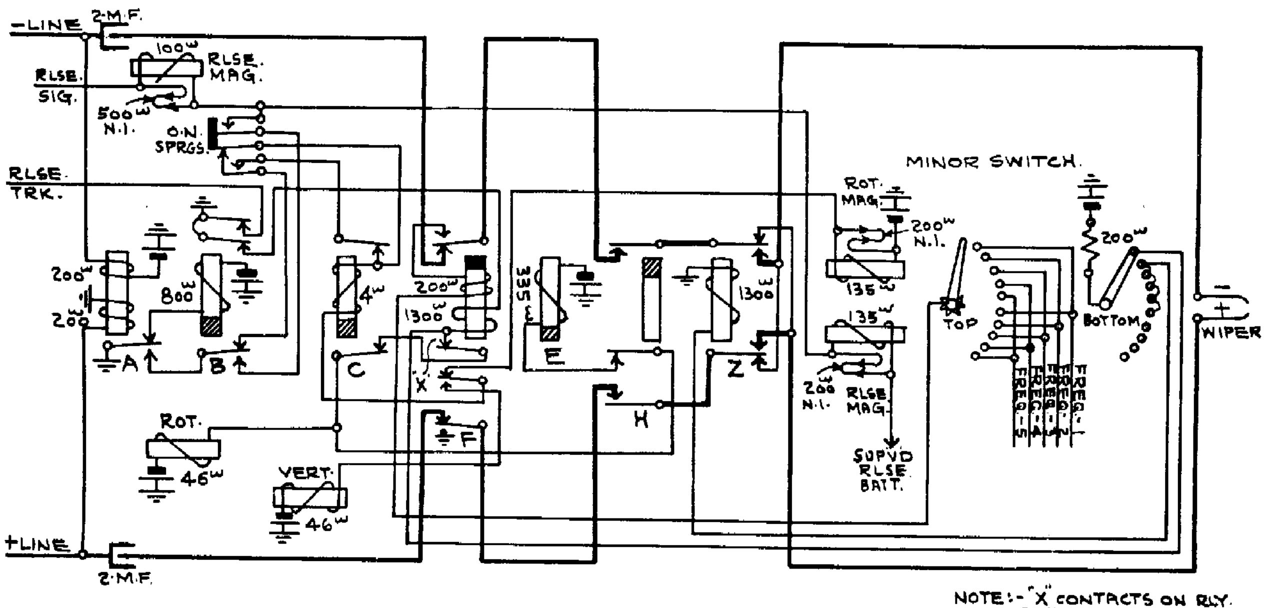


Fig. 75. Circuit of frequency selecting ten party connector

hunt over the entire group and when it is found that all are engaged, it will stop on the last trunk and give the busy tone to the calling subscriber.

The P1 and P2 privates of each line of the group (except the last one) are soldered together at the terminals.

The impulses from the dial step the connector wipers to the first line of a group, and if this line is busy, the automatic rotary feature of the connector comes into action, rotates the shaft and wipers and selects the first idle line. The P1 and P2 privates of the last line not being soldered prevents the connector from rotating past this line.

In Fig. 76 three subscribers line groups are shown, the first consists of 5 lines, the second of 3 lines, and the third of 2 lines.

Assuming the first line of the called group to be busy; upon completion of the rotary impulses (as shown in Fig. 76) relay E falls away but relay J remains operated, due to its slow acting feature and closes a circuit from (+) battery, P1 wiper, contacts relays J, E and F, back contact rotary magnet through the winding of relay G to (—) battery. Relay G operating closes its own locking circuit from (+) battery through contact of relay B; it also closes a circuit from (+) battery, contacts relays B, G and H through the rotary magnet to (—) battery. The rotary magnet operates and steps the switch wipers to the next trunk. Relay J receives a portion of the battery fed to the rotary magnets through the back contact of relay E.

If all lines are busy relay G operates as explained above and steps the wipers to the next line, etc., until the last line in the group is reached; then the wipers come to rest and the busy relay operates from (+) battery, P2 wiper, make contact relay J, contact relay H, through winding of relay K to (—) battery. Relay K operates and forms its own locking circuit the instant relay J falls away from (+) battery through the contacts of relays B, K, J, and H, through the winding of relay K to (—) battery. Relay K also closes the busy tone circuit to the calling party.

One Digit Connector

One digit connector is used when it is desired to serve subscribers having more than 20 trunks with one number in the directory.

A vertical bank of ten contacts is attached to the right side of regular bank. There is a vertical wiper attached to the shaft between the line and private wipers in such a way that it will wipe over the contacts of the vertical bank, but when the shaft starts to rotate, the vertical wiper swings away from the vertical bank.

To operate this connector requires only one digit. This one digit steps the wipers to the desired level, after which the cut in and rotary op-

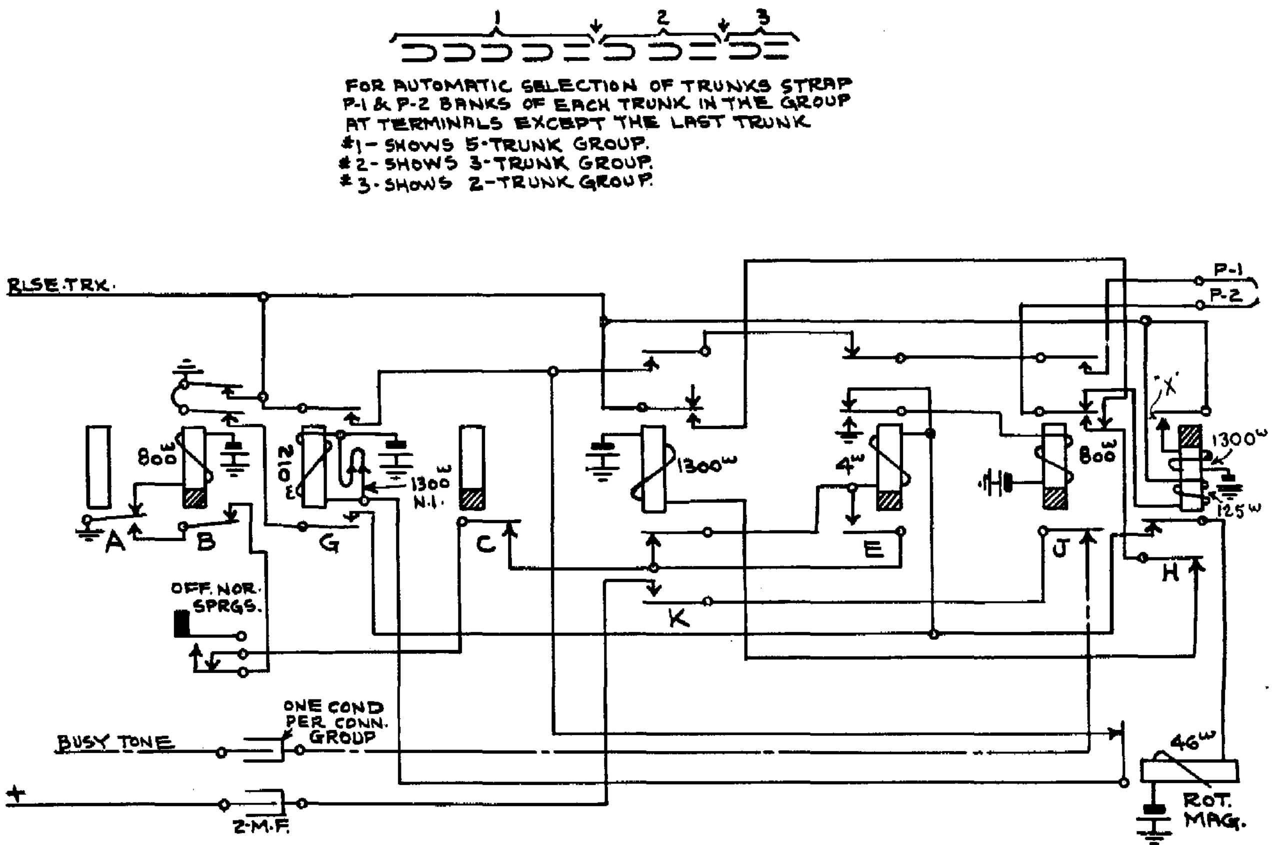


Fig. 76. Circuit of rotary connector

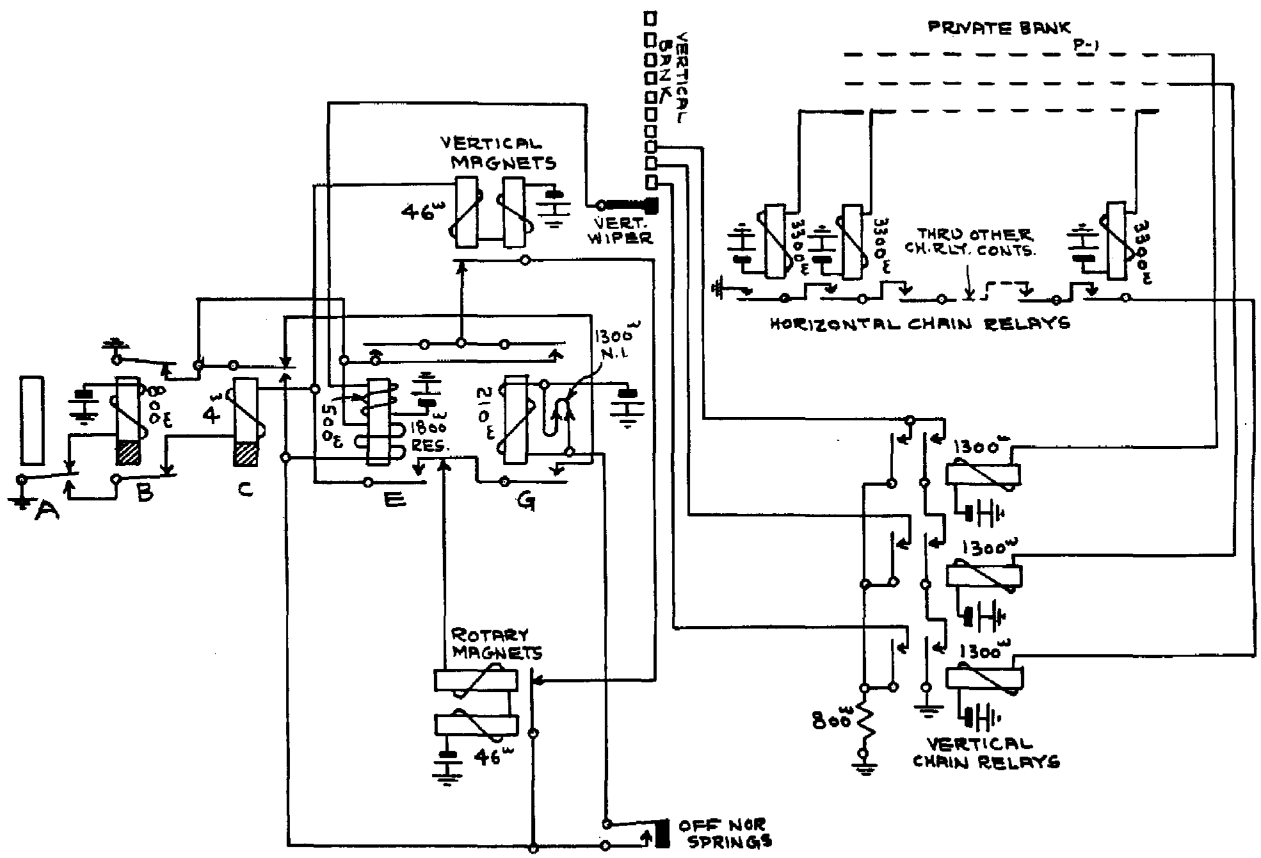


Fig. 77. "One digit" connector, one automatic vertical impulse circuit

eration is automatic. If the level has one or more vacant lines, the switch will rotate and connect to the first idle line. If all lines on the level are engaged, the vertical wipers will connect with (+) battery on the vertical bank contact associated with the called level. This causes the switch to step the wipers to the next level where the test for a non-busy line is repeated. In this way an idle level and idle line are found. If all lines of the group are busy the switch steps to the top level and rotates to eleventh position (see Fig. 32) and gives the calling party the busy tone.

A chain relay (horizontal) is connected to each private bank contact as shown in Fig. 77. The contacts of the horizontal chain relays of each level are connected in series so that when all lines of a level are engaged, the corresponding vertical chain relay is operated. This connects (+) battery to the vertical bank contact

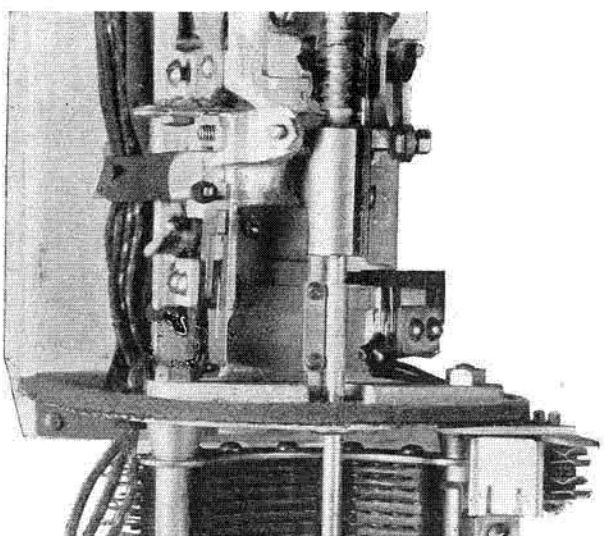


Fig. 78. One digit connector, vertical wiper and bank, normal position

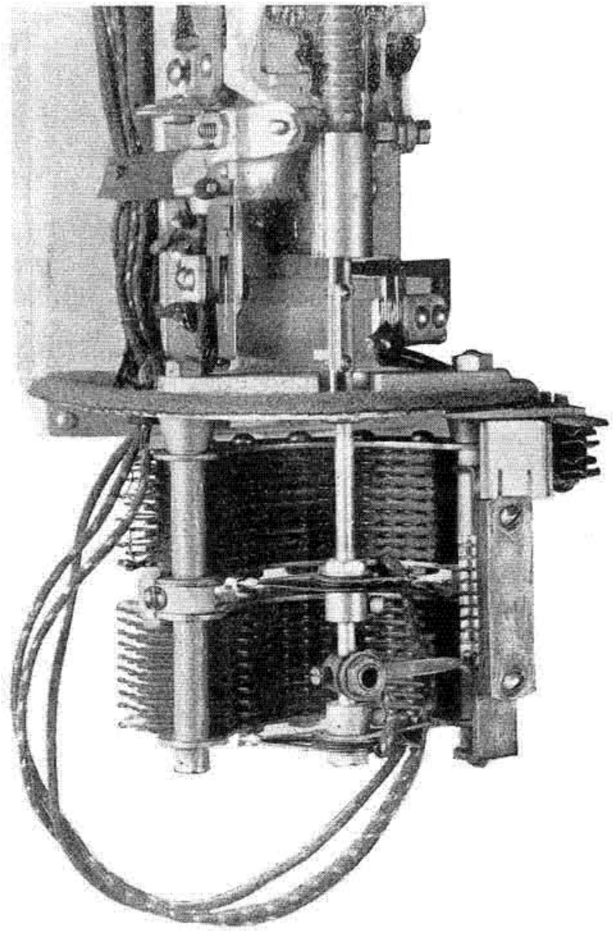


Fig. 79. One digit connector, vertical wiper and bank, operated position

corresponding to the level on which all trunks are engaged.

During the vertical operation of the switch by the dial, a circuit is closed from (+) battery through contacts of relays B and C, off-normal springs, winding relay G to (—) battery. Relay G operating prepares part of the vertical and rotary magnet circuits. Assuming that the first level is dialed and all of its trunks are engaged, the vertical wiper connects with (+) battery on the first vertical step causing relay E to operate and close the vertical magnet circuit the instant relay C falls away, from (—) battery vertical magnet, contacts relays E, G, C, and B to (+) battery.

The vertical magnet operates and steps the wipers to the second level and also opens the circuit to relay G, which falls away and opens the vertical magnet circuit. If all lines of the second level are not engaged, the vertical wiper does not connect with (+) battery. Therefore relay E de-energizes but is retarded in falling away, due to the short circuit on its 1800 ohm winding. Relay E holds a sufficient length of time to allow relay G to operate, and close the circuit to the rotary magnet, causing the switch to rotate and connect to the first idle line.

Review

Fig. 75

1. What relays energize on the frequency selecting connector when it is seized by a selector?
2. On which side of the line does the connector ring when No. 1 party is called? When No. 6 party is called?
3. How is relay F held operated during the frequency selecting period?

Fig. 76

1. How does the rotary connector private bank differ from that of the regular connector?
2. Assuming a party to have 6 trunks, how many of these should be listed in the directory?
3. How are rotary connectors prevented from connecting to another group of trunks in case all trunks of the called group are busy?

Fig. 77

1. When are one digit connectors used?
2. Explain the circuit operation when the vertical wiper connects with (+) battery when the first level of a group is called?

CHAPTER 12

Toll Equipment

THE toll dialing trunks are used for completing connections from toll to local subscribers. They provide means for supervision by the toll operator and all conditions favorable to the best transmission. As a general rule they terminate on toll first selectors in the automatic offices. A typical toll train is shown in Figs. 80 to 84. Combination toll and regular connectors are generally used. The selector trunking is so arranged that they are first choice to toll calls and last choice to local calls.

The toll first selector operates practically the same as a regular selector and extends the lines to the toll second selector, etc.

Toll Transmission Selectors

The toll third or transmission selector in a 100,000 line system repeats the impulses to the toll connector. It is also equipped with a repeat coil, which makes possible a transmission circuit without battery between the third or toll transmission selector and toll board.

In making a call from the toll board, the operator plugs the calling cord into a trunk to a toll first selector in the automatic office; operates the dialing key and dials the desired automatic number. If the busy tone is not received the supervisory lamp associated with the cord circuit will glow the instant the dialing key is restored, indicating that connection has been made to the desired number.

When the operator is ready to ring the called party, the operation of the ringing key associated with the cord circuit, operates an A.C. relay on the toll third selector, which allows the ring cut off relay on the toll connector to de-energize and start the interrupted ringing. When the called party answers, the supervisory lamp on the cord circuit is extinguished.

The supervisory lamp on the cord circuit will again glow when the called party hangs up the receiver, thus giving disconnect supervision to the operator.

Busy Supervision

Assuming the number wanted to be busy, the operator will receive the busy tone the instant the connector steps to the called number. The supervisory lamp on the cord circuit will not glow under these conditions when the dialing key is restored, but will glow the instant the called line becomes disengaged, after which, at her convenience the operator can start the interrupted ringing to signal the called party.

The selecting features of the transmission selector repeater are identical with those of the regular selector. The circuit is shown in Fig. 80.

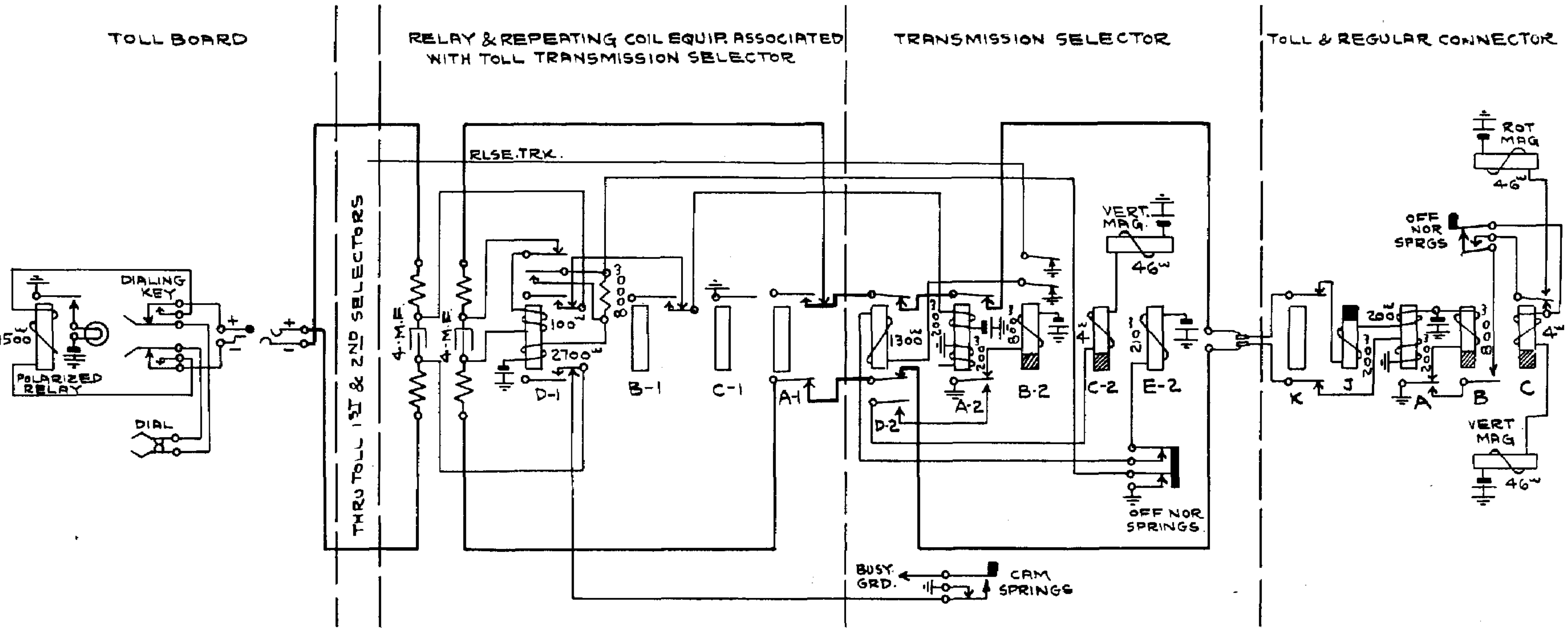


Fig. 80. Toll transmission selector repeater, repeating impulses to toll connector

The operator inserts the plug of the dialing cord into the jack of the trunk to a first selector and operates the dialing key, which closes dialing circuit to toll selector, and dials the first three digits which completes the connection through a first selector, second selector and third or toll transmission selector to a toll connector. A circuit is now complete to relay A2 of the third or transmission selector from (—) battery, winding relay A2, contacts relays B1 and D1, repeating coil, dial, repeating coil, contacts relay D1, cam springs to (+) battery. Relay A2 closes the loop circuit to relay A on the connector from (—) battery through 200 ohm winding of relay A, 200 ohm winding of relay J, contact relay K, — wiper, contacts relays A2, D2 and A1, repeating coil, contacts relay D1, 100 ohm winding of relay D1, repeating coil, contacts relays A1, and D2, + wiper, contacts relay K, 200 ohm winding of relay A to (+) battery.

Each time relay A2 of the transmission selector releases in response to the interruptions received from the dial, the circuit of relay A of the toll connector is opened at the contacts of relay A2, thus repeating the impulses to the toll connector.

Assuming that the called number is busy (see Fig. 81), a circuit is closed from (+) battery at private wiper, make contact relay E, contact relay H, 1300 ohm winding relay G to (—) battery. Relay G operating, closes its own locking circuit after relay E falls away, from (+) battery, private wiper, contacts of relays F, G, E, and H, 1300 ohm winding relay G to (—) battery.

Relay G also closes the busy circuit through its make contact, 2 M.F. condenser, contact relay K, + wiper, contacts relays D2, and A1, repeating coil, 100 ohm winding of relay D1, contact relay D1, repeating coil, contacts relays A1, D2, and A2, — wiper, contacts relay K, 200 ohm winding relay J, through 200 ohm winding relay A to (—) battery. The busy tone is induced in the toll board side of the repeating coil, giving the operator the busy tone.

Camping feature

When the operator restores her dial key the 1500 ohm polarized relay does not operate. Therefore the supervisory lamp will not glow. The instant the called line becomes idle, the battery supply is reversed to the 1500 ohm polarized relay, by the operation of relay D1. The operation of relay D1 is explained in connection with Fig. 81. The polarized relay operating, causes the supervisory lamp in the cord circuit to glow, thus giving the operator non-busy supervision. The interrupted ring which signals the called telephone can be started at the discretion of the operator.

Ringing position

During the time that impulses are repeated to the connector the following relays are energized: D2, A2, B2, J, A, B. (See Fig. 82.)

The instant the connector is stepped to the called number, relay H operates from (—) battery through the B.C.O. coil, private wiper, 200 ohm winding relay H, contact relay B to (+) battery. The instant relay H operates, it locks from (+) battery at relay B through its 1300 ohm winding to (—) battery. It also closes a circuit from (+) battery at contact of relay B through its own make contact, contact relay J through 200 ohm winding relay D to (—) battery.

Relay D operating, reverses the current supply from relay A through the 100 ohm winding of relay D1, causing the electro polarized relay D1 to operate as the battery now flows through the 100 ohm winding in the same direction as that in the 2700 ohm winding. Relay D1 operating closes its "X" contacts first, which shunts the 8000 ohm resistance and completes its own locking circuit. The 100 ohm winding is opened by the operation of relay D1.

Relay D1 operating, reverses the current supply to the 1500 ohm polarized relay in the cord circuit which operates and causes the supervisory lamp to glow.

The operation of relay D1 connects the — winding of relay B1 to the — winding of relay A, and the + winding of relay B1 to the + winding of relay A; therefore, there being no current flow relay A falls away.

Relays B and J being slow acting remain operated for an instant after relay A falls away, closing the circuit to relay K from (+) battery through "Y" contacts of relay K, contacts of relays A and B, off normal springs, contacts relays D and J through the 1300 ohm winding of relay K to (—) battery. Relay K operates and locks to (+) battery through the contact of relay

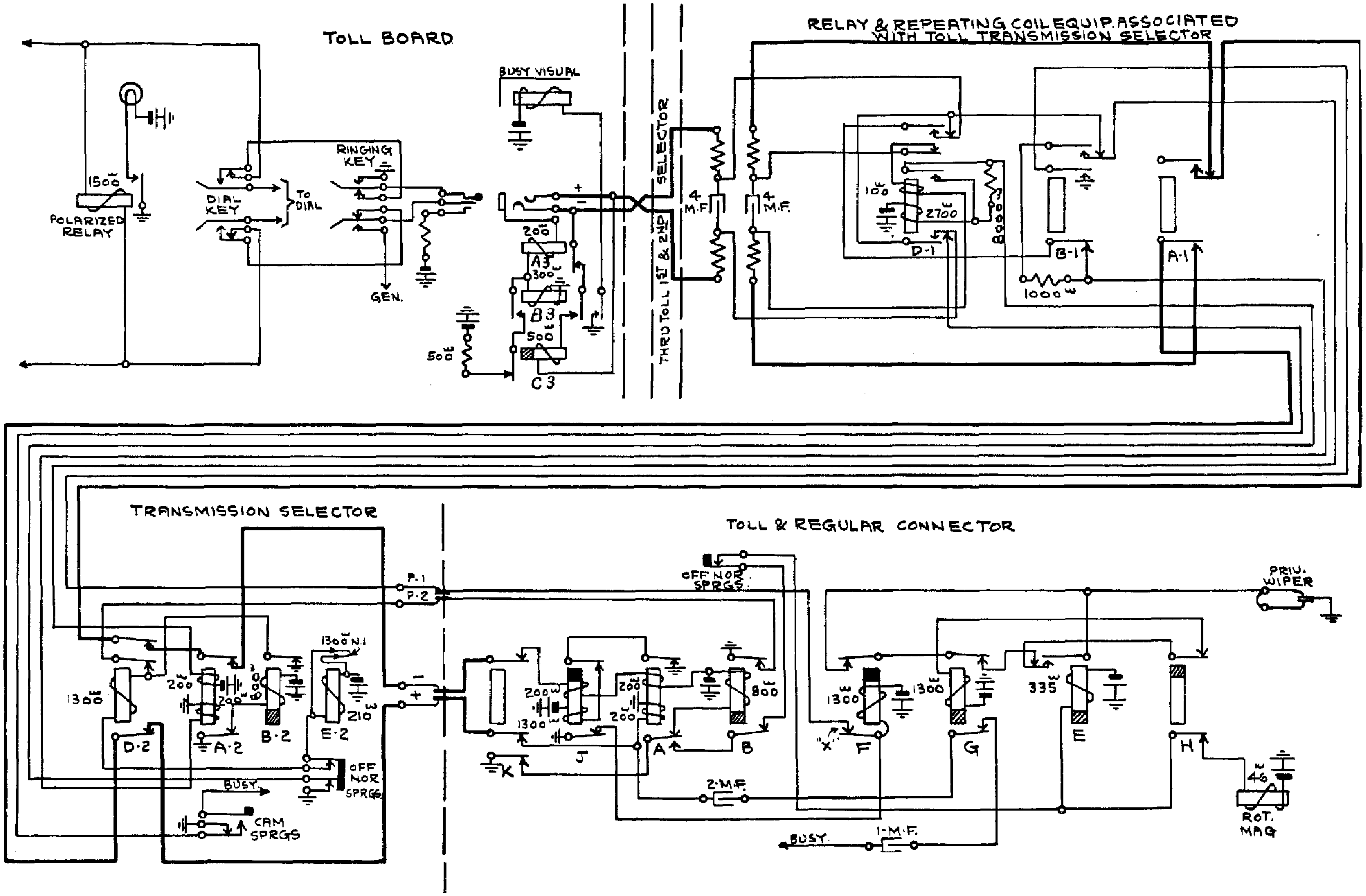


Fig. 81. Toll connection to subscriber's line, giving busy supervision to operator

B2. Relay K operating, opens the circuit to relays A and J and closes the lines, through its make contacts, to the called telephone. By the operation of the ringing key, relay C1 operates from ringing current supply at the ringing key over — trunk through the repeating coil, contact relay D1, 700 ohm relay C1, condenser, repeating coil, + trunk, ringing key to (+) battery.

Relay C1 operating, causes relay A1 to operate which opens the circuit to the ring cut off relay F from (+) battery, through its back contact, contact relay D2, P1 wiper, make contacts "X" on relay F, through the 1300 ohm winding of relay F to (—) battery. This allows relay F to fall away and start the interrupted ring, from the generator through the 200 ohm winding of relay F, contacts relays F, and H, — wiper, line, called telephone, + line, wiper, contacts relays H, and F to (+) battery.

Talking position

When the called party answers relay F operates, stops the ring and connects the lines of the called telephone through to the windings of relay B1, which operates.

Relay B1 operating, closes a 1000 ohm holding loop to relay A2 and removes (—) and (+) battery from the manual switchboard side of the repeating coil, which allows the 1500 ohm polarized cord relay to fall away, extinguishing the supervisory lamp, giving the operator answering supervision.

After the called party answers, the following relays are operated: B1, D1, D2, A2, B2, K, F and H.

During the talking period, relays A3, B3, B1, D1, D2, A2, B2, K, F and H are operated. Relay B1 on the toll transmission selector supplies transmitter battery to the called party. (See Fig. 83.)

Should the operator remove the plug before the called party replaces the receiver, the switches will not release because relay B3 remains operated from (—) battery, contacts relays C3 and B3, through winding relay B3 to (+) battery. Relay B3 closes a locking circuit to the busy visuals thus protecting this trunk from use at the toll board. When the called party replaces the receiver, relay B1 falls away and closes a circuit from (—) battery through the winding of relay A2, contacts relays B1, and D1, repeating coil, winding of relay C3, contacts of B3, A3, repeating coil, contacts relays D1, and B1 to (+) battery at the cam springs. Relay C3 operating, opens the locking current to relay B3, which falls away and allows the busy visual to restore to normal. Relay B3 falling away also opens the circuit to relay C3, which allows the selectors of the toll train to release.

Review

1. Describe toll dialing trunks.
2. What is difference between regular toll selectors and toll transmission selectors?

Fig. 80

3. Which relay repeats impulses to relay A of the connector?
4. Which relays are operated during the impulsing period?

Fig. 81

5. What indication does the operator receive when connecting to a busy line?
6. Is it necessary for the operator to release and call again in case the called line is busy?

Fig. 82

7. What takes place the instant the connector steps to an idle line?
8. What indication does operator receive when connecting to an idle line?
9. How is the interrupted ring started?

Fig. 83

10. What relays are operated during conversation?
11. What relay feeds transmitter battery to the called party for conversation?
12. In case of switchboard cord trouble, can the operator change cords without releasing the connection?

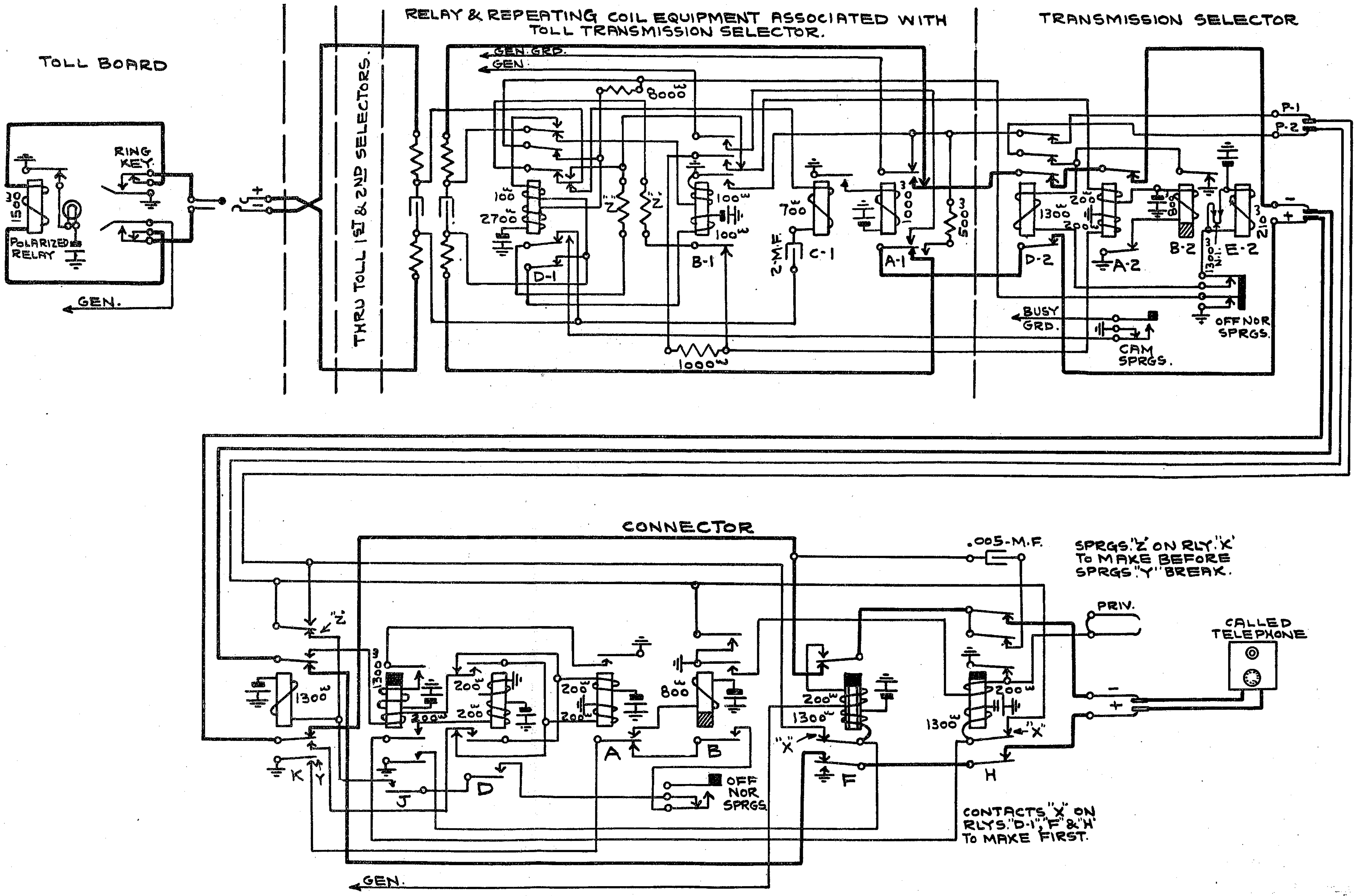


Fig. 82. Toll connection to subscriber's line, ready for operator to start automatic ringing

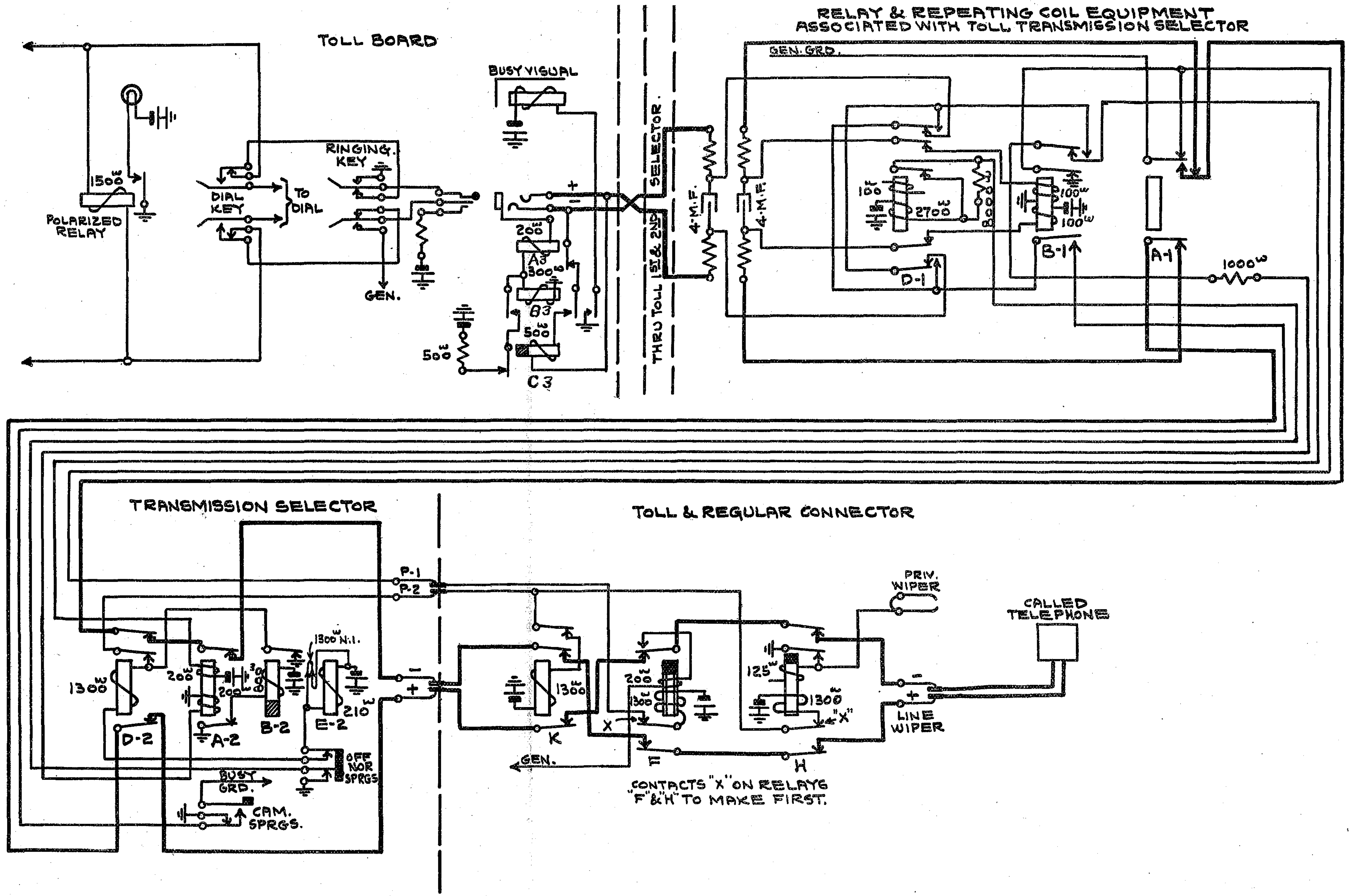


Fig. 83. Toll connection to subscriber's line, talking position, giving supervision to operator

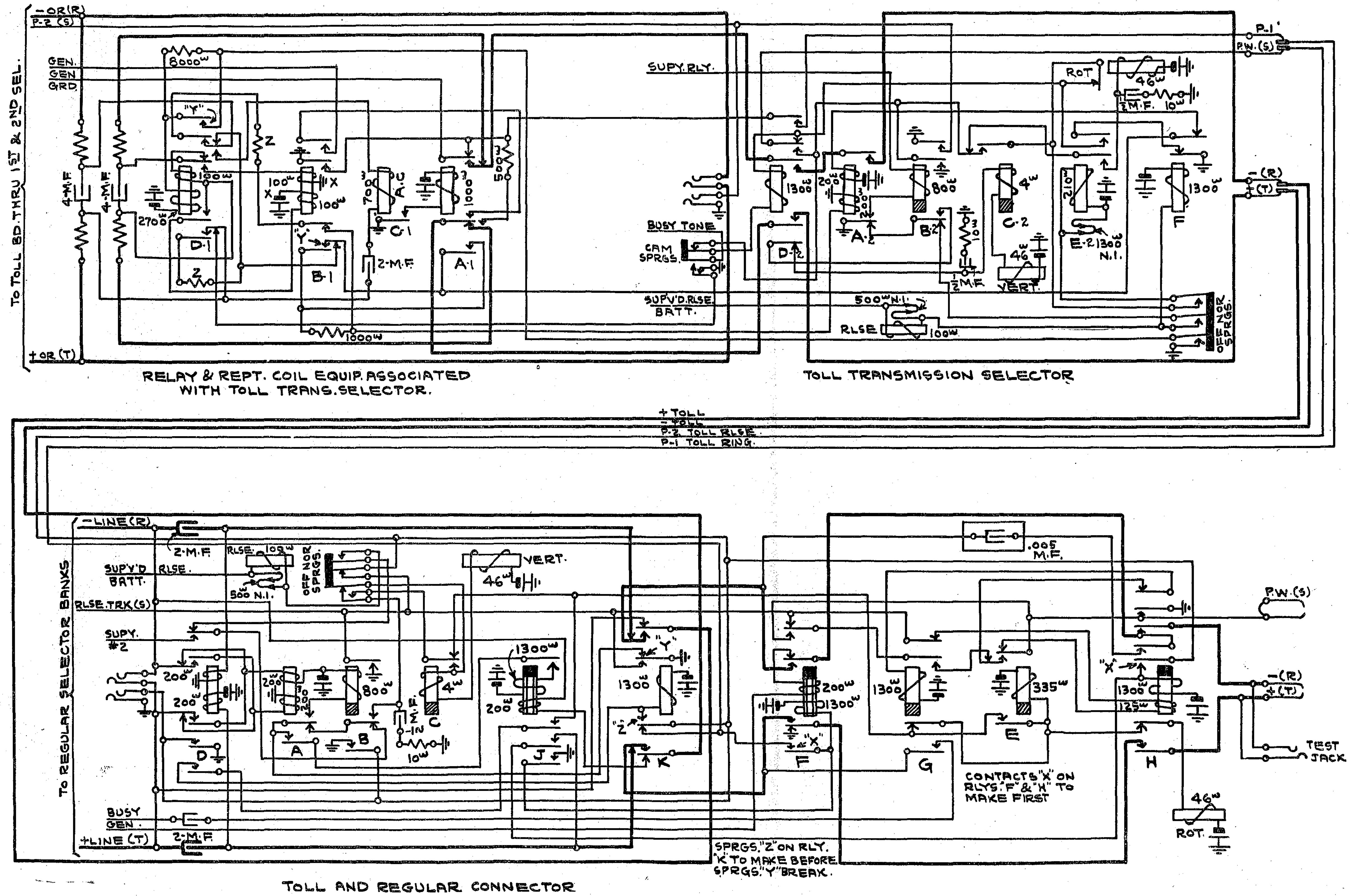


Fig. 84. Toll connection, complete circuit

CHAPTER 13

The Switching Selector Repeater

IN an automatic multi-office exchange area of moderate size it is customary to provide a group of direct trunks between all offices. Referring to Fig. 61 it will be seen that inter-office trunks terminate at the originating end in the first selector banks.

This affords a most efficient arrangement since by the use of outgoing secondary line switches, all of the trunks to a given office may be combined into one large group or at least a small number of large groups. With this arrangement, all of the subscribers' numbers in a given office begin with the same digit or office prefix.

Use of the Switching Selector Repeater

It is sometimes convenient to locate a comparatively small office on the outskirts of the exchange area. To provide a separate group of trunks from such an office to each of the other offices in the system would be very inefficient, as each group of trunks would be comparatively small. A better arrangement, in so far, as the outside plant is concerned, is to carry all of the originating traffic from this branch office to the nearest main office, and from there distribute it to the remaining offices over the same trunks which carry the traffic originating in that office.

This means that the branch office first selectors must be located in the main office so that the inter-office trunks can be selected after dialing the first digit. As far as the outgoing traffic is concerned, this could be done simply by inserting a repeater in the outgoing lineswitch trunks and extending the trunks through the outside cable to first selectors located in the main office.

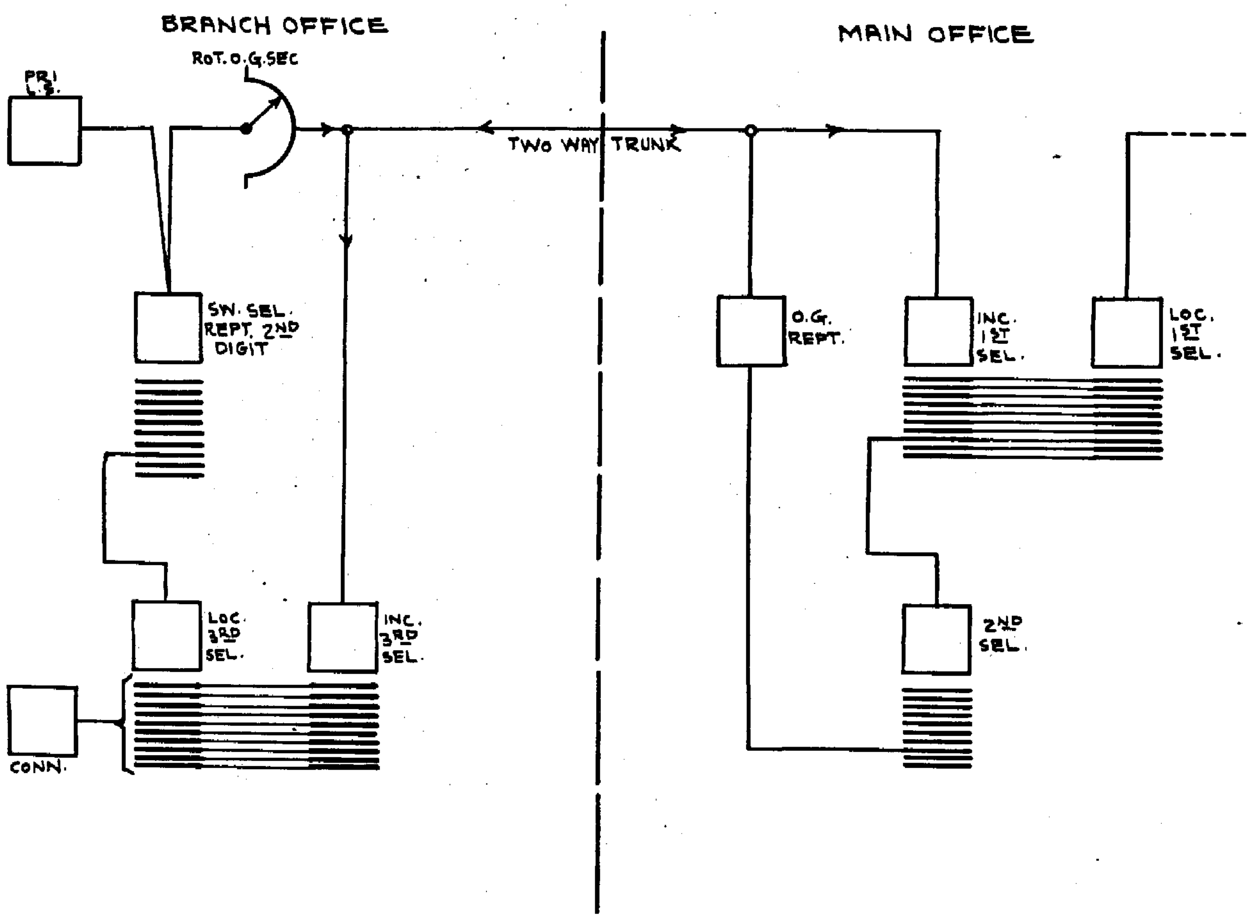


Fig. 85. Switching selector repeater trunking diagram, showing its use in branch office

Since with this simple scheme the first digit dialed by a branch office subscriber operates a switch in the main office, it is evident that should the called subscriber also be located in the branch office, it would be necessary to use a second trunk leading back to the branch office to complete the connection.

In order to obviate the necessity of using the two trunks between a main and a branch office for completing a local call between two branch office subscribers, a switch known as the switching selector repeater was developed. This switch makes possible a connection between two branch office subscribers without using an inter-office trunk.

As its name implies, the switching selector repeater combines the functions of both a selector and a repeater in a single mechanism, together with means for switching from one function to the other. It serves as a repeater on outgoing calls and as a selector on local calls. It occupies a position in the circuit between the primary line switches and outgoing secondary switches. One or more levels of the bank of the switching selector repeater can be connected to local selectors or connectors, depending on the size of the branch office.

A certain block of numbers is assigned to the lines in the branch office and is distinguished by the first, first and second, or first, second and third digits, depending upon the size of the system and the office.

When a subscriber in a branch office equipped with switching selector repeaters originates a call, the primary line switch, switching selector repeater, and outgoing secondary line switch operate to extend the connection to a first selector in the main office. The switching selector repeater being included in the primary trunk operates as an ordinary repeater to relay the dial impulses to the inter-office trunk for the purpose of operating the switches in the distant office.

If the call is for a number not in the same branch office, the switching selector repeater retains its function as a repeater throughout the building up of the connection. In the event, however, that the call is for a subscriber in the same branch office, the switching selector repeater will, as soon as the determining digit or combination of digits is dialed, cut its wipers in on the required bank level, switching the connection through its bank to a local switch, opening the trunk loop to the main office, and permitting the switches which have been operated there to release, and finally releasing the outgoing secondary switch in the branch office and completely freeing the inter-office trunk. From this point the connection is set up over switches located wholly within the branch office.

With respect to the point at which the connection is switched from the outgoing trunk to the local switches, three types of switching selector repeaters have been designed. One switches on the first digit, and is for use where no other numbers in the system begin with the same digit as those of the branch office. The other two switch on the second and third digits, respectively.

In order to make clear the operation of the switching selector repeater, the method of establishing a connection will be described in detail. The switch described will be the one which switches on the second digit since this seems to be the one which finds most frequent application in practice.

Let us take, for example, a five digit or 100,000 line system and assume a branch office with an ultimate capacity of 1000 lines, as shown in Fig. 85. Assume the numbers allotted to the branch office lines to be the thirty-three thousand. In this particular case, the line and private contacts of the third level of the bank of the switching selector repeater will be connected to local third selectors. In addition to the ordinary line bank contacts, the switching selector repeater has a double set of private wiper bank contacts similar to the line bank.

The P1 wiper and its corresponding bank contacts form the means whereby the switch is enabled to determine whether the number being called is in the branch office or not.

When a calling subscriber removes the receiver, the primary lineswitch extends the lines to the switching selector repeater, which in turn causes its associated outgoing secondary switch to operate and extend the connection to the main office. When the subscriber operates the dial for the first digit, the line relay of the switching selector repeater receives the dial impulses and repeats them over the trunk operating the first selector in the main office. The shaft of the switching selector re-

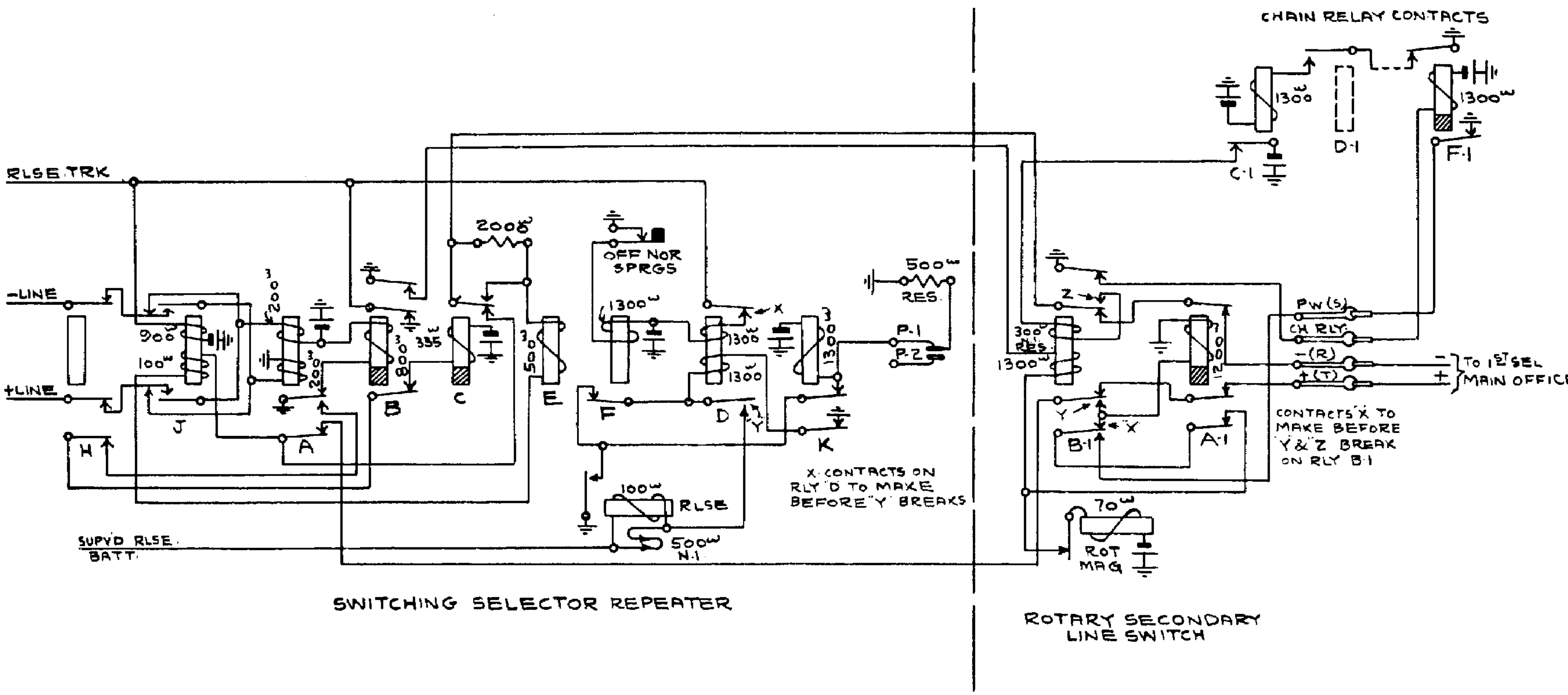


Fig. 86. Switching selector repeater, showing impulse repeating feature

peater is also elevated the same number of steps following which it rotates to the first bank contact; but as this call is destined to a number in the main office, it makes no connection to the banks. The switching selector repeater continues to operate as a repeater and succeeding digits are repeated to the switches in the main office, establishing the connection therein.

Had the call been for a number in the branch office, the shaft of the switching selector repeater would have released following the first digit, and on the second digit, would have rotated over the bank contacts the same as a regular selector, until an idle trunk was found leading to a third selector.

Incoming calls to a switching selector repeater office are handled in the ordinary manner, going out from the main office through repeaters and terminating in the branch office on incoming selectors or connectors. The trunks between offices may be and usually are "two-way" trunks.

It should not be inferred that the switching selector repeater is useful only in a system embodying a number of main offices. This is not the case; it is just as applicable to a system consisting of one main and one branch office.

Circuit of the Switching Selector Repeater

The instant the switching selector repeater is selected, relays A and B operate. The operation of these relays causes relay A1 of the rotary line switch to operate from (+) battery through the winding of relay A1, back contact relay B1, contact relay A, 100 ohm winding relay J, winding relay E, contacts relays C and B1, 300 ohm resistance winding relay B1, through contact of relay C1 to (—) battery. Relay A1 operating, tests the trunk for being engaged and if it is, steps the wipers to the next trunk, etc., until an idle trunk is found. Relay B1 now operates

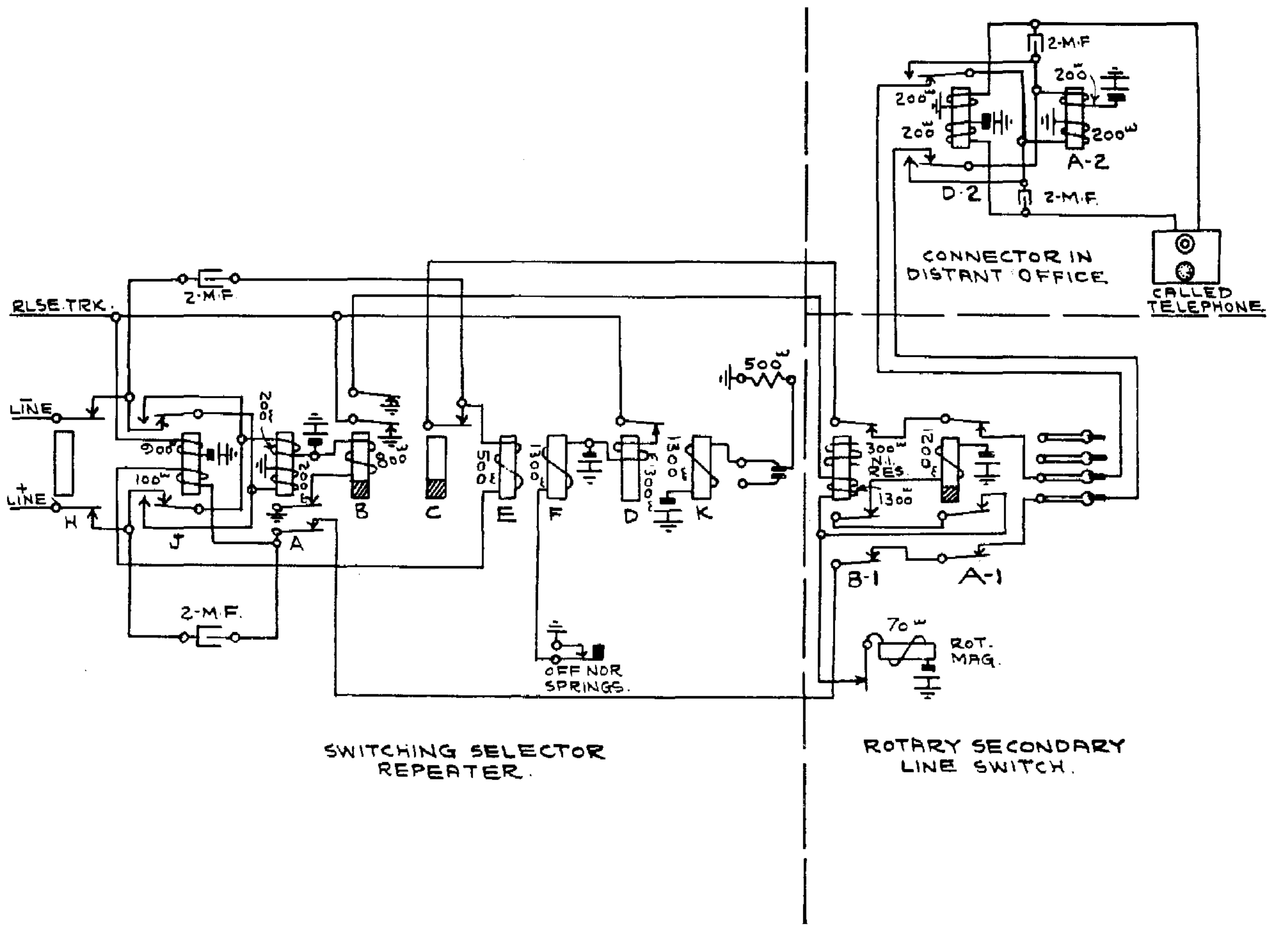


Fig. 87. Switching selector repeater, talking position

and extends the connection to the first selector in the main office.

Repeating impulses

Relay C remains operated during each series of impulses and shunts the 500 ohm winding of relay E, and the 100 ohm winding of relay J. Thus all resistance at the switching selector repeater is removed from the trunk circuit to the first selector in the main office during impulsing.

Fig. 86 shows the circuit of switching selector repeater with the lines extended through the rotary secondary to the trunk leading to the main office. The first selector has been operated and the switch is ready to repeat impulses to the second selector.

Relay F operates from (+) battery at the off normal springs at the first vertical step.

The P1 wiper encounters (+) battery through 500 ohm resistance which determines whether the number called is located in the main office. Relay K operates from (+) battery, 500 ohm resistance, P1 wiper, through its winding to (—) battery. Relay K operating, closes a circuit from (+) battery contact relay K, winding relay D, contact relay D through winding of release magnet to supervised (—) battery. Relay D operating locks from (+) battery at contact of relay B. If a branch office number is dialed relay D fails to operate until the shaft restores to normal after the first digit has been dialed.

When the called party answers, the battery to the 100 ohm winding of relay J is reversed to that of the 900 ohm winding. Reversing the direction of current in the 100 ohm winding causes it to flow in the same direction as that of the 900 ohm winding, which operates relay J, thus reversing the polarity of the battery to the calling party.

Talking circuit

Fig. 87 shows the circuit of the switching selector repeater in the talking position with battery reversed to the calling party.

Relays J, A, B, E, F, D, K, B1, A1, D2 and A2 are operated during the talking period. Relay A feeds transmitter battery to calling party for conversation.

Preparatory to switching

Assume that a subscriber in the branch office originates a call to telephone number 33400 in the same office. (See Fig. 88.)

When the first digit (3) is dialed, the switching selector repeater wipers are stepped to the third level and cut in on the first set of contacts. Relay K operates from (+) battery, contacts relays B and D, P1 wiper, winding relay K to (—) battery. Relay K operating, closes the release magnet circuit from supervised release (—) battery, release magnet, contacts of relays D, F, and K, P1 wiper, contacts relays D and B to (+) battery. The release magnet operates and allows the shaft to restore to normal. The circuit to relay F is opened at the off normal springs the instant the shaft restores to normal. Relay F releasing, removes the shunt from the 1300 ohm winding of relay D, which operates from (+) battery, contacts relay K, winding relay D, contacts relay D, through the release magnet to supervised release (—) battery. Relay D operating, locks from (+) battery at release trunk before relay K falls away.

Relay D operating, opens the (+) battery circuit to the P1 private contact of the third level. The second digit (3) is now dialed and the wipers

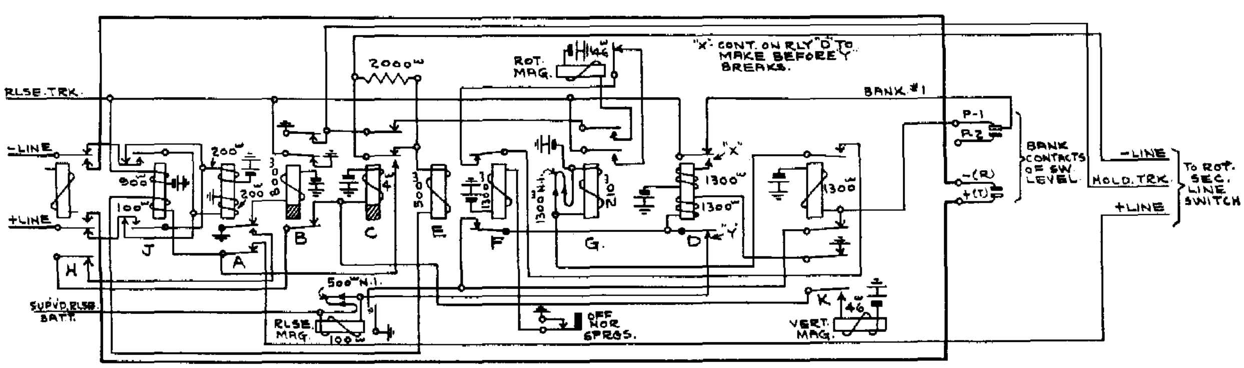


Fig. 88. Switching selector repeater, preparatory to switching

are stepped to the third level and rotated one step. The P1 wiper finding no (+) battery indicating that the number wanted is located in the branch office, and since this is the level which is connected to third selectors, the wipers continue to rotate until an idle trunk is found and come to rest, switching the lines through in the usual manner. When this occurs, the connection to the main office is broken, the outgoing secondary switch, first and second selectors in the main office are released and the inter-office trunk is immediately available for another call.

Switched through to succeeding switch in branch office

Fig. 89 shows the switching selector repeater switched through to the third selector. The remaining three digits of the number operate the third selector and connector respectively. The circuit of the switching selector repeater in this case is the same as that of a selector.

The complete circuit of this switch is shown in Fig. 90. Assuming all trunks to the main office to be busy, the chain relay associated with each trunk is operated, closing a series (+) battery circuit to relay C1, operating it, and disconnecting (—) battery from the 300 ohm winding of relay B1. In case another call to the main office is originated, relay A1 of the rotary lineswitch associated with the switching selector repeater fails to operate, thus connecting busy tone through its back contacts to the calling subscriber.

The P1 and P2 bank privates shown in Fig. 90 represent the ten bank levels of each switching selector repeater. The P2 privates are multipled throughout the switching selector repeater group. The P1 privates are not multipled.

Levels 1, 5, 6, 7, 8, 9, and 0 are wired for outgoing service. In other words, the telephone lines commencing with these digits terminate in a distant office.

The third level corresponds to both the first and second digits of the local branch office numbers. Should it be desired to install another 1000 numbers, for instance the 22000, it would be necessary to remove the (+) battery from the P1 contacts of the second level banks and wire then similar to the third level.

Review

Fig. 85

1. When are switching selector repeaters generally used?
2. What advantage is gained by the use of switching selector repeaters?

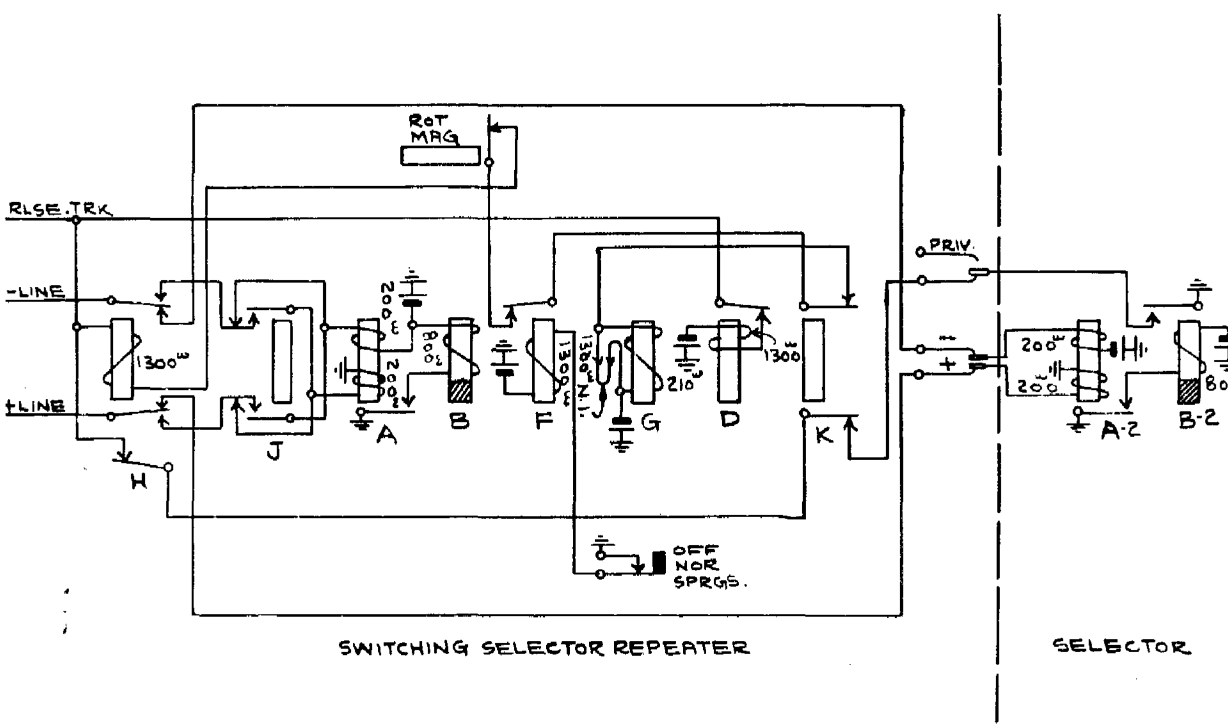


Fig. 89. Switching selector repeater after being switched through to succeeding selector in same office

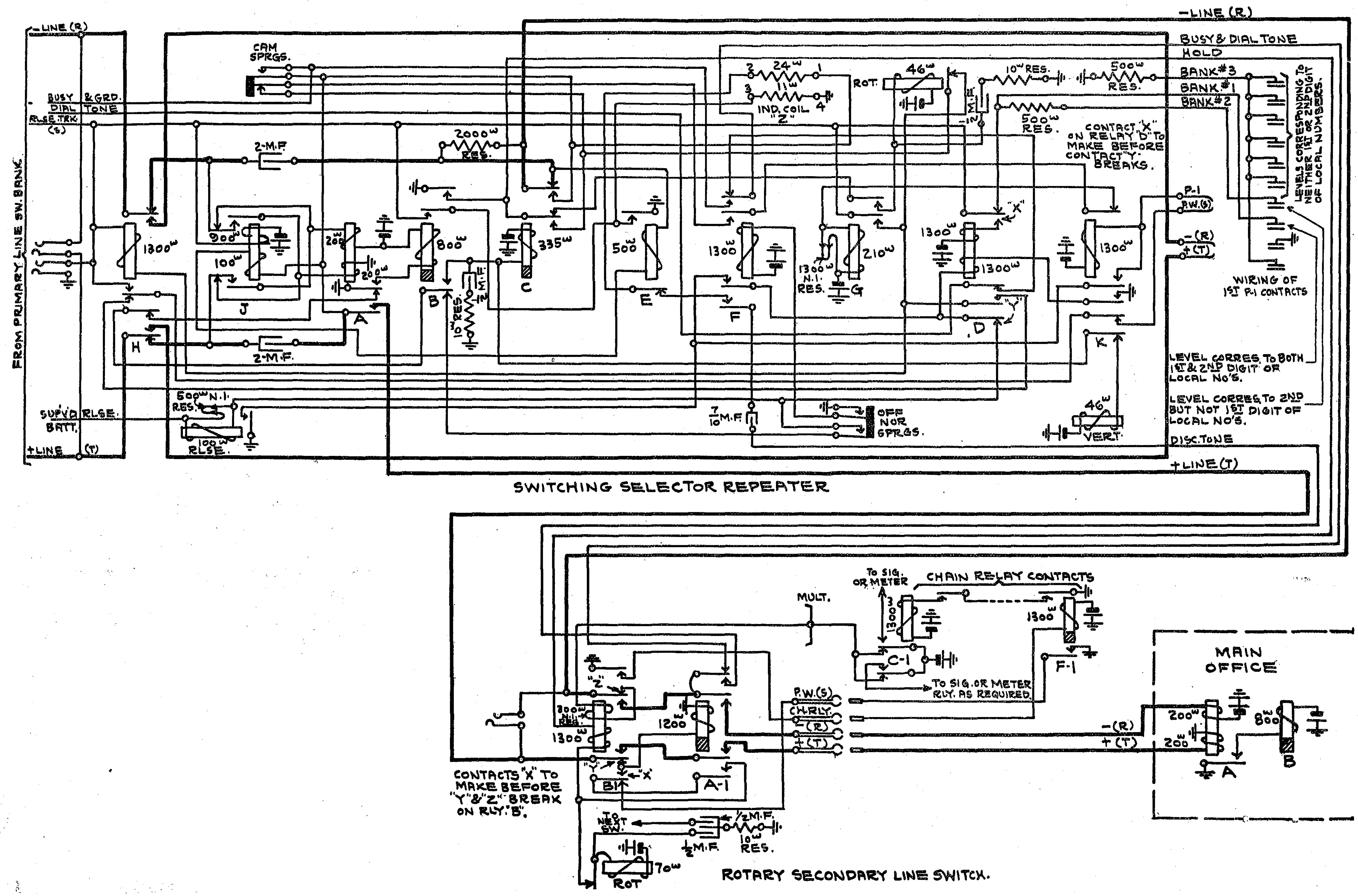


Fig. 90. Switching selector repeater, complete circuit

3. When does the switching selector repeater operate as a repeater?
4. When does the switching selector repeater operate as a selector?
5. What happens on the switch in the main office when the first digit is dialed on the switching selector repeater?

Fig. 86

6. Trace the trunk circuit through the switching selector repeater to the main office.
7. Trace the trunk circuit to the main office during the impulsing period.
8. Explain the operation of relay D on a call to the main office.

Fig. 87

9. What relays are operated on a call to the main office?
10. How much resistance is bridged across the trunk to the main office during the talking period?
11. Why is it necessary to provide a relay for reversing the battery on the switching selector repeater?

Fig. 88

12. Explain the closing of the release circuit when the switching level is dialed.
13. Explain the operation of relay D when the first digit (3) is dialed.

Fig. 89

14. What relays are operated on a call through switching selector repeater to a subscriber in the same branch office?
15. When a call is originated and terminates in the branch office, is a trunk to the main office occupied until the connection is released?

Fig. 90

16. How is the busy tone connected to the calling party's line in case all trunks to the main office are busy?

CHAPTER 14

Reverting Call Equipment

REVERTING call switches provide means whereby one subscriber on a party line can dial and signal another party on the same line.

The dialing is done in the usual way except that a special number received from the information operator, is dialed instead of the one listed in the directory. This connects the subscriber's line to the reverting call equipment. After dialing the special number, the calling party places the receiver on the hook, and the reverting call equipment rings alternately the bells of the calling and the called telephones. When the called party answers, the ringing stops, which indicates to the calling subscriber that the party called has answered. He then removes the receiver and starts the conversation.

When the calling party answers, the reverting call switch restores to normal but does not allow the selectors back of it to restore. The transmitter battery is furnished from relay A of the reverting call switch. In exchange systems where a dial tone is not used, the switches back of the reverting call equipment are allowed to restore to normal, in which case the transmitter battery is furnished from relay A of the first selector.

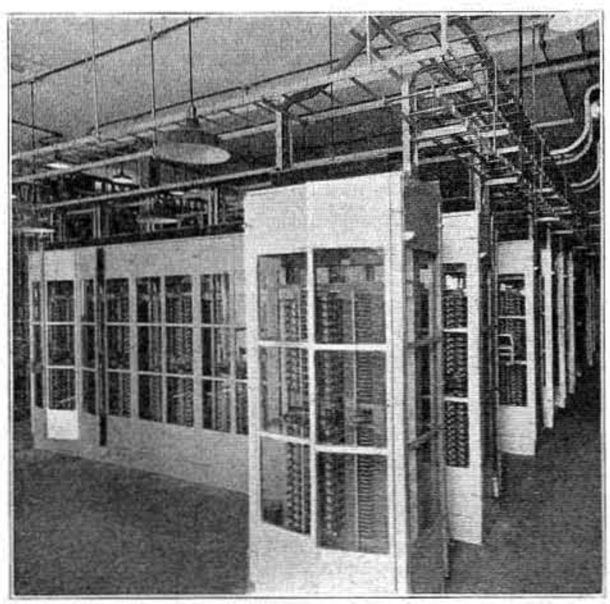


Fig 91. View of switchroom showing lighting scheme and primary line switches

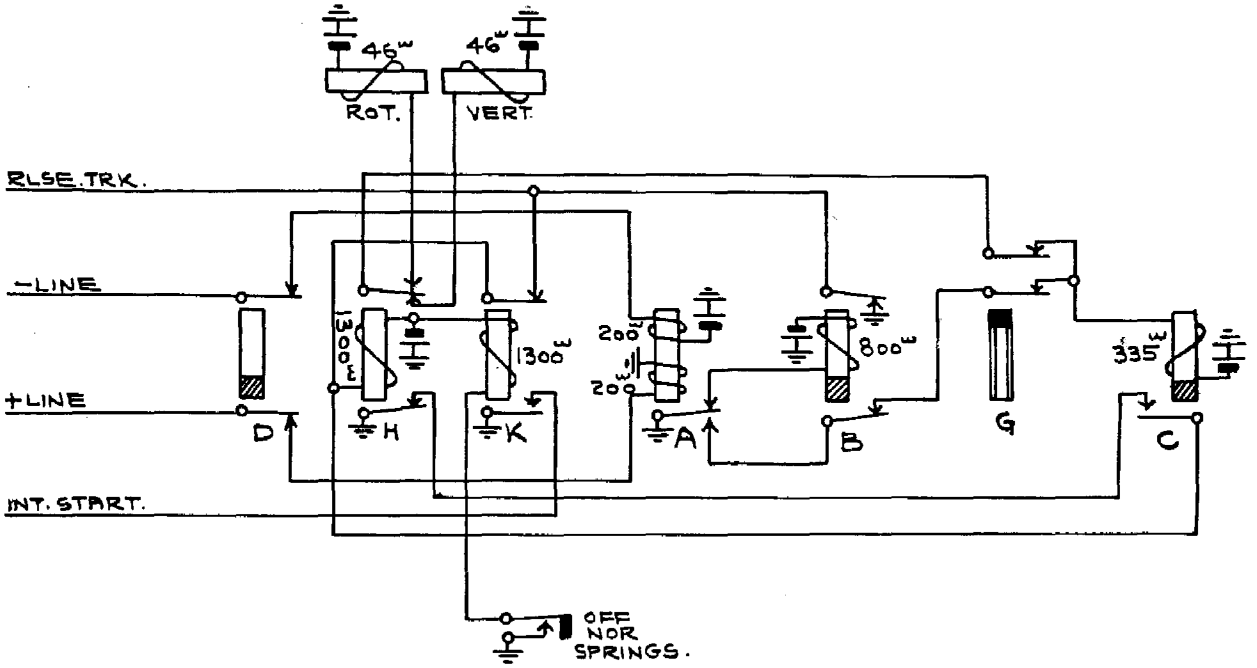


Fig. 92. Reverting call switch, impulse circuit

Impulse circuit

In Fig. 92 is shown the impulsing circuit of the reverting call switch. The instant the switch is seized, relay H operates from (+) battery through contact of relay B, preparing the vertical impulse circuit.

Relay K operates on the first vertical step, opening the circuit over which relay H first energized, but relay H remains locked by (+) battery through the make contacts of relays H and C. Upon completion of the vertical impulses, relay C restores to normal and allows relay H to restore and prepare the rotary magnet circuit through its back contacts.

After the wipers of this switch have been stepped to the bank contacts of the reverting combination called (See Fig. 93), relay G operates from (—) battery super-imposed on the ringing current, — wiper, contacts relays E, F, C and G through winding of relay G to (+) battery. Relay G operating, locks from (+) battery at relay B, and also prepares the circuit to relay D, which operates when the calling party replaces the receiver on the hook, from (—) battery through the winding of relay D, contacts relays F, G, B and A to (+) battery. Relay D operating, disconnects the line relay A from the line. Relay B remains energized after relay A falls away, from (+) battery, through contacts of relays K, F and D, through winding of relay B to (—) battery.

Ringing position

After relay A is disconnected, the line is free for the ringing current to pass back over the line and signal the called party. The calling party answering, causes relay J to operate, which in turn operates the ring cut-off relay F, opening the circuit to relay D and closing the circuit to the release magnet, from (+) battery, through back contract of relay A, contacts relays B, G, and F, off normal springs, through winding of release magnet to supervised release (—) battery, causing the release magnet to operate and restore the shaft and wipers to normal. Relay D now releases and closes the lines through to relay A to supply transmitter battery for conversation. During the talking period, relays A, B and G are operated.

Various combinations of ringing can be had from the reverting call switches, such as ringing on either side of the line to ground with different ringing current frequencies. These com-

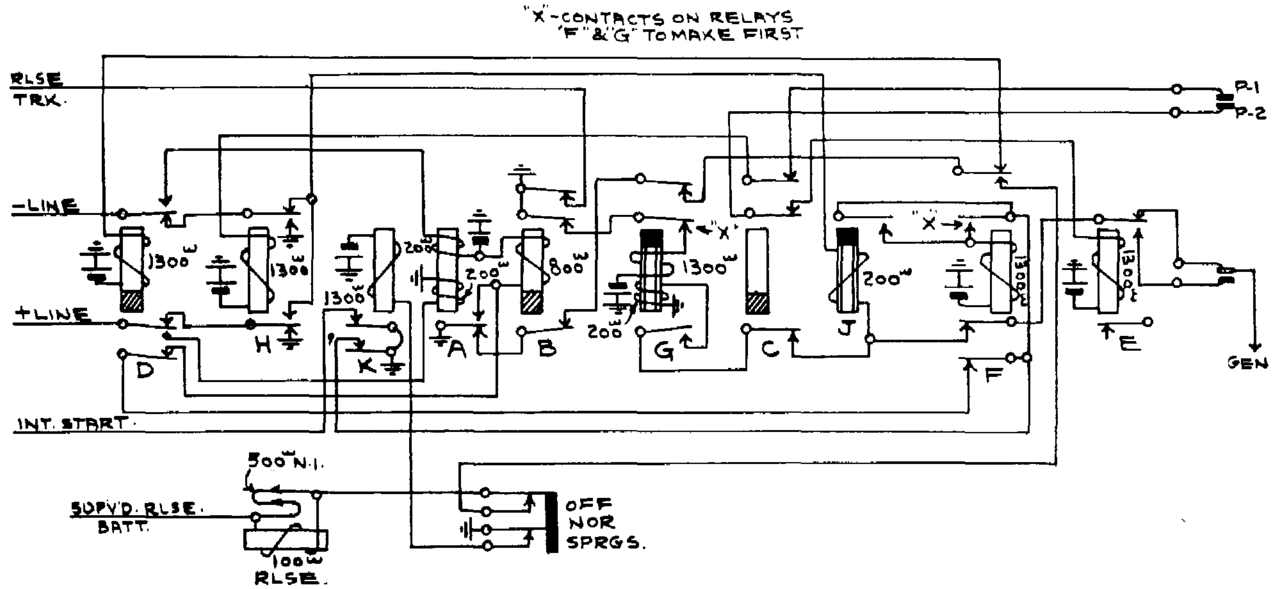


Fig. 93. Reverting call switch, ringing position

binations are determined by the conditions which the switch meets on its bank contacts. For instance both P1 and P2 may be connected to (+) battery, while in other cases only one may be so connected, etc. The operation of relays H or E is dependent on the (+) battery received at the P1 and P2 bank contacts.

It is possible to obtain 100 ringing combinations with this reverting call equipment.

Review

1. Why are reverting call switches used?
2. What is the procedure in calling a party on the same line?
3. What is the position of this switch during the talking period?
4. What relay furnishes transmitter battery for conversation?
5. What is the position of relay A during the ringing period?

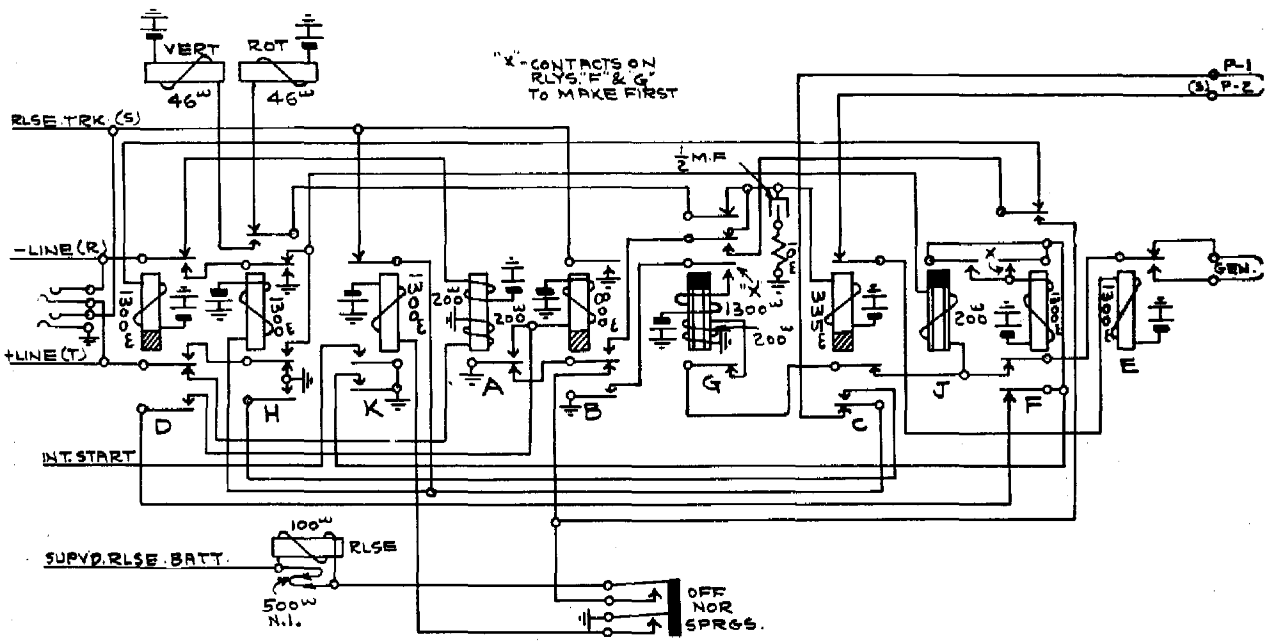


Fig. 94. Reverting call switch, complete circuit

CHAPTER 15

Testing Equipment

Test Desk

THE test desk, as shown in Fig. 95, provides means for testing the subscribers' lines and station equipment. With the exception of the apparatus to test the speed of the dials, a test desk used in an automatic system is the same as that generally used in manual systems.

It is composed of one or more positions, depending upon the number of employes required to test the complaints and construction orders.

In an automatic system the connections are established to the lines by dialing on a test distributor and then a test connector (one for each 100 lines) instead of ordering the connection up by an operator as in manual practice.

The equipment of each position usually consists of the following circuits:

Operator's telephone circuit.
Wire chiefs test circuit.
Trunks to test jacks at main frame.
Toll test plug circuit.
Trunks to test distributors.
In and out trunk circuit.
Hospital trunks.
Howler circuit.
Out and in order wire circuits.
Master ringing circuit.
Supervisory pilot circuit.
Fuse alarm circuit.
Dial speed indicator circuit.

In multi office automatic exchange systems it is common practice to centralize the testing, that is, make all tests from one test desk located for the entire exchange area. This expedites the handling of complaints, increases the efficiency of the testers and sub-station repairmen and permits more economical operation.

Test Distributor

The test desk is equipped with trunks terminating on test distributors in each office. The

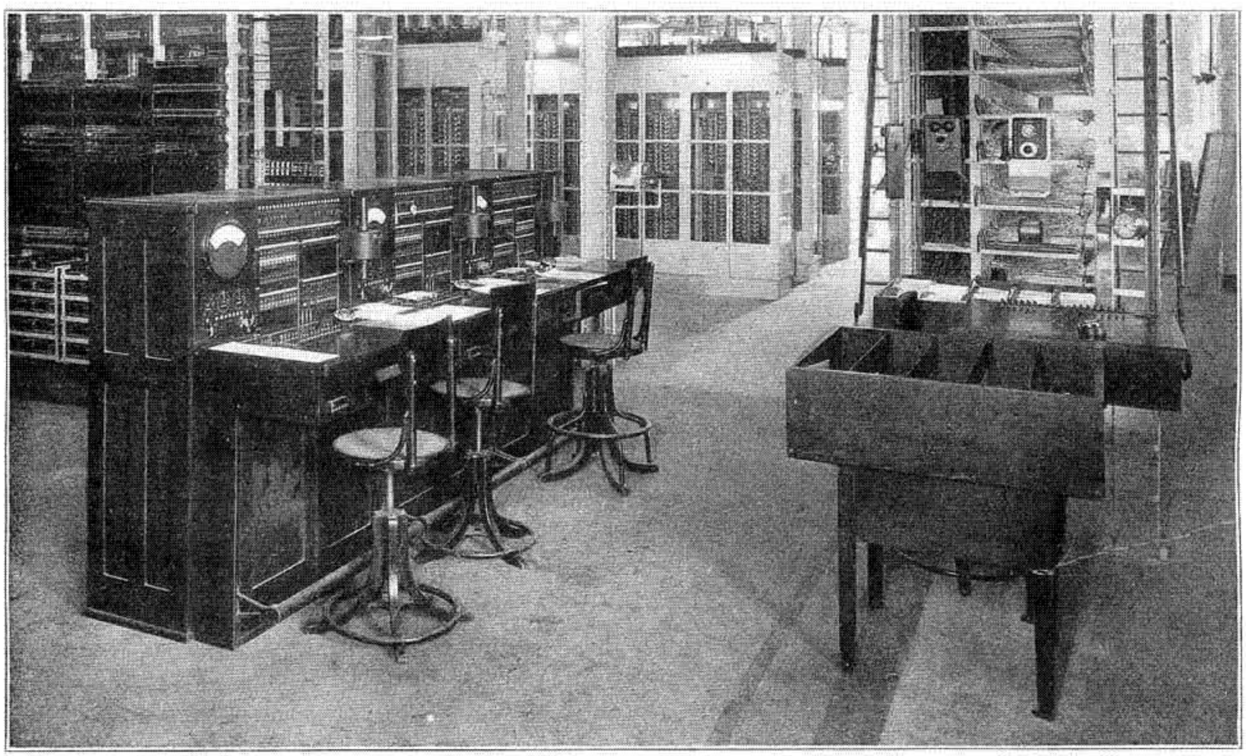


Fig. 95. Three position test desk and combination complaint and card file desk

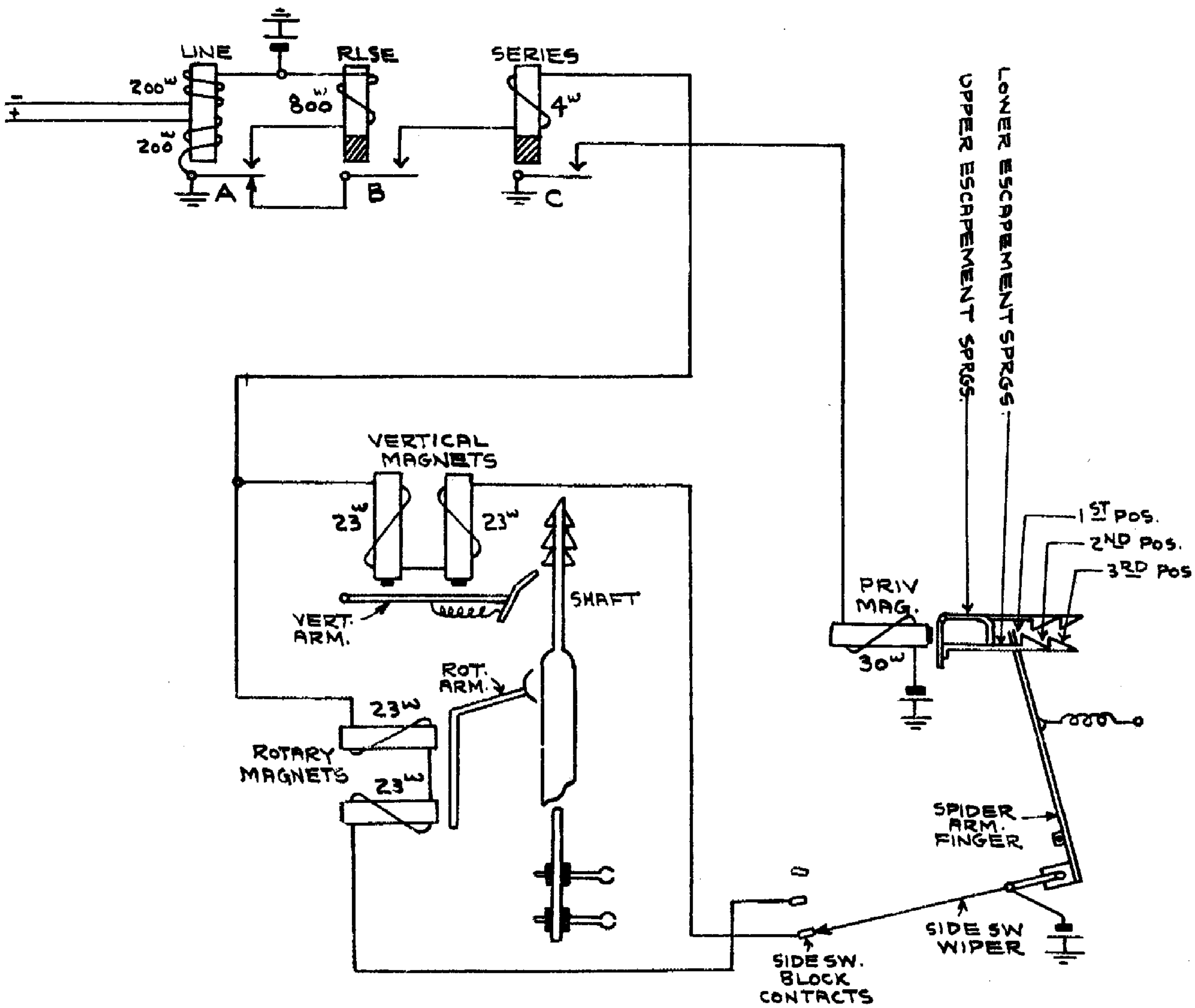


Fig. 95. Test distributor circuit, showing side switch operation

trunks from the banks of the test distributors terminate on test connectors, one for each one hundred line unit, which provide means for correcting to all lines in each unit.

When direct trunks to each office in a 100,000 line system are used, the first digit or office prefix is not dialed. The second and third digits select the one hundred line group and the last two digits the individual line in the group.

Operation of side switch

In previous discussions of impulsing circuits the change from vertical to rotary operation has been accomplished by relays. In the test distributor this switching is done by the side switch as shown in Fig. 96. This mechanism was formerly used on all switches.

Relay C operating during the impulsing period, causes the private magnet to operate from (+) battery at contacts of relay C and allows the spider arm finger to advance to the back of the first tooth of the upper escapement spring. After the first series of impulses have been completed, relay C falls away and allows the private magnet to de-energize, which lets the escapement spring move up and the spider arm finger advance to the second position and carry with it the side switch wipers and connect them to the second contact of the side switch block.

The next series of impulses are sent in the same way and the same action takes place except that the impulse circuit now leads through the rotary magnet and the second contact of the side switch block over the side switch wiper to (—) battery, advancing the shaft in a horizontal direction.

After this second series of impulses, the private magnet again falls away and allows the spider arm finger to advance to the third position and carry with it the side switch wipers which make contact on the third contact of the side switch block.

Test distributor operation and testing methods

The circuit of the wire chief's testing equipment is shown in Fig. 97. The tester operates the "distributor and dial" keys which completes a connection to the test distributor from (—) battery through the winding of relay A, contacts relay F, distributor key, release key, dial key, dial, 60 ohm winding relay F1, 500 ohm resistance, conn. release key, B.C.O. key, dial key, distributor key, contact relay F, winding relay D to (+) battery. Relay A by the operation of its spring contacts energizes relay B and prepares the vertical magnet circuit to receive the impulses. Relays A releases each time the circuit is broken at the dial and operates the vertical magnet from (+) battery contacts relays A, B, winding relay C through vertical magnets to (—) battery. Relay C operating, causes the private magnet to operate which allows the spider arm finger to advance to the back of the first tooth of the upper escapement spring. The private magnet also opens the testing circuit at its back contacts during each series of impulses.

The next series of impulses are sent in the same way, except that they pass through the rotary magnet connected to (—) battery through the second contact of the side switch block. After the completion of the second series of impulses the spider arm finger and associated wipers advance to the third position. Relay H now operates from (—) battery at the side switch wiper and connects the operating lines to relay A1 from (—) battery, winding relay A, — wiper, contacts relays A and H + wiper, winding relay A to (+) battery. The test circuit is also closed through the + and — test wipers to the test connector.

The first digit dialed on the test distributor selects the thousand group, the second the hundred group, and the last two series of impulses are repeated to the test connector by relay A, thus stepping the test connector to the desired line. The dial key is restored to normal upon completion of connection to line to be tested. The test distributor remains operated due to short through the 60 ohm winding of relay F1.

The testing circuit is closed from the voltmeter and associated test keys through the contacts of the private magnet, test distributor, — and + test wipers, contacts relay C1, test connector, — and + wipers to line under test.

To test the line switch for (+) and (—) battery the B.C.O. key is operated which allows relay D on the test distributor to fall away, opening the holding circuit to the lineswitch B.C.O. relay of line under test, which restores to normal and connects (+) and (—) battery to the + and — normals, thus giving a 46 volt reading on the test desk voltmeter.

To test additional lines in any hundred line group, the tester operates the connector release key, which causes relay A of test distributor to fall away, releasing the test connector, but not the distributor. Then the tester dials the last two digits of the next desired line.

In case a call is originated to a 100 line unit and the test connector is being used by another tester, the test distributor spider arm finger and associated wipers are held in the second position, causing relay E to operate from (—) battery through the private magnet, contact relay C, winding relay E, second position sideswitch wiper, P2 wiper, contact relay B1 to (+) battery, closing the busy circuit through its spring contacts to tester and also closes the circuit to relay F, which operates and reverses the battery to the electro polarized relay F1 which operates, causing the supervisory pilot lamp associated with the test position to glow indicating that the test connector is in use. Relay F is held operated from (+) battery at the spring contracts of relay E.

When the pilot lamp glows and the busy tone is not received, indicates that the line dialed is busy. Under this condition, relay F operates from (+) battery at private wiper of test connector. This same (+) battery also forms a locking circuit for relay G. Relay F operating,

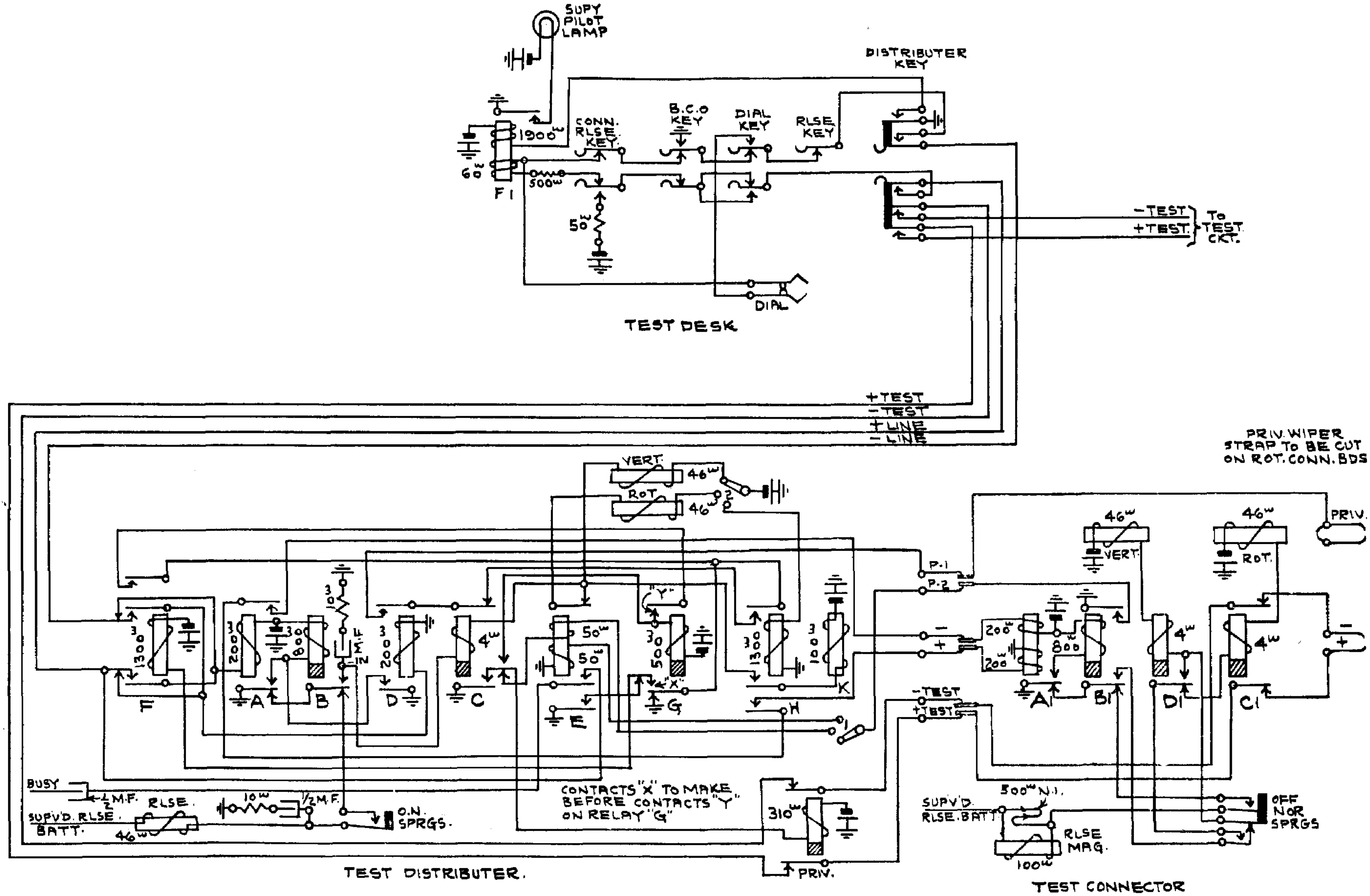


Fig. 97 Wire chief's testing equipment

reverses the battery through the electro-polarized relay F1 which operates and causes the supervisory pilot lamp to glow, indicating that the line is busy.

Review

Fig. 97

1. Describe briefly the purpose of the test distributors.
2. Why are the test wires open during impulsing?
3. Describe how the test distributor operates the test connector.
4. What relay on the test distributor operates when a busy line is called?
5. Will test connectors stop on a busy line?
6. What indication does the tester get when a busy line is called?
7. What indication does the tester get when the test connector is in use?

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