

ROTOR RELAY C.A.X.

Type 36-A-24

(Modified)

BULLETIN 672

September 1940

AUTOMATIC  ELECTRIC

**MAKERS OF TELEPHONE, SIGNALING AND COMMUNICATION APPARATUS
ELECTRICAL ENGINEERS, DESIGNERS AND CONSULTANTS**

1033 W. Van Buren St., Chicago, U. S. A.

CONTENTS

PART I

PRINCIPLES OF RELAY SWITCHING

	Page		Page
1. Introduction	1	5. Connector Operations	5
2. The Rotor Relay	1	6. Automatic Selection of PBX Trunks	6
3. Basic Relay Switching	2	7. Selection of Switch-Thru Trunks	8
4. Linefinder Principles	4		

PART II

EQUIPMENT AND GENERAL DESCRIPTIVE NOTES

8. General	9	17.5 Identification of Trunks Calls	14
9. Capacity	10	17.6 Restricted Service	14
10. Mounting	10	18. Networks	14
11. Subscribers' Line Equipment	12	19. Paystations	15
11.1 Intercepting Service	12	20. Subscribers' Line Services	15
11.2 Class of Service Tone	12	20.1 Code Ringing	15
12. Link Circuits	13	20.2 Harmonic Ringing	16
13. Pulse Compensating Feature of Links	13	21. Ringing Equipment	16
14. Call Allotter	13	22. Number Assignments	16
15. Reverting Calls	13	23. Line Terminals Available	18
16. P.B.X. Trunks	13	24. Tone Equipment	18
17. Trunks to Other Offices	13	25. Timing Relays	18
17.1 Verification Service	14	26. Conversation Timing	18
17.2 "Camp-On-Busy" Service	14	27. Traffic Registers	18
17.3 "Camp-On-Line"	14	28. Alarms	18
17.4 All-Links Busy Tone	14		

PART III

METHOD OF OPERATION

29. Local Calls	19	32. Toll Operation	20
30. Reverting Calls	19	33. Traffic Registers	21
31. Paystation Calls	20	34. Alarm Checking	21

PART IV

INSTALLATION

35. Placing Switchboard Into Position	22	44. Cabling and Cable Runways	24
36. Cover Assembly	22	45. Common Equipment Cabling	24
37. Radio Suppression	23	46. Subscriber's Line Cabling	25
38. Battery Cabinet	23	47. Wiring of Ground-Return Lines	25
39. Battery Installation	23	48. Local Battery Telephones	25
40. Charging Equipment	23	49. P.B.X. Trunks	25
41. Battery Charger	23	50. Trunks to Other Offices	25
42. Exchange Ground	23	51. Trunk Equipment, Distant	26
43. Main Distributing Frame	24	52. Trunk Repeaters	26

PART V

INSTALLATION TESTS

53. Installation Notes	27	61. P.B.X. Trunk Test	30
54. Call Through Test	27	62. Manual Trunk Circuit Test	30
55. Link Fails to Find Calling Line Test	28	63. Automatic Trunk Circuit Test	30
56. Busy Tone Test	28	64. Paystation and Class of Service Tone	30
57. Ringing Tests	28	65. Intercepting Service	30
58. Reverting Call Test	29	66. Restricted Service	30
59. Timing Relay Tests	29	67. Ground-Return Line Test	30
60. Line Lockout Relay Test	29	68. Alarm Circuits Tests	30

PART VI

MAINTENANCE

69. Maintenance Routines	31	71. Traffic Register Test	31
70. Alarm Circuit Tests	31	72. Call-Distributor Test	31

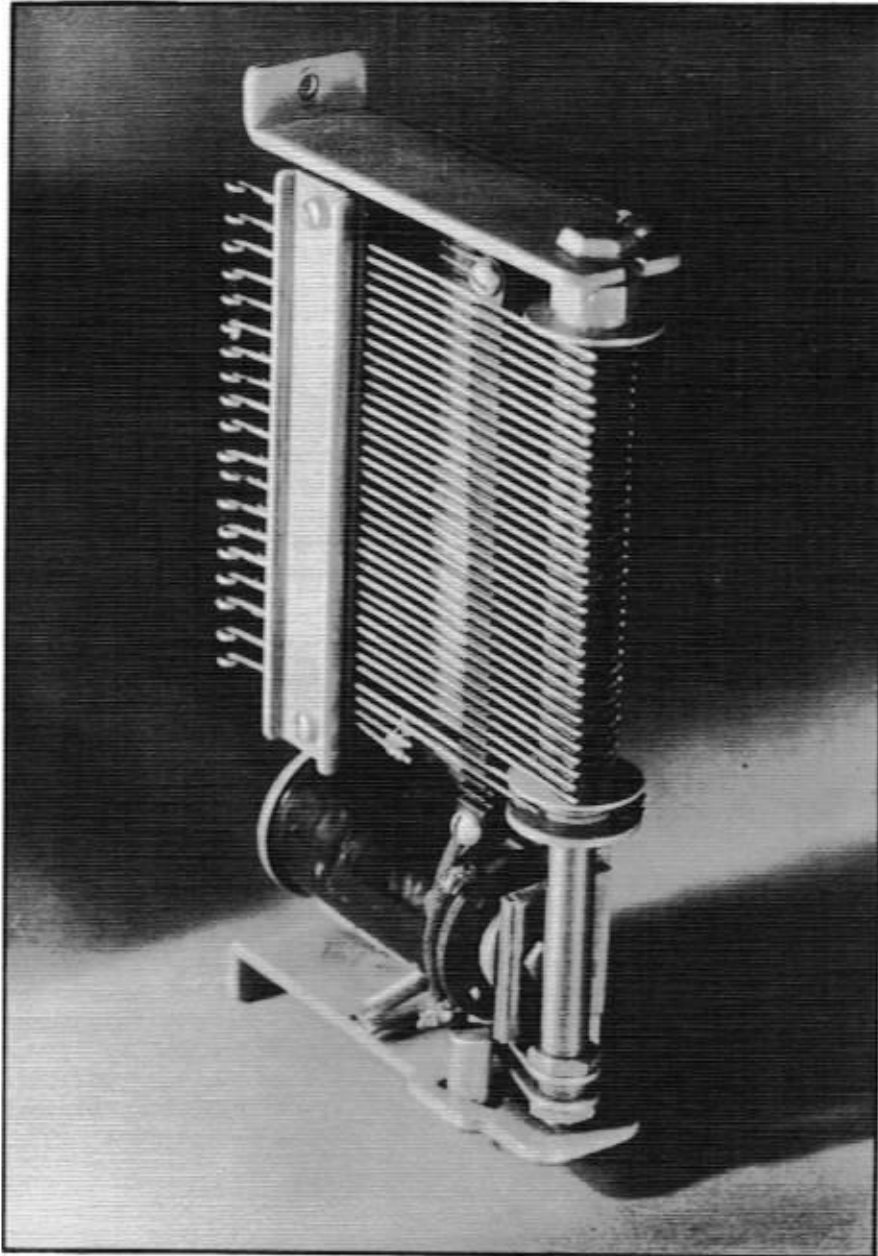


FIGURE 1. A ROTOR RELAY

TYPE 36-A-24 ROTOR RELAY C.A.X. (Modified)

Part I

PRINCIPLES OF RELAY SWITCHING

1. INTRODUCTION

This series of rotor relay switchboards provides for full automatic operation on an unattended basis with capacities for 60, 100, or 200 lines. The many new features now made available in this board are fully described in Part II, "Equipment and General Descriptive Notes," page 9. Part I briefly outlines, in a simplified manner, the operations of rotor relay switching.

The rotor relay automatic switchboard is a mechanically static system. No mechanical motion is present beyond the slight movement of relay armatures and the flexing of their springs. All conducting paths from every station to every other station are permanently wired, but they remain open until closed by the operation of certain relays. Because one fundamental mechanism, the relay, is used to perform all operations, the system is mechanically simple.

Actually of course, several types of relays are used. For instance, linefinding and connecting operations are best performed by multi-contact relays. Automatic Electric has developed the 35-contact rotor relay for these two important operations.

2. THE ROTOR RELAY

The Automatic Electric rotor relay, used for making connections to "groups" of subscribers' lines, has 35 sets of make-contacts, each having dual contact surfaces. Fig. 1 shows an individual rotor relay. Fig. 2 diagrammatically illustrates the operating principles.

In A of Fig. 2, the associated pair of contact springs "a" are resting with predetermined pressure against the insulating stops "b." This is the normal position with cam "c" free of the springs. When the relay magnet "d" is energized, Fig. 2-B, the cam-shaft is partially rotated, forcing the cam "c" against the contact springs to complete the circuits. Since there

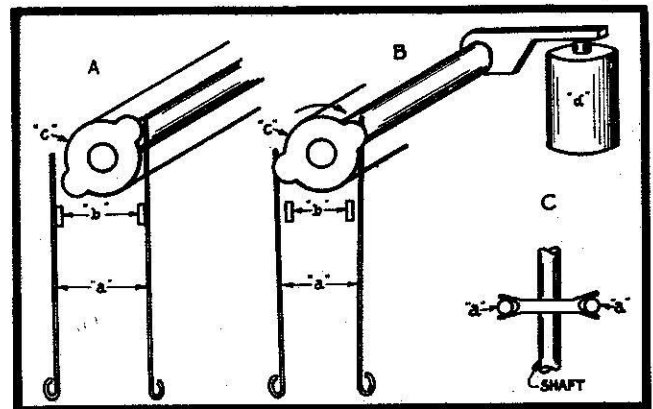


FIGURE 2. OPERATING PRINCIPLE OF A ROTOR RELAY

are 35 of these contact-spring pairs with their associated cams, the corresponding number of circuits can be simultaneously closed. Customarily, there are three leads ("+", "-", and "c") associated with each subscriber or trunk line. Thus, ten lines can be handled by a rotor relay; these are then called tens-relays. Note in Fig. 2-C, the dual contact surfaces on each spring, and the wiping action brought about by rotation of the cam. Cams and contactors are silver plated to further reduce contact resistance and to provide protection against microphonic noise.

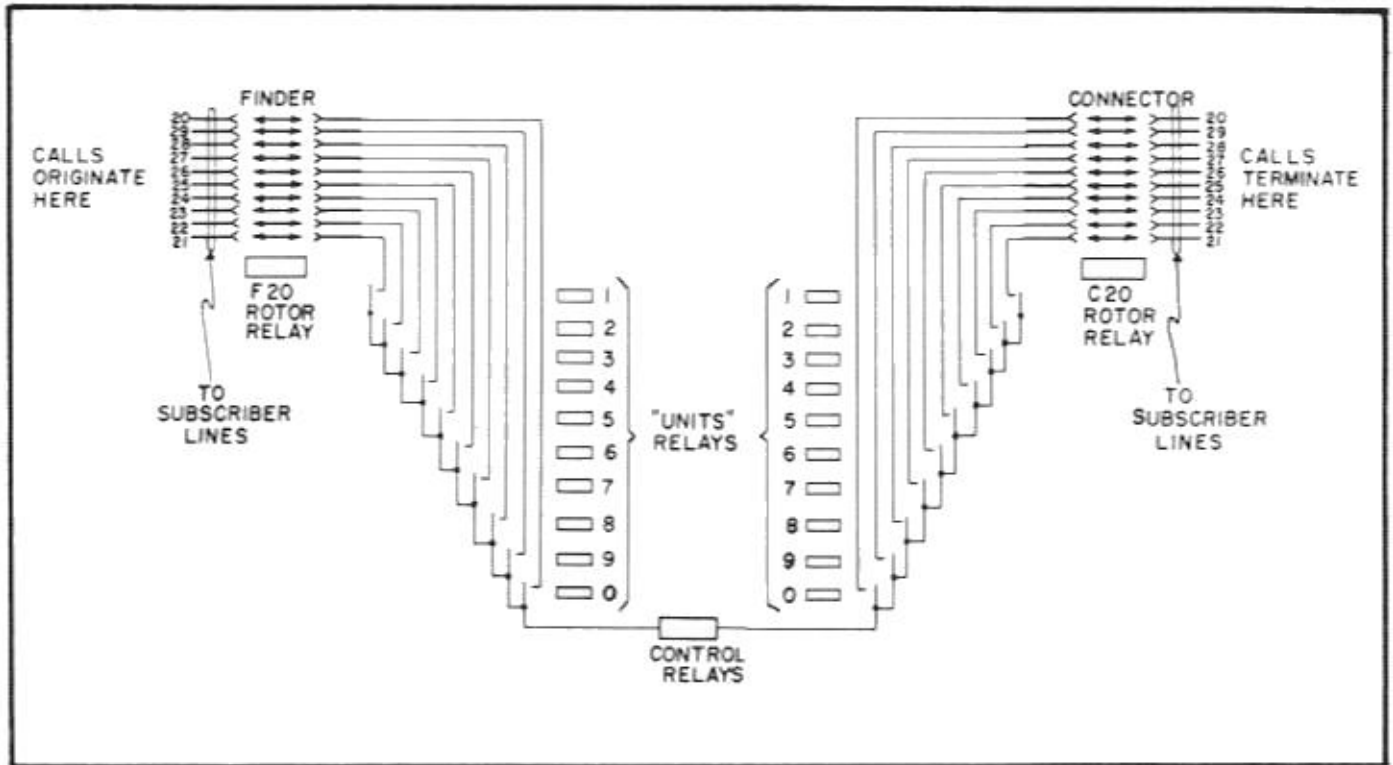


FIGURE 3. SCHEMATIC DIAGRAM SHOWING BASIC SWITCHING PRINCIPLES FOR RELAY SYSTEMS

3. BASIC RELAY SWITCHING

Fig. 3 is a one-line diagram illustrating the basic switching principles underlying relay systems. The calling line is found by the finder half of a free finder-connector link. A link may be compared to a manual operator's cord in that it finds the calling line on one end and the called party's line on its outgoing end, connecting the two. In the 60, 100, and 200 line switchboards, each connector can reach every line and trunk in the exchange. The connector, of course, functions under the direction of dial pulses.

Upon a subscriber in the 20's group lifting his handset, the F20 tens-rotor-relay will operate connecting all ten lines in the 20's group to their corresponding "F" units-relays. Should "21" be the calling line, units-relay F-1 will operate. Now calling subscriber "21" is connected through to the control relays. Upon his dialing the wanted number, say "29," these control relays will cause tens-rotor-relay C20 to operate and then units-relay C9. A complete connection has now been established between parties "21" and "29."

It should be understood that since only ten lines are shown, only one tens-rotor-relay per finder and one per connector are needed. Additional tens-rotor-relays as shown in Fig. 5, if added, would be multiplied to the same group of "F" units relays. Fig. 3, therefore, constitutes the basis of Fig. 5.

The idea of rotor-relay switching is developed further in the 200-line system shown in Fig. 5. A subscriber whose telephone number is 221 re-

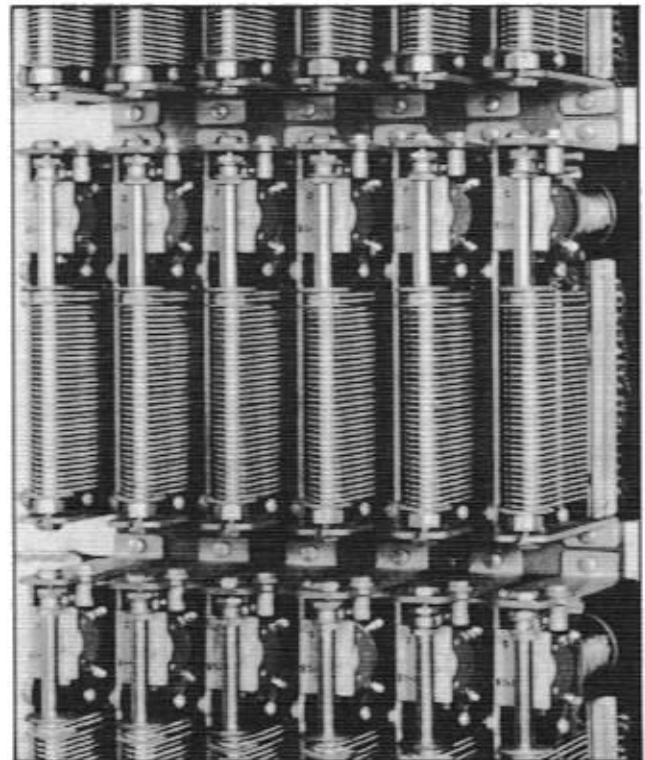


FIGURE 4. A GROUP OF ROTOR RELAYS

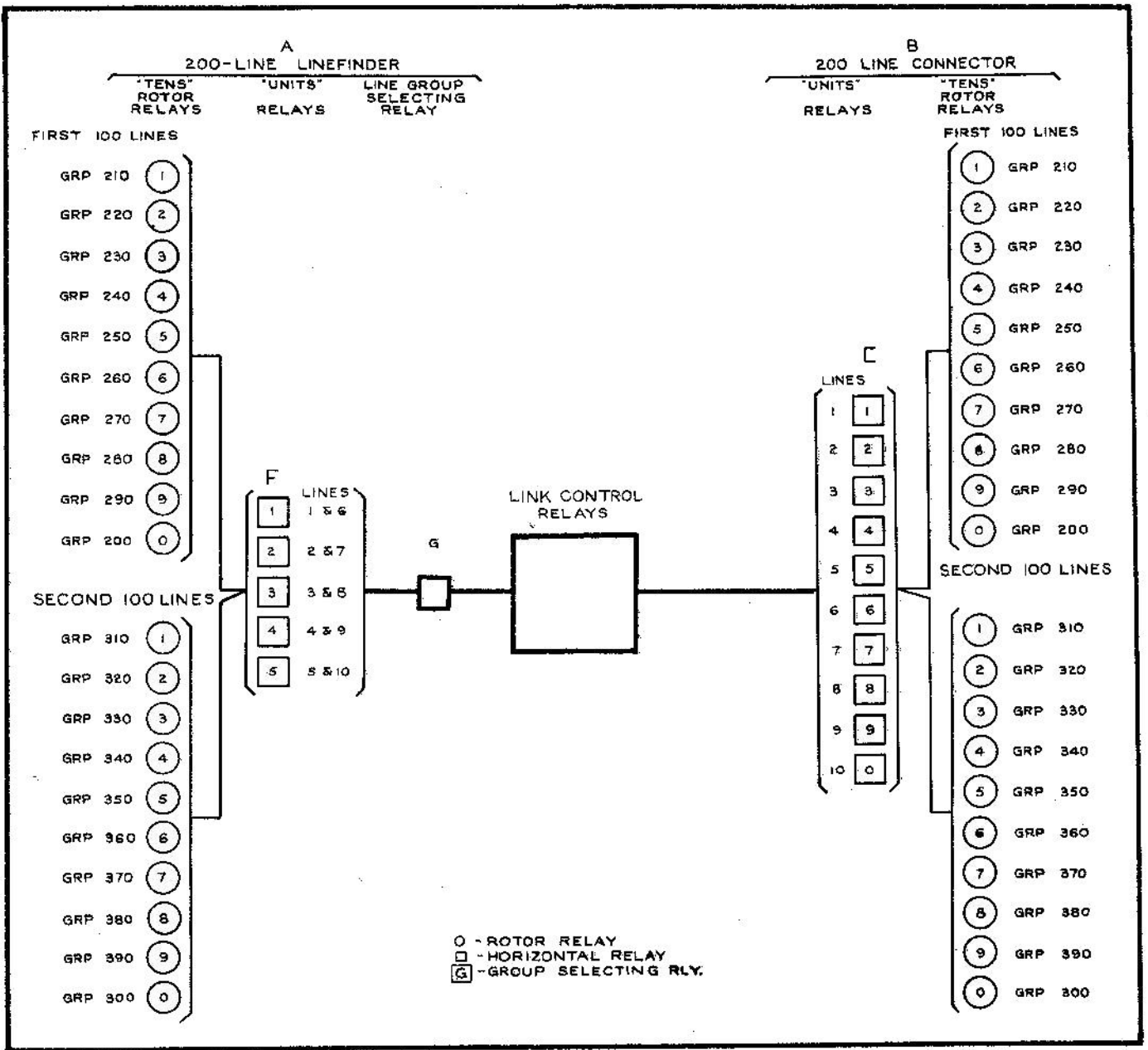


FIGURE 5. BASIC SCHEME OF A 200-LINE RELAY LINK

moves his handset. This action causes rotor relay 220 to operate connecting the line thru to the "F" units-relays. Rotor relay 220 completes connections for all ten lines in the 220 group. Which of these ten will be passed to the control relays is determined by the particular "F" units-relay which operates. Subscriber's lines are divided into two groups, lines 1-5 and 6-0. One line from each group is associated with a units-relay. The group relay G determines which of the two lines will be passed to the connector. Thus all lines ending in the digit "1" or "6" operate a certain units-relay. Group relay G remains unoperated when the calling line is the first of the two alternate lines. The calling telephone is now connected to the control relays. Note that the finding of a line is not accom-

plished by a hunting operation but rather by the closing of a path from the calling telephone to the link-control relays.

The subscriber dials the wanted number, say "376." This causes, first, the "370" "C" tens-rotor-relay to operate; then the C-6 units-relay which now completes the connection between the calling and the called telephones. In the connector, there are ten units-relays per link. Thus, no "group" relay is needed. Guard relays are provided to protect the link against interference from simultaneous calls. The number of links available determines the number of conversations which may take place at one time in an exchange.

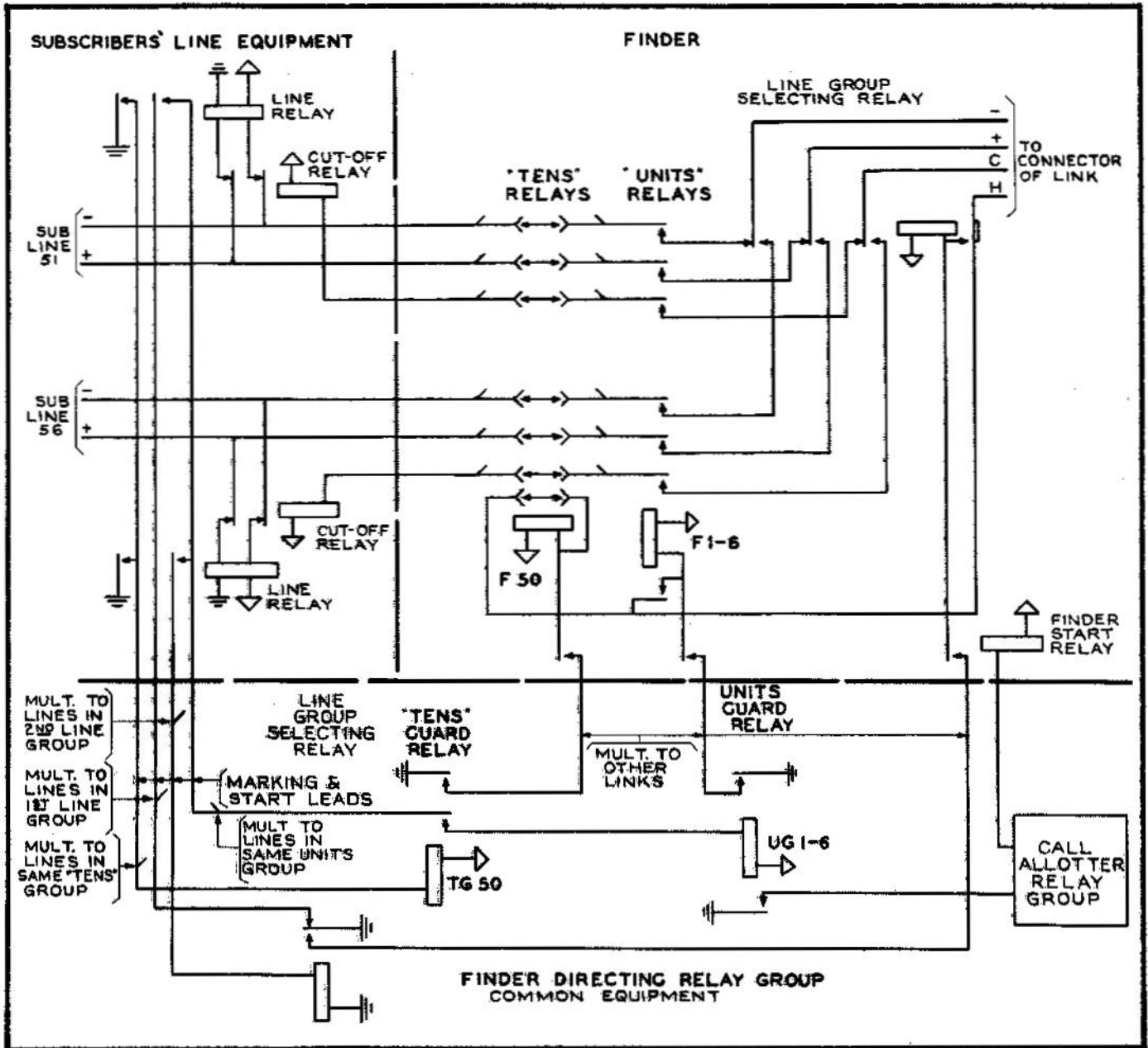


FIGURE 6. SCHEMATIC CIRCUIT OF A RELAY-TYPE LINEFINDER AND LINE EQUIPMENT

4. LINEFINDER PRINCIPLES

A simplified circuit of the general type of linefinder used with the 60, 100, and 200 line boards appears in Fig. 6. As in the diagrammatic sketch, two lines are associated with each units-relay. The "line-group-selecting" relay "G" operates to choose a line from the second group. Thus, a total of five units-relays per link is saved by the addition of the group relay.

In the sketch, two lines have been shown to illustrate the operation of the line-group-selecting relay. Only one rotor relay (tens F-50) has been included and one units-relay (F1-6). Both lines 51 and 56 are in the same tens-group and associated with the same units-relay.

A subscriber, say "51," upon removing his handset operates the line relay, left, top Fig. 6. This closes circuits to tens-guard relay TG50 and to units-guard relay UG1-6, common to all links. These prevent any other tens- or units-guard relays from operating during the next fraction of a second. Thus, simultaneous calls are prevented from interfering with one another for the reason that only guard relays may close ground to tens- or units-relays. Guard relays are common to all links.

The call allotter, lower right, now assigns a free finder-connector link to the call by energizing the proper finder-start relay. The tens-rotor-relay (F-50), on which the calling line appears, operates at this time as does the pro-

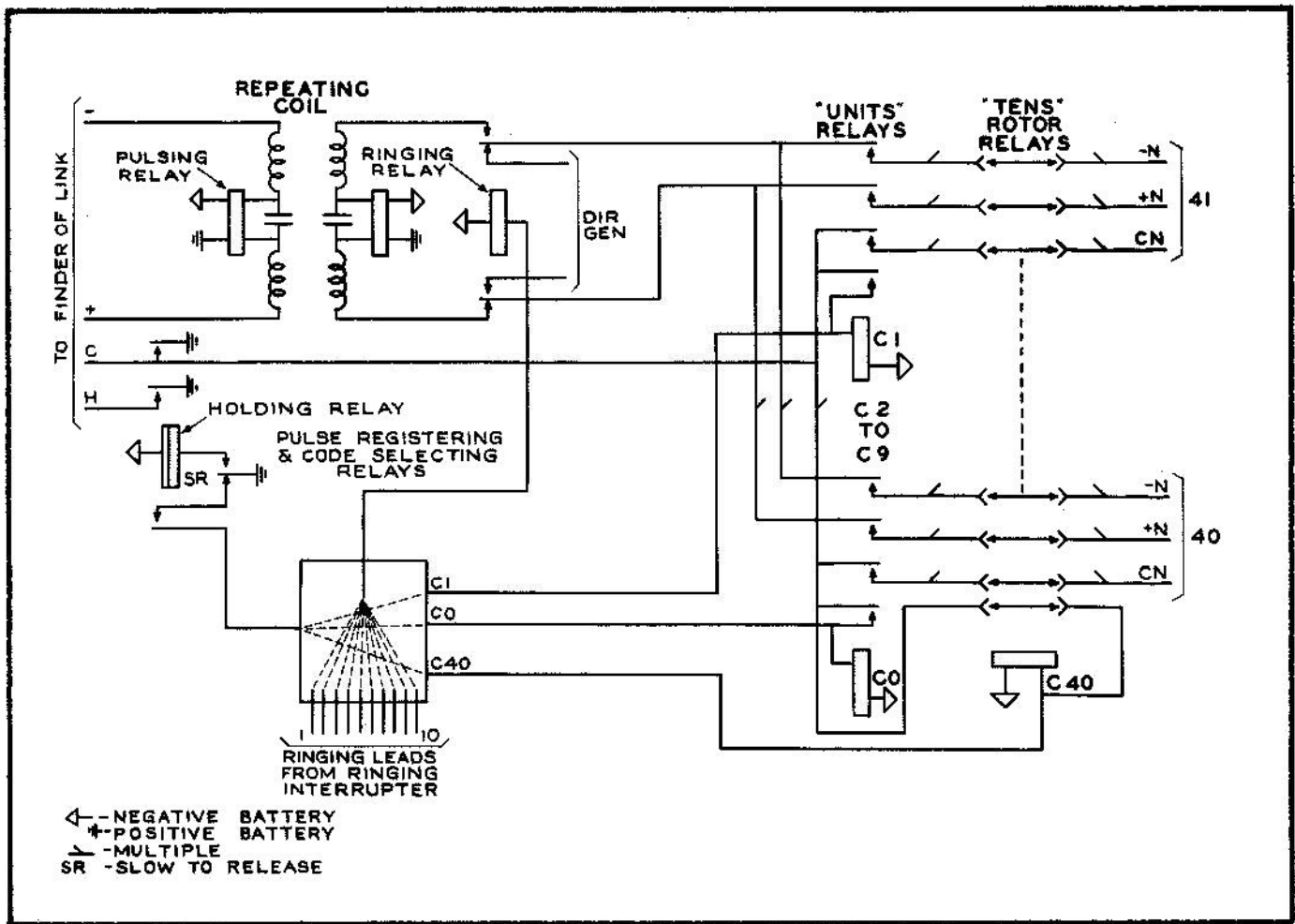


FIGURE 7. SCHEMATIC CIRCUIT OF A RELAY-TYPE CONNECTOR

per units-relay (F1-6). The group relay does not operate on calls from the first line group as from "51."

Now two of the ten lines from the tens-group are led thru to the line group relay which, unoperated, passes only the first onto the connector. The calling line has now been extended to the pulsing relay of the connector. The pulsing relay causes a hold relay to place ground on the "H" lead to hold the finder relays for the duration of the call. It also places ground on the "C" lead making the calling number (51) busy to other calls and operating the line cut-off relay (Fig. 6). Operation of the cut-off relay removes the line relay from the circuit. The line relay, falling back, releases the tens and units-guard relays permitting another call to seize the guard relays and hence seize the next free link assigned by the call allotter. These operations take place in fractions of seconds. The connector is now under control of the calling party's dial.

5. CONNECTOR OPERATIONS

The calling party, hearing dial tone, dials the called party's number. Each digit is recorded

momentarily by the pulse-registering and ringing-selecting relays. Since there is a considerable difference between the 100-line connector and the 200-line connector, each will be described separately. Connectors are equipped with ten units relays in contrast to the group system of the finder. The 60-line boards are similar to the 100-line in operation.

5.1 The 60 and 100-Line Switchboards

In practice a subscriber's number consists of four digits, the first and last controlling ringing. The first line-selecting digit which is the second digit dialed causes the appropriate tens-connector to operate (Fig. 7). Thus if the wanted number is "2411," dialing of the "4" will cause the C40 tens-relay to operate and lock itself up on the "C" lead. The next digit, "1," causes the C1 units-relay to operate and likewise lock on the "C" lead.

The calling subscriber will now receive ring-back tone if the called line is free or busy tone if it is busy. The connection is under control of the calling party.

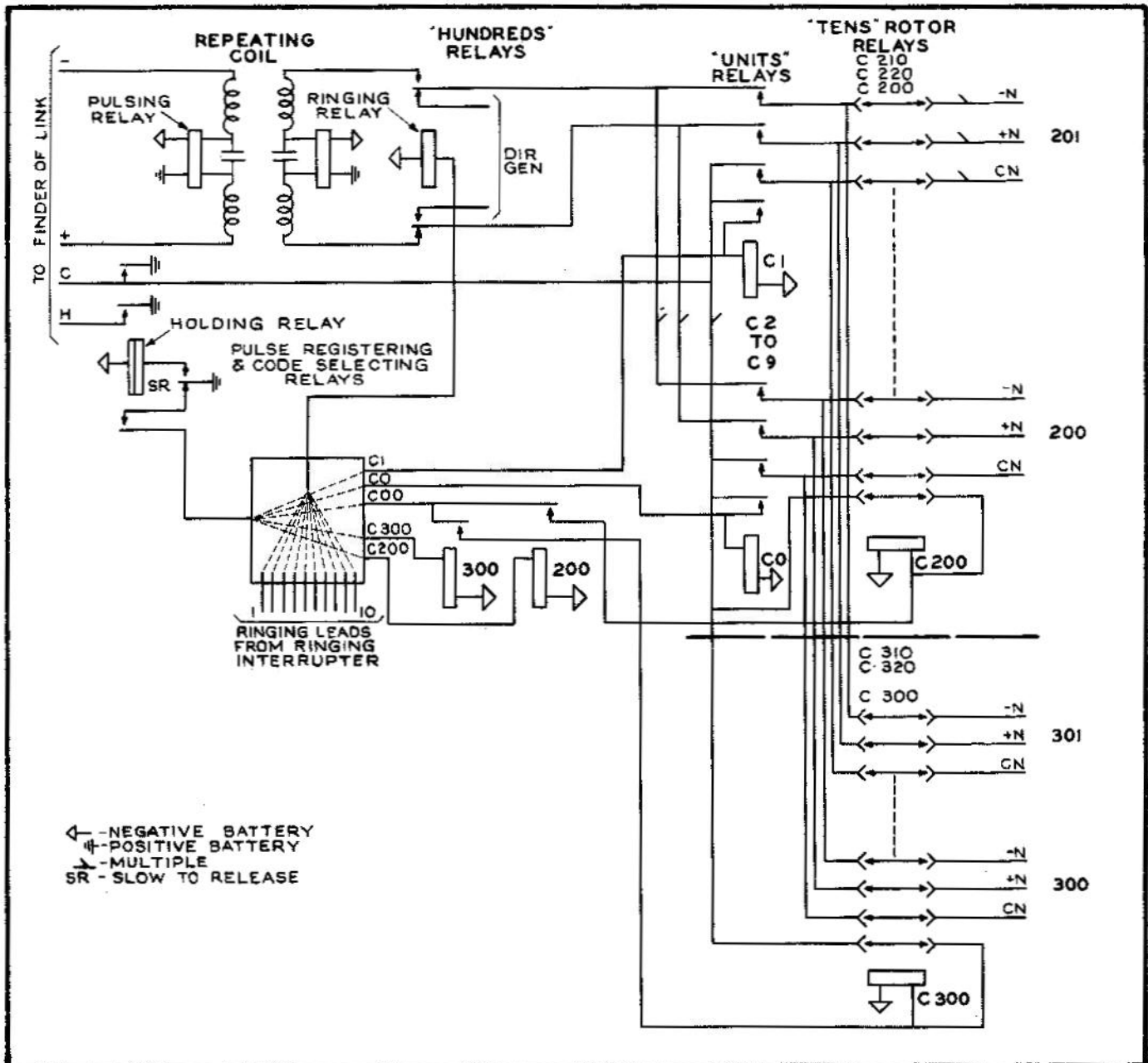


FIGURE 8. SCHEMATIC CIRCUIT OF A 200-LINE RELAY-TYPE CONNECTOR

5.2 200-Line Connector (Figure 8)

The 200-line connector has access directly to 200 lines. Dialing of the first digit selects the hundreds group. Thus if the wanted party has 2001 listed as a number, dialing of the "2" will cause the 200-group lever-relay, lower center, to operate. Then the dialing of "0" will send ground to the tens-rotor-relay C200. C200 will operate and lock on the "C" lead. Dialing of the second "0" will operate units relay C0 which also locks on "C." Had a "3" been the first digit dialed, the 300 relay would have closed and the subsequent digit would have operated a tens-relay in the 300 group. One set of units relays serves both hundreds groups.

On harmonic ringing boards, the last digit selects the frequency to be sent out. For details see Part II, Section 22.2. On code ringing boards, the fourth digit selects the code though first digits such as 4 and 5 must be used with 20-party bridged ringing lines. See Part II, Section 22.12.

6. AUTOMATIC SELECTION OF P.B.X. TRUNKS

These switchboards are arranged for automatic selection of private branch exchange trunks. These are reached by calling the first four-digit number in the consecutive number series assigned a subscriber. Thus, if a certain firm were to be assigned five trunks, the line numbers must be consecutive, and the first must be

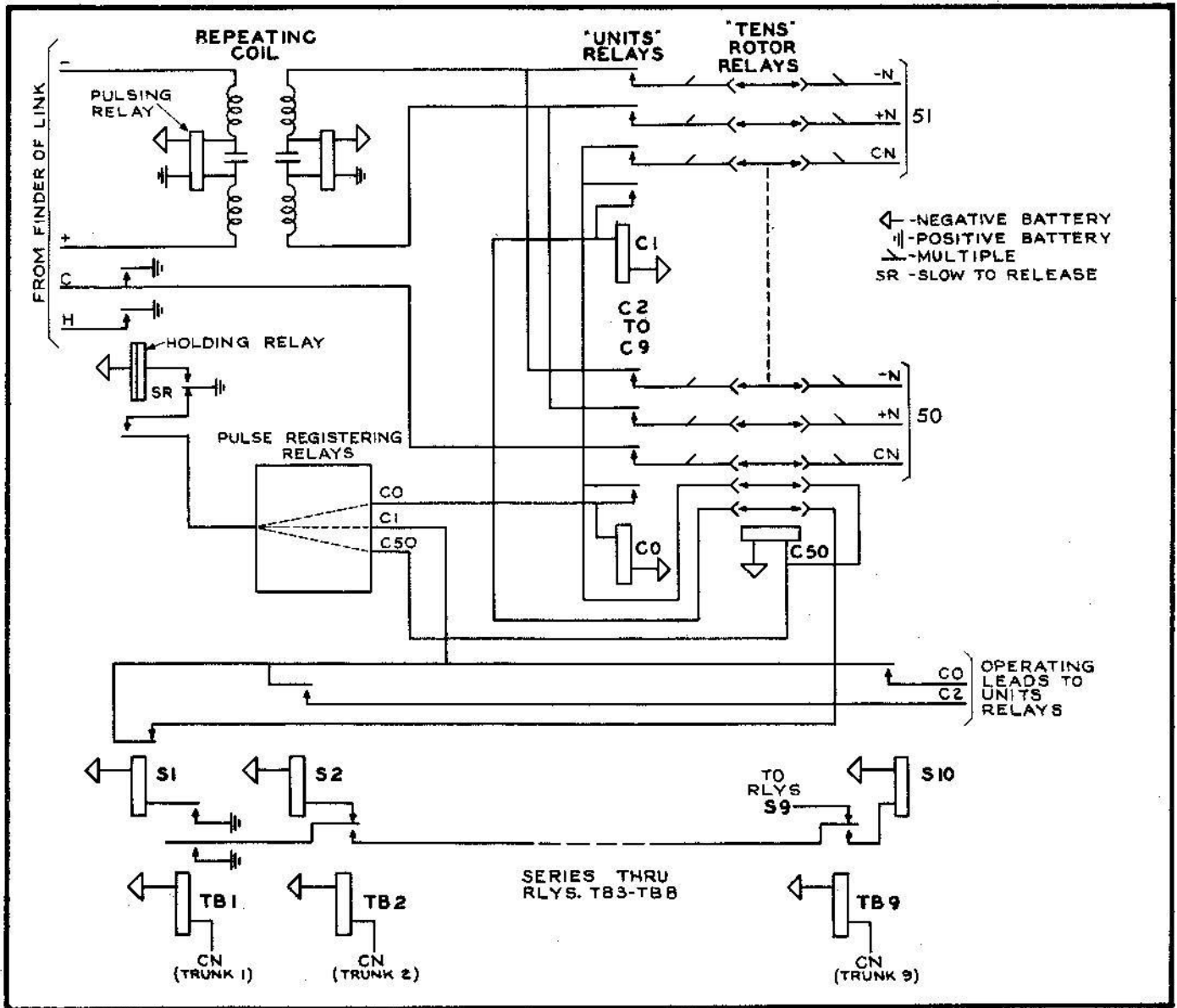


FIGURE 9. AUTOMATIC P.B.X. TRUNK SELECTION ON A RELAY-TYPE CONNECTOR

associated with line "1" in a tens-group. Thus lines 51, 52, 53, 54, and 55 could be used. The directory number would include the regular prefix and suffix as "2511" for the first number. The second would be "2521" and would not be listed except possibly as a night number. Trunks are automatically selected beginning always with the first non-busy number in the group, i.e., "1" first, then "2" if "1" is busy and so on. Automatic trunk selection takes place only when the first number is dialed. If, for example, a subscriber dials 2521, he will always seize trunk "2" and ring the phone that happens to be associated with that trunk (line).

In Fig. 9, the circuit is shown in conjunction with the connector previously explained. If a subscriber dials 2511, the number listed in the directory, the "5" will pull-up rotor relay C50;

the "1" instead of operating the C1 units-relay passes thru the trunk selecting group to relay S1 which, if relay TB1 is not holding it operated by a busy condition on C (trunk #1), permits the ground to continue over the break contact of S1, thru the C50 relay, to C1 which will operate in the ordinary manner. If a second call should now come in, ground on the C1 pulse relay lead will find the break contact at S1 open because of the busy condition on trunk #1. S2 will be operated by TB1 closing the make contact to units-relay C2. Should all trunks be busy TB9 (next to the last trunk in any case) will operate S10 (the last "S" relay associated with the last trunk in the series). Ground from units lead C1 will go out to units-relay C10. This, being occupied, will cause the busy tone to be returned to the calling party. The first non-busy trunk will always be selected if there is one available.

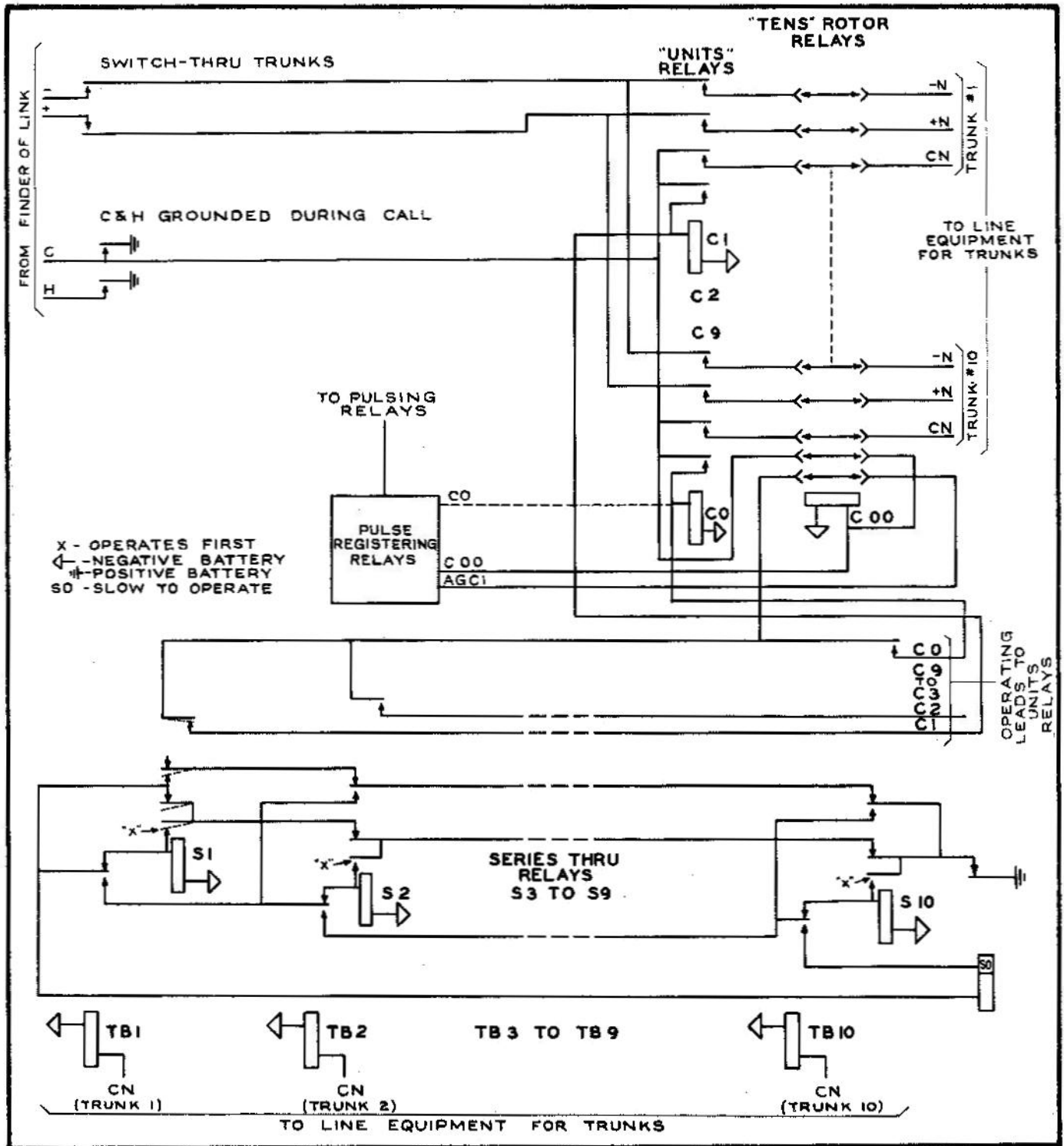


FIGURE 10. AUTOMATIC SELECTION OF SWITCH-THRU TRUNKS ON A ROTATING BASIS

7. SELECTION OF SWITCH-THRU TRUNKS

The selection of switch-thru trunks such as those used for toll service and for service to neighboring exchanges is automatic upon the dialing of a single digit--"7," "8," "9," or "0." Successive calls to the same level are routed over different trunks. The trunks are preselected in a rotating order such that no

trunk is used twice until all free ones in the group have been used. Thus a fault in any one trunk will not limit service. The "S" relay which has preselected the next trunk remains locked-up until the trunk is used. (Fig.10). This is in contrast to the "S" relays of the P.B.X. trunk groups which remain operated only as long as the preceding trunk is in use. Referring to Fig. 10, note that the C00 and the

AGCl leads are associated with the pulsing relays such that ground is sent over both when the single digit, e.g., "0," is dialed. Ground on COO pulls up tens-relay COO which connects the grounded AGCl lead via the lower contact to the "S" trunk selecting relays.

At the beginning of a cycle of operations, relay S1 is held operated by ground on its "X" contact. S1, therefore, connects ground from the AGCl lead from the tens-relay to units-relay C1. As soon as trunk one is thus seized, ground on its CN lead operates relay TB1 which operates S2 by placing ground on its lower pair of contacts. Relay S2 locks-up on its "X" contact and releases relay S1. The next call for an "0" trunk will connect the AGCl lead to C2 and trunk "2" will be seized. Ground over the CN lead of trunk "2" will cause TB2 to operate which will operate the next "S" relay and so seize the next trunk. The last trunk, in this instance "10," is seized like any other; however, the transfer of the cycle back to the first trunk and relay

S1 presents several interesting points. Upon the seizure of trunk 10, TB10 will be operated by ground on the CN lead. TB10 closes ground to the S0 (slow to operate) relay, lower right. When the S0 relay finally operates, it removes ground not only from the S10 (last "S" relay) but also from its own windings. Both relays release. Ground now passes thru the middle series contacts of the "S" relays to S1 which operates if the first trunk is not busy. In any event, the first non-busy trunk will be prepared for the next call, and the cycle of operation recommences.

Since the trunk selecting "S" relays play no part in the talking circuit, they may thus be released while the trunk is in use. The "TB" relays will, however, remain operated as long as their associated trunks are busy, protecting the busy trunks against intrusion should the cycle be repeated before the trunks are freed. Only one "S" relay may be operated at any one time in contrast to the "TB" relays.

Part II

GENERAL DESCRIPTION

6. GENERAL

This series of rotor relay switchboards provides for full-automatic operation on an unattended basis. Supervision may be exercised by the toll or manual operator at a neighboring attended exchange. Many special features and services are available. For example, verification, camp-on-busy, and intercepting service represent a few of the features which may be had with the boards. Ringing may be harmonic or code. Ring cut-off is optionally delayed or instant.

Each installation is covered by a "job" specification. This specification itemizes the apparatus and material that is being shipped, and also lists the associated manufacturing numbers. The shipment should, therefore, be carefully checked against the job specification to determine that every listed item has been received. The job specification also indicates items, such as the main distributing frame, which are to be supplied by the telephone company.

Any deviations from the boards described here are detailed in the specification as are the blueprints included in the shipment. These blueprints provide specific information concerning the assembly of the switchboard, wiring, cabling, and circuits. Combined with the notes and data

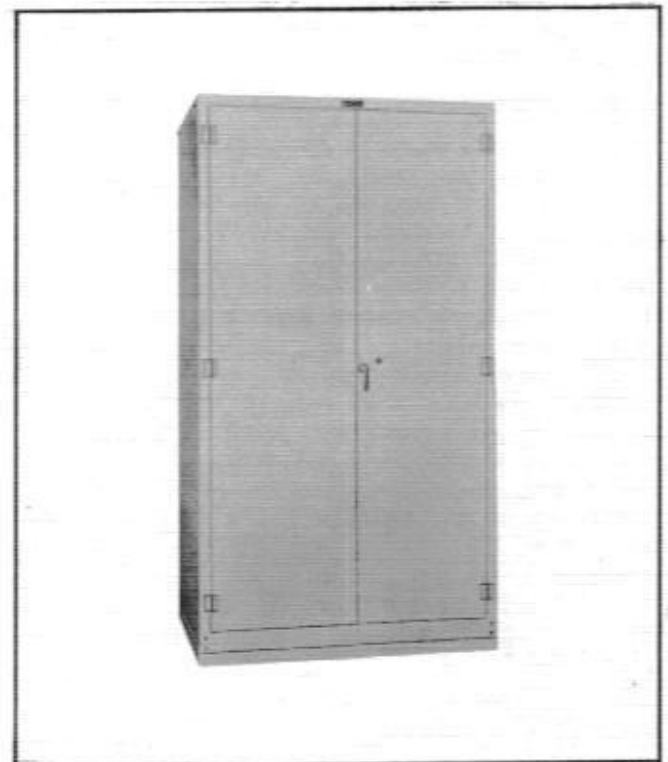


FIGURE 11. A SWITCHBOARD CABINET

in this bulletin, they give complete information and instructions for installing and placing the switchboard into service. Part IV of this bulletin outlines the general installation of these boards.

9. CAPACITY

These switchboards are made in three capacities, 60, 100, and 200 line terminals. When fully equipped each has 7, 10, and 20 finder-connector links respectively. The number of links present determines the number of simultaneous conversations which may take place. Three trunk groups (four on certain 200 line boards) are normally provided for making connections with neighboring exchanges. A maximum of ten trunks may be in a group with automatic selection on a rotating basis. Mounting space generally permits a total of 10 trunks for the 60-line; 10 on the 100-line; and 18 on the 200-line board. These may be divided as necessary among the three or four levels. Provision is made for two (three on the 200-line board) Private Branch Exchange trunk groups.

Lines*	Links	Trunks	Trk.Grps.	P.B.X.Groups
60	7	10	3	2
100	10	10	3	2
200	20	18	4	3

* Including trunks

Switchboard Dimensions:

Switchboard	Length	Width	Height
60	3'-8-1/4"	2'-0"	6'-9"
100	5'-2-1/4"	2'-0"	6'-9"
200*	3'-8-1/4"	2'-0"	6'-9"

* The complete exchange switchboard consists of four such units.

Common Equipment Frame:

60	2'-0-1/8"	2'-0"	6'-9"
100	2'-0-1/8"	2'-0"	6'-9"
200	2'-0-1/8"	2'-0"	6'-9"

10. MOUNTING

The equipment for each switchboard is mounted on double-sided framework enclosed in sectional switchboard cabinets. The equipment consists of line relays, trunk repeater units, connecting links, call allotter, common equipment, fuse panels, ringing converter, ringing interrupter, voltmeter, ammeter, and power board. If harmonic ringing is supplied, the harmonic converter shelf, which replaces the above ringing converter, is wall mounted. The storage battery and charger associated with each switchboard are mounted separately. In general the equipment units making up a switchboard are readily identifiable.

10.1 The 60-Line Switchboard

Line equipment (line, cut-off, and lock-out relays for each line) is mounted on the top, front side of the switchboard. The rotor relays

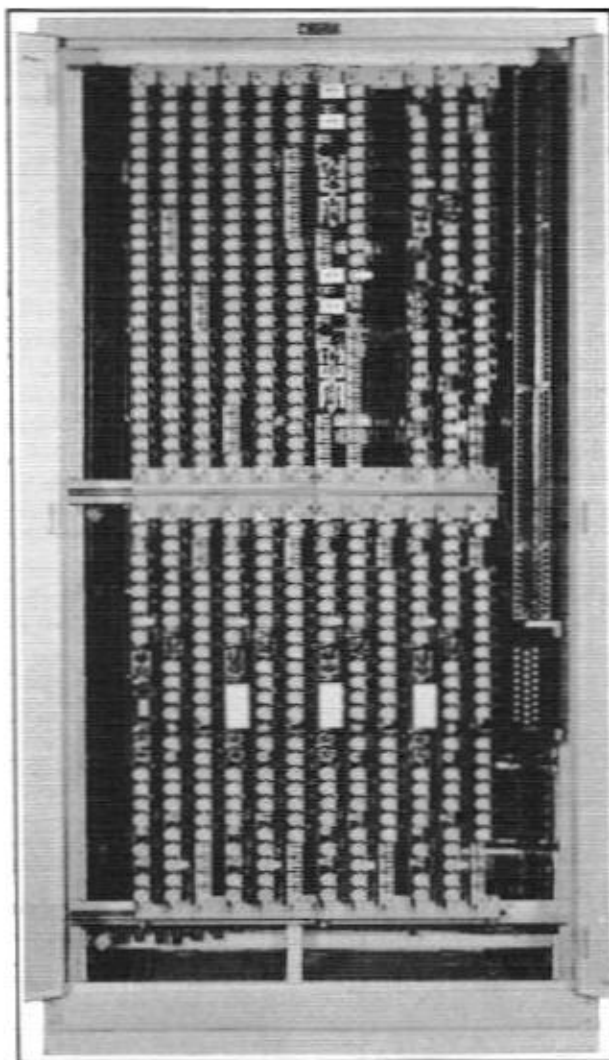


FIGURE 12. FRONT, INTERIOR OF A SWITCHBOARD UNIT

are below. Each link circuit is equipped with two rotor relays, designated "F" (finder) and "C" (connector) respectively, for each group of ten lines. These relays are known as "tens" relays, each acting as a connector or finder for a tens-level. A link for 60 lines consists of 12 rotor relays and a group of finder and connector units-relays. Each link group is mounted in a horizontal row, space being provided for seven links.

To the right of the rotor relays is the call-allotter which selects the link to be used for each call. This includes the protective tens-guard (TG) and units-guard (UG) relays which permit only one of several simultaneous calls to occupy a link. Above, top right, is the line and trunk terminal board including the fuse panel.

On the rear side of the frame are the pulsing, counting, and other relays associated with each

link. These are mounted on vertical strips. At the right are the trunk and P.B.X. selecting relays.

The common equipment frame holds the tone and ringing equipment including repeater mounting space for eight trunks on the front side. On its rear, there is space for two additional trunk repeaters and extra common equipment.

10.2 The 100-Line Switchboard

Rotor relays appear prominently on the front side of this board. There is space for ten horizontal rows, each row containing the necessary rotor relays for a complete link. Two rotor relays, designated "F" (finder) and "C" (connector) respectively are required for each level of ten lines. These relays are known as "tens" relays, each acting as a connector or a finder for a tens-level. A link for a 100-line board consists of 20 rotor relays and a group of

finder and connector units-relays. Each link group is mounted in a horizontal row, space being provided for ten links.

To the right top of these is the call-allotter which selects the link to be used for each call. This includes the protective tens-guard (TG) and units-guard (UG) relays which permit only one of several simultaneous calls to occupy a link. At the very top, right are the terminal blocks for lines and trunks plus the fuse panel. Below are the trunk selecting relays.

Line relays appear on the rear side at the left. Each line requires three relays - line, cut-off, and lock-out. To the right of these are the pulsing, counting, and other relays associated with each link. These are mounted on vertical strips, three strips per link.

The common equipment frame contains the tone and ringing equipment (at top), the power panel, and

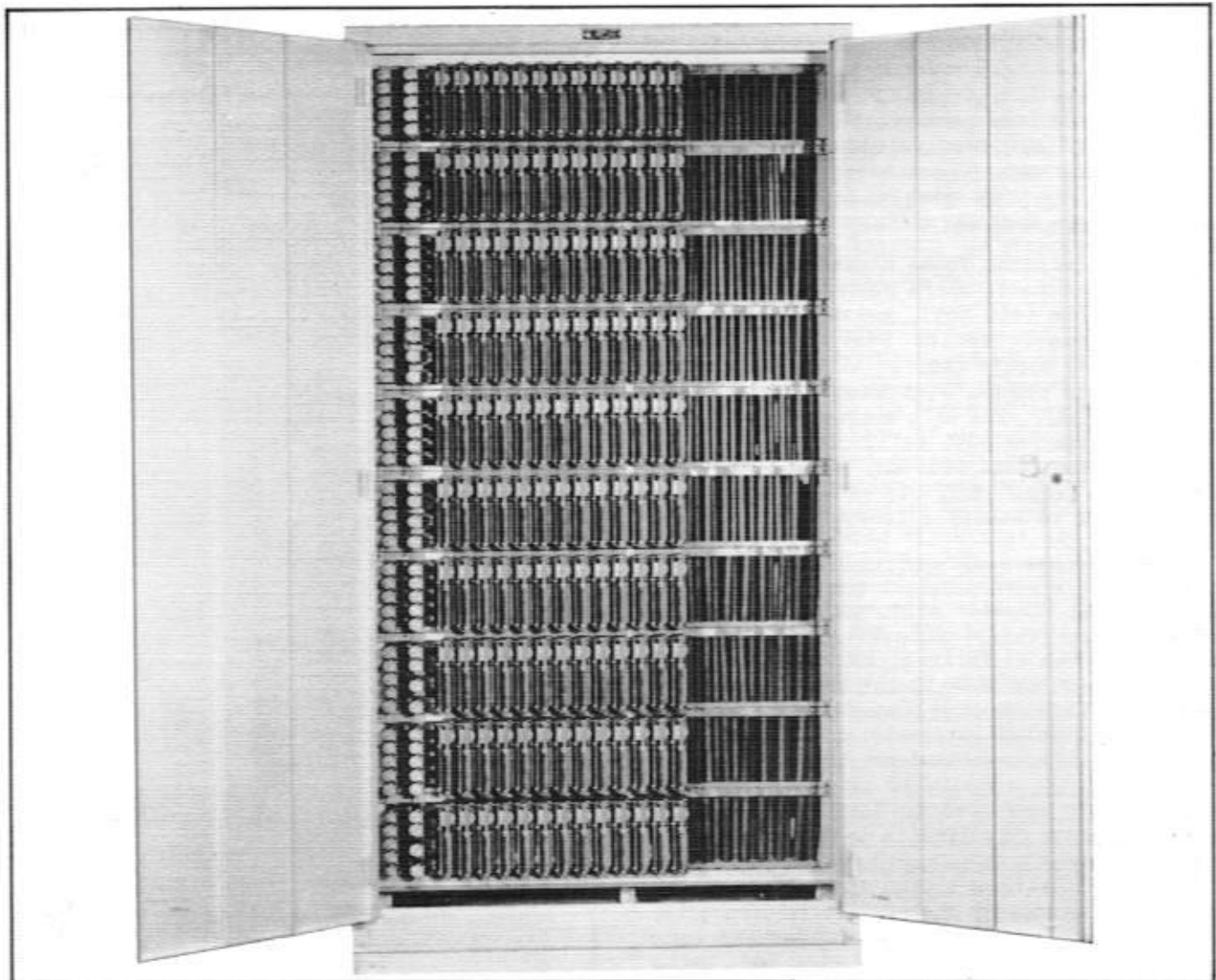


FIGURE 13. REAR, INTERIOR OF A 50-LINE UNIT OF A 200-LINE EXCHANGE, PARTIALLY EQUIPPED

mounting space for eight trunk repeaters (bottom front). The rear side has space for miscellaneous common equipment, two trunk repeaters, and spare space.

10.3 200-Line Switchboard

The equipment is divided among four line and link frames which are identical, each caring for 50 lines. On the front of a typical unit is mounted the line equipment (top left). Each line requires three relays, line, cut-off, and lock-out. To the right of these are three trunk repeater strips. At the far top, right is the line and trunk terminal blocks plus the fuse panel. Across the bottom are mounting strips for miscellaneous link relays. Each link occupies three vertical strips here and three just to the left of the line terminal block (top). The miscellaneous relays associated with each link include the pulsing and counting relays.

The rear side is devoted exclusively to finder and connector relays. There are five links per unit. Each link occupies two horizontal rows across the frame. The top row from left to right contains the connector units-relays and 20 rotor relays designated "C" (connector) with the appropriate line tens-group numbers marked. Below are the associated finder relays of exactly the same number as the connector series. These are designated "F" (finder) followed by the line tens-group which they serve.

The common equipment frame mounts on its front side, tone equipment, alarm sender, power panel, terminal blocks (all top), and trunk selecting relays (bottom). On its rear side are six trunk repeater strips (top). At the bottom are miscellaneous common equipment and the call allotter (right). The call allotter selects the link to be used for each call. It includes the protective tens-guard (TG) and units-guard (UG) relays which permit only one of several simultaneous calls to occupy a link.

11. SUBSCRIBERS' LINE EQUIPMENT

The equipment for each line consists of three relays; i.e., line, cut-off, and lock-out designated L, CO and RC followed by the associated line number. In addition to the usual functions, the line equipment provides for locking-out lines which develop low-resistance shorts ---- such lines remaining locked-out until the trouble clears, when the associated line circuits are automatically restored to normal. Also, on reverting calls, the line is locked-out from a link when the call is answered, so that the link is used only during the time the call is being initiated. Because of the circuit requirements, the "C" terminals in the line finder and connector "tens" relays are separated, "CN" being the designation for the connector lead.

Ground-return lines have the same line equipment as the metallic lines; however, certain wiring

changes are made in the standard line relay wiring. No change in the universal connector circuits is required, but grounded lines may be assigned only in the 200 group of the 200 line switchboard.

Local battery telephones may be used on subscribers' lines as detailed in Section 46.

Information on line standards is contained in Section 13, "Pulse Compensating Feature of Links".

11.1 Intercepting Service

This is provided especially as a convenience to subscribers calling lines recently disconnected or parties on individual lines whose number has been changed.

11.2 Class of Service Tone

Class of service tone may be impressed on any or all lines by making the proper connection to the class of service tone condenser at the subscriber's line terminal. This tone (rapidly interrupted) will be heard by the toll operator who may act accordingly.

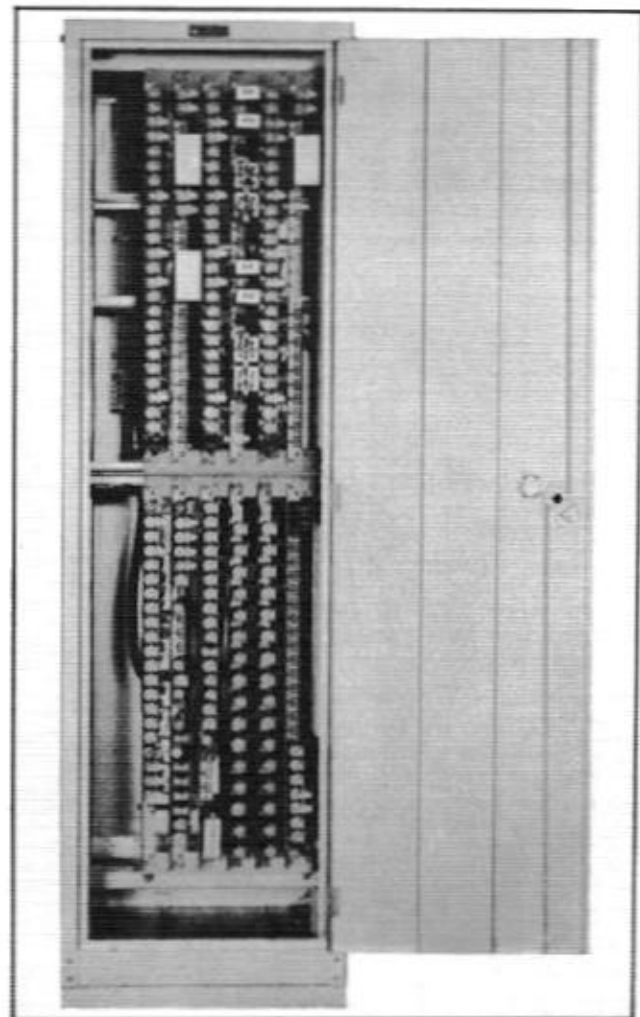


FIGURE 14. REAR, INTERIOR OF COMMON EQUIPMENT

12. LINK CIRCUITS

The function of the link circuits is to automatically find the calling line when a call is initiated and extend the calling line to the desired line in accordance with the number dialed. The link circuits are arranged for reverse battery answering supervision. The link circuits employ 35-contact, rotor relays for connecting with the calling and called lines.

While the link capacity represents the number of calls that may be in progress at one time, it should be noted that the traffic capacity of each link is exceptionally high because: (1) reverting calls (Section 30) occupy a link only while the called party is being selected and rung; (2) links are automatically timed-out when held by "permanent" lines, unanswered calls, etc. (Section 25).

13. PULSE COMPENSATING FEATURE OF LINKS

A "pulse compensating" feature has been incorporated in the connector circuits in order to permit dialing over varying line conditions which are usually encountered in rural districts. The name of this feature, "pulse compensating," describes in part at least its main purpose; an impulse, once initiated, completes its function by means of a locking circuit regardless of outside influences which ordinarily affect the impulse length and consequently apparatus operation. If the pulses from the pulsing relay's back contact are too short as caused by a line with low leakage resistance, they will be lengthened by the locking feature. If the pulses are too long as they would be on a high resistance loop line, an artificial shunt increases the operating speed of the impulsing relay. Yet it introduces no detrimental effects on the release characteristics of that relay on heavily loaded lines.

The large range of this pulse compensating feature is outlined here. The data given, of course, permits operation with all variables at the unfavorable limits. The dialing range is 0 to 1000 ohms line loop resistance and shunts of infinity to as low as 8000 ohms across the line (leakage) or between either or both sides of the line and ground. This dialing range permits wide voltage limits with dial pulses of 8 to 11 per second, and 20 low impedance ringers bridged across the line or five between each side of the line and ground. The dialing range of the trunk repeaters varies with the types of trunks and repeaters employed, but in general, the range is ample to meet requirements.

14. CALL ALLOTTER

The call allotter distributes calls evenly over all links and prevents connection with a calling line by more than a single link. It assigns a different link on successive calls from the same line, providing that another link is available.

The allotter also assigns another link if the first link assigned to a call fails to make connection with the calling line.

15. REVERTING CALLS

This switchboard provides for the making of reverting calls on party lines by the dialing of the directory number. Tick-tone is employed to inform the called party that the call is from his own line, in the case of harmonic ringing boards. On code ringing exchanges, a ring-back signal is furnished the calling party. See Section 30 for operating details.

16. P.B.X. TRUNKS

Provision is made for two P.B.X. groups of trunks on 60 and 100-line boards; three groups, on 200-line boards. Automatic trunk selection on a "non-rotating" basis is employed, the first free trunk in the group being selected. Levels commonly assigned to this service are the "50" and "60" on 100-line boards. Trunks are assigned at the beginning of a level, and unused numbers may be assigned to other subscribers. Any number may be used for night service except the first. The trunks go-out either to consecutive numbered telephones or to a P.B.X.

17. TRUNKS TO OTHER OFFICES

Three groups of such switch-through trunks may be employed on the 60 and 100-line boards; four groups, on the 200-line. These trunks have single-digit call numbers, "0", "9", "8", and "7". Up to ten trunks may be assigned in a group and any unused numbers in the particular tens level may be given regular subscriber numbers or employed for paystations. The trunks within a group are selected automatically and in rotating order such that no trunk is selected a second time until after all free trunks in the group have been used. The total number of trunks is limited by the mounting space provided for trunk repeaters. This space regularly provides for 10 trunks on the 60-line; 10, on the 100-line; 16, on the 200-line board. The capacity for subscribers' lines is, naturally, reduced by one for each trunk equipped. Links are arranged for switch-through service to a repeater on trunk calls.

Sometimes it is desirable to multiple trunks from one tens group to a second group. For example, if "0" level held only three toll trunks, it might be desirable to multiple free service trunks from another level to the "0" level. In a case of this kind, both trunk groups, must, of course, end in operator positions.

When trunk selection is required in a trunk group which contains some trunks multiplied from another group, trunk selecting relays without "rotation" should be used in order that the regular trunks, which appear first, may be used most often, the

multipled trunks getting only the overflow. Conversation timing may be provided on the free service but not on the toll trunks.

17.1 Verification Service

An operator may monitor or talk-on a busy line by prefixing the digit "1" to the regular four-digit subscriber number. This feature is convenient for verifying the calling station's number on requests for toll service as well as for checking reported "busies." Only toll operators may avail themselves of this service; it may be removed if desired.

17.2 "Camp-On-Busy" Service

The toll operator, if she desires, may after dialing the subscriber's number prefixed by a "1", camp on a busy line. When the busy condition is removed, ringing will automatically begin. At any time, she may converse with the parties on the line.

17.3 "Camp-On-Line" or Delayed-Ring Service

An operator may dial the first three digits of a subscriber's number to seize the line. She may then "camp on the line," delaying ringing until she has completed, say, a toll connection. The line on which the operator is camping will test busy to other calls and should a party on the line lift his receiver while the operator is "camping," she will receive answer supervision. The operator may then talk to the party. This does not disturb the connection for after the party has replaced his handset, the operator may at any time dial the fourth digit to ring the wanted line.

17.4 All-Links Busy Tone

If desired, connections may be made such that a busy tone will be returned to an operator on switch-through trunks when all links are busy. Local subscribers, of course, fail to get dial tone under such busy conditions.

17.5 Identification of Trunk Calls

Trunk calls through the links are identified from the call allotter, permitting the special features of the links to function on trunk calls but not on subscriber calls even though these lines are assigned in the same group as trunks.

17.6 Restricted Service

Frequently, it is desirable to restrict all subscribers or a group of subscribers from connecting with certain trunks such as toll lines accessible only to the operator. On some boards, this can be provided on a tens-group basis, i.e., all the lines in one or more tens-group may be prevented from dialing certain trunks.

18. NETWORKS

In a telephone network such as the typical example shown in Fig. 15, the above services, available on these Automatic Electric rotor relay switchboards, prove of exceptional value, especially when combined with the trunk repeaters discussed in Section 52. The network shown consists of a Toll Center, "A"; a tandem rotor relay exchange, "B" (200 lines); a sub-tandem rotor relay exchange, "C" (100 lines); a magneto-manual exchange, "D," out of "C"; and a Strowger automatic exchange, "E" out of "B".

The toll operator in "A" may be reached by any subscriber in the unattended automatic exchanges. Calls from "C" are automatically tandemmed through "B" where there is a trunk finder group for the two metallic and one phantom circuit to "A." The magneto manual operator at "D" has a dial by which she can reach the toll operator in "A" by dialing "0" as a subscriber in "C" would do.

Where free service is provided between two exchanges, the subscriber (of an automatic exchange) may dial directly into the neighboring system. For example, a subscriber in exchange "E" may dial "8" for free service to exchange "B".

Where a toll charge is to be made as between exchange "C" and "E," the subscriber in "C" must dial "0" for the operator in "A." The call is automatically tandemmed through exchange "B" to "A." The operator there records the charge and may utilize the verification feature, when provided, to check the source of the call if she desires. As the calling party wants a connection with "E," the operator at "A" dials "8" back over a trunk to "B" which makes connection with "E." The operator upon hearing dial tone from "E" dials the number of the wanted party.

Trunks between "A" and "B" may be released by the operator, in some circuits. Each network presents problems peculiar to itself, and therefore, each such installation must necessarily differ from every other to a considerable degree.

In Figure 15

"A" (Toll Operator) Dials

"7" for "C"
 "8" for "E"
 "78" for "D"

"B" Dials

"0" for Toll, Information, Etc.
 "9" for Free Service to "C"
 "8" for Free Service to "E"

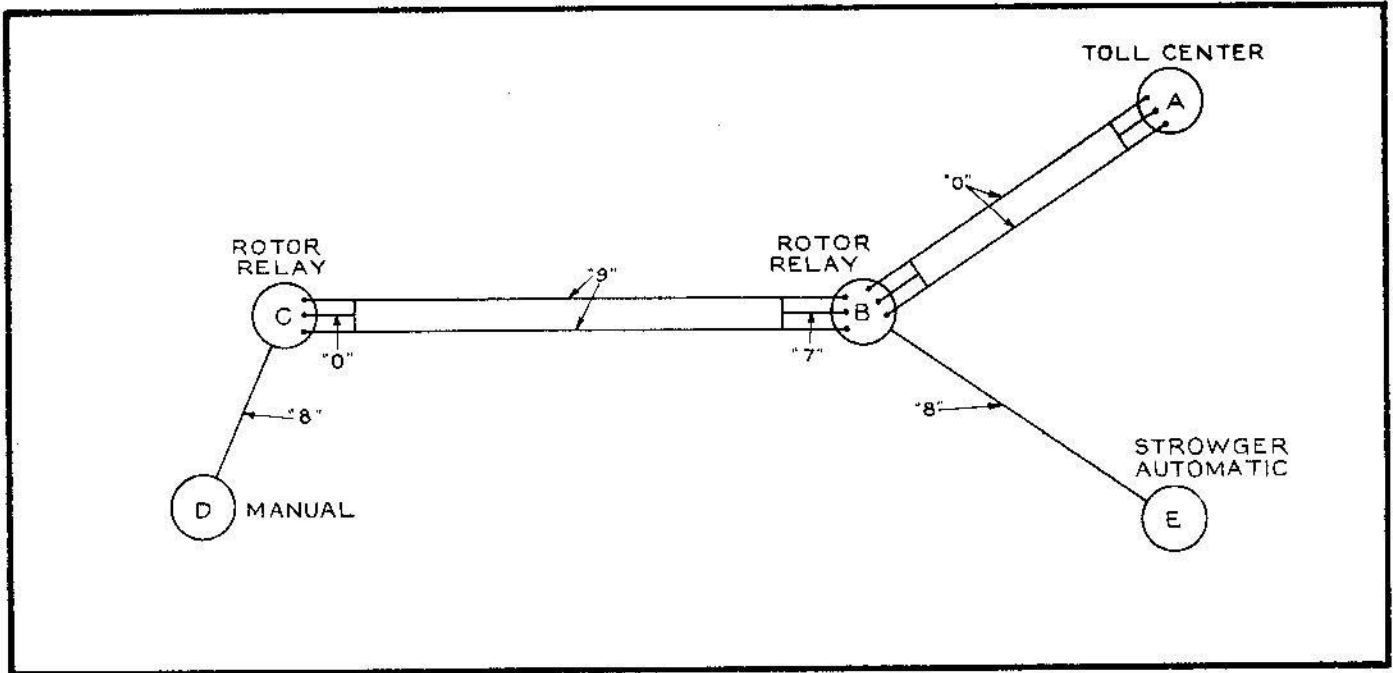


FIGURE 15. AN ILLUSTRATIVE NETWORK PLAN

"B" is Blocked from
 "98" to "D"
 "7" to "C"

"C" Dials
 "0" for Toll, Information, Etc.
 "9" for Free Service to "B"
 "8" for Service to "D"

"C" is Blocked from
 "08" to "E"
 "98" to "E"

"D" (Operator only) Dials
 "0" to "A"

"E" Dials
 "80" for Toll, Information, Etc.
 "8" for Free Service to "B"

"E" is Blocked from
 "89" to "C"
 "87" to "C"

19. PAYSTATIONS

Paystations of the post-payment type may be connected to any line terminal. These coin collectors require reverse battery, however; so see the installation information in Part IV, Section 48. Reverse battery, received when the called party answers, places a shunt on the transmitter so that a conversation cannot be carried-on until a nickel has been deposited. No coin is required to talk to the operator who receives paystation tone when she answers the call. At any time, she may recall paystation tone by momentarily removing her plug from the

jack before her. Other types of paystations and paystation service may be employed. For example, if local calls are free, an ordinary automatic telephone with a supplementary coin box may be employed.

20. SUBSCRIBERS' LINE SERVICES

One of the following two groups of services (Section 20.1 or 20.2) may be supplied depending on whether the board is arranged for harmonic or code ringing. In either case ringing of the called station is automatic and intermittent. Ring cut-off may be instantaneous upon the called party's removing the handset, or the cut-off may be delayed, i.e., during any silent period within or at the end of a ringing code. A "generator drain" relay is provided to permit operation on heavily loaded lines. This relay drains any charge remaining on the line after a ringing cycle.

20.1 Code Ringing

The equipment is arranged to provide, on a terminal per line basis, the following classes of service:

- (a) Individual
- (b) Two-party, selective divided ringing
- (c) Four-party, semi-selective divided ringing
- (d) Ten-party, semi-selective divided ringing
- (e) Ten-party, non-selective bridged ringing
- (f) Twenty-party, non-selective bridged ringing
- (g) Paystation

The ringing of the called station is automatic. Ringing starts with the first complete cycle after the completion of dialing.

The code cycle is repeated approximately every 8 or 10 seconds as desired, the change in length of the code cycle being accomplished by a change in strapping. The length of the code cycle has no effect on the codes sent. The codes are as follows:

Code 1 - 1 Long
 Code 2 - 2 Shorts
 Code 3 - 4 Shorts
 Code 4 - 1 Long, 1 Short
 Code 5 - 1 Long, 2 Shorts
 Code 6 - 2 Shorts, 1 Long, 1 Short
 Code 7 - 2 Longs
 Code 8 - 2 Longs, 1 Short
 Code 9 - 1 Long, 3 Shorts
 Code 10 - 2 Shorts, 1 Long
 Code 11 - 1 Short, 1 Long
 Code 12 - 3 Shorts
 Code 13 - 5 Shorts
 Code 14 - 1 Short, 1 Long, 1 Short
 Code 15 - 1 Short, 1 Long, 2 Shorts
 Code 16 - 3 Shorts, 1 Long, 1 Short
 Code 17 - 1 Short, 2 Longs
 Code 18 - 1 Short, 2 Longs, 1 Short
 Code 19 - 1 Short, 1 Long, 3 Shorts
 Code 20 - 3 Shorts, 1 Long

The second ten codes are the same as the first but with one short ring prefixed.

20.2 Harmonic Ringing

Harmonic ringers, supplied subscribers, are tuned to ring only when one given frequency is impressed on the line. Thus, full-selective, ten-party service may be given on all terminals with divided ringing. Semi-selective ringing employing one and two rings may be furnished to give semi-selective service on ten-party bridged ringing lines. Grounded lines must necessarily employ this latter method. Harmonic services are as follows:

- (a) Individual
- (b) Two-party, selective divided ringing
- (c) Five-party, full selective bridged ringing
- (d) Ten-party, semi-selective bridged ringing
- (e) Ten-party, full selective divided ringing
- (f) Paystation

If desired, individual or two-party lines may use the regular straight line ringers. Ring digits (Section 22) should be assigned which will select frequencies of 20, 25, 30 or 33-1/3 cycles. The frequencies generated are shown below. New installations are frequently supplied in the non-multiple series.

Frequencies	
Non-Multiple	Multiple
20	16-2/3
30	25
42	33-1/3
54	50
66	66-2/3

21. RINGING EQUIPMENT

Choice of ringing equipment is determined by the kind of line service desired, i.e., code or harmonic ringing. In either case vibrating-type ringing converters are used. With code ringing, only one converter need be used. This produces current at a frequency of approximately 20 cycles per second. The codes are produced by a relay-type ringing interrupter. Ring cut-off may be instantaneous or delayed. Duplicate ringing converters with automatic transfer may be supplied if desired.

A harmonic ringing converter consists of five vibrating reed converters, one for each of the five frequencies. A relay-type interrupter is also used with harmonic ringing. Ordinarily it merely provides single ringing intervals (one ring); however, it may produce two rings per period for the ten-party semi-selective service. These harmonic converters may also be supplied in duplicate with automatic transfer in case of failure of any one of the five vibrators. Ringing current is connected to the called line through a 25 watt generator lamp individual to the link, as protection to the ringing current supply. Ring cut-off may be instantaneous or occur during the first silent period after the subscriber lifts his handset.

22. NUMBER ASSIGNMENTS

Subscribers' numbers consist of four digits. The first digit determines the class of service and also, in the case of codes, how ringing current is to be applied to the line; the second and third digits select the line; and the fourth digit, the ringing code or frequency. Codes and frequencies are listed in Sub-Sections 20.1 and 20.2 respectively. Trunk groups are assigned a single digit as "0." P.B.X. trunk groups are assigned regular four-digit numbers. The first number (directory listed) should be line 1 in the tens-group. For night service, any number except the first may be used. Subscribers' stations may be assigned the unused numbers at the end of either inter-office or P.B.X. trunk groups.

22.1 Code Ringing

As mentioned previously four-digit numbers are assigned, and it is, therefore, necessary to use a different system in assigning first digits for the several boards.

22.11 60 and 100 Line Capacity

Individual, coin-box and divided-ringing stations on metallic lines are assigned the digit "2" as the first digit. On divided-ringing lines, the last (fourth) digit determines the side of the line to which the ringing will be applied as well as the ringing code --- digits 1-5 ring on the negative side of the line, and digits 6-0 on the positive side of the line,

GENERAL DESCRIPTION

using the first ten ringing codes shown in the table included in Sub-Section 20.1.

Bridged-ringing stations (metallic and ground-return lines) are assigned either digit "3" or "4" as the first digit. The digit "3" is assigned to each station to be signaled by one of the first ten ringing codes, and the digit "4" is assigned to each station to be signaled by one of the second ten ringing codes.

22.12 200 Line Capacity

Individual, coin-box, and divided-ringing stations on metallic lines are assigned the first digit "2" for lines in the "200" group and the digit "3" for lines in the "300" group. On divided-ringing lines, the last (fourth) digit determines the side of the line to which the ringing will be applied as well as the ringing code-- digits 1-5 ring on the negative side of the line, and digits 6-0 on the positive, using the first ten ringing codes shown in the table included in Sub-Section 20.1.

Bridged-ringing stations (metallic and ground-return lines) are assigned only in the "200" line group being given the first digit "4" for the first ten ringing codes and the digit "5" for the last ten codes. (See Section 22.3 which summarizes this information.)

22.2 Harmonic Ringing

The first-digit numbering of harmonic ringing switchboards is quite simple. A first digit, "2," is used for the first one-hundred lines (200 line group) giving the following service: individual, coin-box, divided-ringing (metallic lines, 10-party full selective), bridged-ringing (metallic and all ground-return lines; 5-party full selective, 10-party semi-selective).

First digit "3" gives identical service on the "300" line group of 200-line boards.

The fourth digit selects one of the five frequencies and determines the side of the line to which ringing current will be applied for divided ringing. Digits "1" to "5" ring on the negative side of the line; digits "6" to "0" on the positive.

If 10-party semi-selective, one and two ring, bridged ringing is to be employed, fourth digits of "1" to "5" connect the appropriate frequency to the negative side of the line as above. Each ringing cycle consists of one ring followed by a silent period--usual practice. Fourth digits of "6" to "0" connect the desired frequency to the positive side of the line. Each ringing cycle consists of two short rings followed by a silent period, thus serving as a simple code. The side of the line, opposite to that on which ringing current is placed, receives ground.

22.3 Number Assignment Table

Digit	Number	Use
First Digit All Boards (Ten-thousands)	1----	Verification Service (Operator Only)
(Thousands)	1---	Absorbed
	2---	Individual Coin Box *Divided Ringing 10 Stations (First 10 Codes or 5 Frequencies)
60 and 100 Line Boards	3---	°Bridged Ringing (First 10 Codes)
	4---	°Bridged Ringing (Second 10 Codes)
	5---	Absorbed
	6---	Absorbed
	7, 8, 9	Absorbed or Trunk Service
	0	Trunk Service
	200 Line Boards	2---
3---		*300 Subscriber Line Group Individual Coin Box Divided Ringing (code or harmonic) Bridged (harmonic)
(Code Only) 4---		°200 Subscriber Line Group Bridged Ringing (First 10 Codes)
(Code Only)	5---	°200 Subscriber Line Group Bridged Ringing (Second 10 Codes)
Second and Third Digits (Hundreds Tens) All Boards	-XX-	Line Selection
Fourth Digit (Units) All Boards	---1 to ---0	Code Selection Frequency Selection Side of Line on Divided Ringing

*Frequency Ringing Grounded Lines Here
°Code Ringing Grounded Lines Assigned Here

23. LINE TERMINALS AVAILABLE

The following Sub-Sections show the line terminals available in the three sizes of switchboards.

23.1 60-Line Switchboard

51	61	71	81	91	01
52	62	72	82	92	02
53	63	73	83	93	03
54	64	74	84	94	04
55	65	75	85	95	05
56	66	76	86	96	06
57	67	77	87	97	07
58	68	78	88	98	08
59	69	79	89	99	09
50	60	70	80	90	00

23.2 100-Line Switchboard

11	21	31	41	51	61	71	81	91	01
to	to	to	to	to	to	to	to	to	to
10	20	30	40	50	60	70	80	90	00

23.3 200-Line Switchboard

211	221	231	241	251
to	to	to	to	to
210	220	230	240	250
261	271	281	291	201
to	to	to	to	to
260	270	280	290	200
311	321	331	341	351
to	to	to	to	to
310	320	330	340	350
361	371	381	391	301
to	to	to	to	to
360	370	380	390	300

24. tone EQUIPMENT

The tone equipment is provided with a special starting circuit. This "thump start," as it is called, insures the starting of the tone generators over a voltage range of 42 to 56 volts without critical adjustment. These tone generators have more than ample output, produce few harmonics, and generate a low voltage. They are consistent in pitch of tone produced and cannot be put out of commission by an overload. A radio frequency choke coil is provided on each tone lead to eliminate radio interference. Dial tone and paystation tone are provided from one tone circuit, the two tones being identical. Busy tone, 60 interruptions per minute, has its individual tone generator. Associated with it is the revertive "tick" tone which gets its 120 ticks per minute from doubling springs on two busy-tone relays. "Class of service" tone has a separate generator circuit which gives a rapidly interrupted tone of 400 interruptions per minute. This is similar to the busy signal but more rapidly interrupted.

25. TIMING RELAYS

Timing relays operated from the exchange battery deliver time pulses that are used for timing the occupancy of links. They will cause a link to be released within two to four minutes under the following conditions:

- Calling party fails to dial
- Call is not answered
- Calling party fails to disconnect
- "Permanent" line seizes a link

After the link has been released, the "permanent" line will remain locked-out until conditions on the line have cleared, when the lock-out will automatically release.

26. CONVERSATION TIMING

Conversation timing may be employed if desired. In which case, a conversation would be timed out in six to eight minutes. This time may be increased to 14 to 16 minutes; however, increasing the time interval for conversation timing also increases the intervals for permanent lines and ineffectual calls. When conversation timing is used, the parties to a connection receive the first warning signal (dial tone) approximately one-half minute before disconnection and the final warning about two seconds before the connection is automatically released. Toll calls do not have timing of conversations.

27. TRAFFIC REGISTERS

A peg count meter is arranged to operate each time a number has been dialed. This is controlled from the call allotter.

An overflow meter registers each time that an "all-links-busy" condition exists. From this, an operating company can keep informed as to traffic conditions in the exchange.

28. ALARMS

These automatic switchboards not only provide for an alarm checking number but also give a visual indication in case of alarm conditions. A non-locking key has to be operated to check the visual signals for an alarm condition. Visual signals operate on:

1. Charging Failure
2. Blown Fuses
3. Generator Failure
4. Blown Heat Coils
5. Line Equipment in Lockout Condition

An alarm checking number, usually "2001," will transmit the following signals, when dialed:

<u>Class of Alarm</u>	<u>Alarm Condition</u>	<u>Signal</u>
No Trouble	None	Ringback
Major	Charging Failure	None
	Blown Fuses (Common Equipment)	None
Minor	Generator Failure	Tick
	Blown Fuses (Link & Trunk)	Busy
	Blown Heat Coils	Dial

The alarms are given preference in the order of their importance. In addition, an alarm sender can be employed to send an alarm indication to an attended office. See Section 34.

When duplicate ringing equipment is furnished, failure of one ringing converter will register an alarm condition. If the second ringing converter functions upon automatic transfer, the

alarm condition is removed; however the alarm receiving circuit at the distant office has operated. When the manual office calls the alarm checking number to determine the nature of the alarm, ring-back tone will be received if the second converter is functioning.

Transfer from one ringing converter to the other can be effected at a distance by dialing the ringing transfer number desired; these are usually "2991" and "2901."

Checking for a line in the lockout condition from a distant office is not standard equipment; however, a second alarm checking number may be used for this purpose, determining whether or not a line is in the lockout condition. Dial tone is received when any line is in that condition, and ring-back, when no line is locked-out. An alarm, major or minor, may be sent over an alarm sender to the distant office if this feature is desired.

Part III

METHOD OF OPERATION

29. LOCAL CALLS

To make a call, the subscriber first removes the handset and listens for "dial tone." Hearing dial tone, the subscriber proceeds to dial the desired station number (four digits). The first digit determines the class of service; the second and third digits select the line; and the fourth digit, the proper ringing code. The ringing of the called telephone is automatic and intermittent. "Ring-back" tone is received by the calling party during the ringing periods as an indication that the called station is being signaled. The connection is released when the calling party disconnects.

If the called line tests busy, the calling party will receive busy tone, and the connection is released by the calling party replacing his handset on the cradle. On successive calls from the same line, a different link is assigned to find the line, providing that another link is available. This is accomplished by means of a distributor circuit. The distributor will also assign another link if the first assigned link fails to make connection with the calling line.

In order that the availability of the links be kept at a maximum, all links are supervised to free them from "permanent" lines and ineffective calls. When a link has found a calling line, an automatic timing circuit times the completion of the connection, and the link is released when

the connection is not completed within a minimum of 1-3/4 minutes or a maximum of 3-1/2 minutes. Consequently, when a link is occupied by a calling line and no impulses are received within the timed interval, or when the called station does not answer within the same period, the link is made available for another call. A link is also released when the calling party fails to hang up within the timed interval after the called party has disconnected.

In the case of a network of automatic exchanges, it may be desirable to restrict service from certain subscribers in one exchange to certain other exchanges. The restrictions may be applied to individual subscriber-lines or to tens-groups of subscriber lines. Such restricted service prevents subscribers from dialing through tandem exchanges into a toll area. Calls to such areas, therefore, must be completed through the toll operator. The use of this arrangement permits great flexibility in building up automatic networks.

30. REVERTING CALLS

To call a party on the same line, the calling party removes the handset and listens for dial tone. When dial tone is received, the regular four-digit number of the desired station is dialed. Busy tone is received, because the subscriber has called his own line. He then replaces the handset on the cradle. This action

does not release the connection, as would occur on a line-to-line call, but causes the ringing code (code system) of the called station to be placed on his line. If both the calling and called station ringers are bridged across the line or connected to the same side of the line and ground, both bells will ring. When the ringers are connected to opposite sides of the line, the calling station will receive a short ring at the end of each ringing cycle as an indication that the called station is being signaled. When the called station answers, the ringing is cut off, and the calling party removes the handset to start the conversation. With harmonic boards, no ringing indication is given the calling party, so he must not remove his handset until sufficient time has elapsed for the called party to be rung. Tick tone is placed on the line when either party removes his handset. This is an indication to the called party that a reverting call is on the line and that he should wait. Both parties hear this tone for approximately 3 seconds. When it is removed, conversation may begin. Even though the calling party impatiently removes his handset after only one or two ringing cycles, the called party may still answer. Tick tone will always hold the party who answers first.

The link circuit is used only during the period of dialing and ringing. When the called station answers, the link is automatically released; the line is locked out (to guard against seizure by another link); and transmission battery is supplied to the line from the line relay.

Subscribers should be thoroughly instructed in reverting call operation, as failure to restore the handset and wait for the ringing period will prevent a connection being completed.

31. PAYSTATION CALLS

Coin boxes of the post-payment type may be connected to any line terminal. The calling party operates the telephone in the same manner as an ordinary telephone with the exception that a nickel is dropped in the slot (on local calls) when the called station answers. No coin is required to call the toll operator.

A three-slot, post-payment coin collector as the Type 750 or the single slot, Type 29 may be used successfully. If no charge is to be made for local calls, any regular dial telephone may be used in combination with a separate coin box preferably of the multi-slot type.

Paystation calls are ordinarily identified at the toll position by means of a tone placed on the connection by the paystation line. When tone condenser equipment is not provided at the switchboard, the identification of paystation calls will be by line number only.

32. TOLL OPERATION

The toll operator will very likely be located in an attended exchange connected to the C.A.X. by toll trunks. Toll operators may be obtained by dialing one of the trunk groups ("0," "9," "8," etc.). Usually "9" and "8" are assigned for dialing directly into a neighboring exchange with "0" reserved for the toll operator. Note that the operator has control over the release of trunk calls to her. For this reason, the calling subscriber as well as the called party can re-signal the operator at any time without losing the connection.

32.1 Local to Toll

The calling party removes his handset and listens for dial tone. When dial tone is received, he dials the toll number, say "0," which extends the call over a free trunk to the toll switchboard. When the operator answers, she may receive one of several tones which gives her information as to the service which she may render the calling party. Paystation tone announces that the call has originated at a coin box. On other lines "class of service" tone indicates the extent of the service which the operator may render the calling party. She may recall the tone by momentarily removing her plug from the jack.

From this point, the connection is completed according to the prevailing toll operating practices; however, certain special services are available to the toll operator. For example, verification service permits an operator to monitor or talk to a busy line by first dialing the digit "1" followed by the desired subscriber's number. If she dials only the first three digits of the subscriber's number, the operator will seize the line and may monitor it if it is busy. Dialing of the fourth digit will start the ringing of the line whether the verification prefix was used or not. Verification service is restricted to operators, and it permits them to verify the origin of calls.

When the connection desired by a subscriber cannot be completed with the calling party remaining on the line, the toll operator advises the calling party that he will be called. When the desired connection is ready, the toll operator dials the prefix "1" and the four-digit number of the calling party over the toll trunk as for a toll to local call.

While building-up a toll connection, an operator may, if she desires, "camp" on the calling party's line. This is accomplished by dialing only the first three digits of the subscriber's number. Such action would busy the line to all other calls and should anyone on the line remove his handset, the operator would receive supervision and could talk to the individual. When she is ready to ring the calling party, she will dial the last (ringing) digit.

32.2 Toll to Local

Incoming (terminating) toll calls to the switchboard are completed by the operator's dialing the wanted subscriber number. If the number tests busy, the operator, by use of the verification service, may monitor the line. To do this, she prefixes the digit "1" to the subscriber's regular number. She may then talk to the parties or merely "camp on busy." In the latter case, ringing of the called station will automatically begin when the line is freed. Provision can be made to eliminate the "camp on busy" feature when desired.

33. TRAFFIC REGISTERS

To provide the telephone company with information relative to the operation of the switchboard, a "peg count" (PC) register of calls made and an overflow register are provided and are controlled from the call allotter. The peg count register will operate only after a number has been dialed in order to avoid counting incomplete calls. The overflow meter provides a check on the number of times all links are busy.

34. ALARM CHECKING

In addition to the visual alarms displayed when a non-locking "alarm checking" key is operated, the switchboard is wired so that the alarm condition may be checked from any line or trunk.

The alarm checking circuit is connected to a subscriber's line terminal enabling a supervisor such as a toll operator at a distant exchange to determine whether any alarm condition exists at the switchboard. Usually the number "2001," is assigned for this purpose. Line lock-out requires a separate checking number though a visual signal is given on the switchboard itself.

When the alarm-checking number is dialed, the condition of the office may be determined by the tone heard as follows:

<u>Class of Alarm</u>	<u>Alarm Condition</u>	<u>Signal</u>
No Trouble	None	Ringback Tone
Minor Alarm	Blown Fuses (Links & Trunks)	Busy Tone
	Blown Heat Coils	Dial Tone
Major Alarm	Charging Failure	No Tone
	Blown Fuses (Common Equipment)	No Tone
	Generator Failure	Tick Tone

Should more than one alarm be operating simultaneously, the above alarms are given preference according to their importance as follows:

1. Charging Failure
Blown Fuses (Common Equipment)
2. Generator Failure
3. Blown Fuses (Line & Link).
4. Blown Heat Coils

In addition to the provision for alarm checking, the switchboard is arranged for an alarm sender to send major and minor alarms to the toll operator over loop dialing or simplex dialing trunks. A relay at the manual office is normally held operated over the trunk when the trunk is free. When an alarm condition exists, this relay in the manual office is released by the alarm sender. Alarms are sent only when the trunk circuit is free. The operator, noting the alarm, then dials the alarm checking number to discover the kind of alarm.

A "permanent" checking number may be provided in addition to the alarm checking one. This number is usually 2091. If any line is in the "lock-out" position, dial tone will true lock-; if no line is locked-out ring-back will be heard. The alarm, however, does not distinguish lock-out from reverting call lock-out. Should a major alarm occur after a minor alarm has been received but not cleared, or vice versa, it will again signal the operator.

When duplicate ringing machines are provided, operation may be transferred from one to the other by dialing 2901 for one and 2991 for the other. Busy tone is heard if the converter is operating. Failure of one ringing converter will register an alarm condition. If the second ringing converter functions on automatic transfer, the alarm condition is removed; however, the alarm receiving circuit at the distant office has operated. When the manual office calls the general alarm checking number to determine the nature of the alarm, it will receive ring-back tone if the second ringing converter has started and tick-tone, if it has failed to start. When a transfer is made from one ringing converter to the other manually, an alarm condition is not registered in the alarm checking equipment. If the manual transfer is conducted by dialing one of the ringing converter transfer numbers, busy tone will be heard indicating that the transfer has been made to the ringing machine associated with the number dialed.

Part IV

INSTALLATION

35. PLACING SWITCHBOARD INTO POSITION

The cable from the main distributing frame enters the switchboard unit through its top panel at the terminal block end. Viewing the 60- and 100-line switchboards from the front, this opening is to the right. Therefore, it is desirable that this terminal end be close to the main distributing frame. Also the common equipment cabinet is usually placed to the right of the switchboard unit.

Sufficient wall clearance should be provided so that the hinged door panels on both sides may be swung open. Figs. 32 and 33 in Bulletin 325, "Floor Plans and Building Design for Small Unattended Exchanges," 1939, show 100-line boards, their cabinets being 5'-2-1/4" x 2'. Dimensions for the 60-line board are 3'-8-1/4" x 2', and for the common equipment cabinet, 2'-0-1/2" x 2'. The plans mentioned will serve equally well for the 60-line board. Reference to Fig. 34, op. cit., or the appropriate "ordering" drawing will indicate the placing of 200-line boards. The 200-line boards consist of four small line and link frames (3'-8-1/16" x 2') plus one common equipment frame (2' x 2'); two line and link frames are usually butted together and placed facing the similar pair. The common equipment frame and battery cabinet are then conveniently located. The dimensions of the floor drillings are shown on the proper "method of assembly drawings" included with the board.

36. COVER ASSEMBLY

The cover assembly for 100-line boards is shown on H-65984; common equipment cover and 200-line covers on H-65926. The method of assembling the 100-line switchboard covers will be outlined below as an example. The assembly of other equipment covers is so similar that no specific information on them will be given. The appropriate drawings shipped with each job shows quite clearly how the assembly is made.

The switchboard is preferably unpacked near its permanent location. Then the frame is placed in its permanent location over the floor drillings. A sub-base may or may not be used. The floor angles at each end of the frame should now be leveled not only in the direction of their own length; but also with each other.

Metal or wooden shims may be used to accomplish this. Before bolting the framework to the floor, it is desirable to put the covers in place in order that the base rails will not be affected by any irregularity in the floor.

The end covers are mounted first. Each is fastened at the bottom to the floor angle of the framework by two end-cover-adjusting nuts which are part of the frame assembly. The holes drilled through the end covers are for joining additional units such as the common equipment cabinet if this is to be done.

The top cover is now placed in position and fastened by 1/4"-20 x 3/8" R.H.I.M.S. at the four corners. These pass through the top cover, the end cover, and the top angle of the framework. A 1/4" washer is used on top, and a packing washer of the appropriate type, if needed, is placed under the end cover. The two covers for the cable hole are held by machine screws as indicated on the drawing and are shaped and placed so as to cover the opening around the cable.

The two bottom sills, floor rails, are put in place on the front and rear sides of the switchboard and fastened to the end covers by 10-32 x 1/2" R.H.I.M.S. two at each corner. Lockwashers are used at these locations. Should there be any bulge in the floor, the sills may be forced out of line making it necessary to shim up the floor angles of the framework to correct the situation.

The framework may now be permanently bolted to the floor with lag screws. Check that the end covers are properly aligned at right angles to the top cover and to the front and rear base rails in order that the door panels may swing freely without bind when they are mounted. It may be necessary to loosen the screws and especially, the adjusting bolts on the floor angles; then the end covers can be shifted into proper alignment. Tighten all screws. After the cabling has been completed, mount the front and rear door panels by aligning the hinges and inserting the hinge pins. Adjust the panels to swing freely without bind. Adjustments may be made readily by loosening the screws which attach the hinge pieces to the door panels, then shifting the panels, and once more tightening the screws.

Weather-strip gasket is supplied for making the door panels dust-tight at their tops, bottoms, and sides. The application of the weather-strip is shown on the appropriate drawing. The metal is thoroughly cleaned, and the strip is cut into lengths corresponding to the door openings at the top, bottom, and sides of the covers. The strip is placed between hinged sections. The protective tape is removed exposing the adhesive side. This side is now placed toward the frame, non-movable or least movable part in every case, as shown in sectional drawings on the appropriate print.

Two adjacent boards or cabinets may be bolted together by the use of four 1'2"x2" R.H.I.St. bolts. Two bolts pass through the floor angles of one frame, the metal covers, and the floor angle of the adjoining board. Likewise two bolts are used through the top angles of the boards.

37. RADIO SUPPRESSION

Radio suppression is provided in the ringing and tone circuits, but equipment for subscribers lines, trunks, and commercial power leads is not supplied as standard, and therefore, if it is ordered, the job specification will include any necessary information.

38. BATTERY CABINET

The exchange battery is usually placed in a battery cabinet. This is best located alongside and butted against the "common equipment cabinet" which contains the power panel. The possibility of radio interference is, thereby, minimized. Local conditions may, however, warrant a different arrangement. The ampere-hour capacity and number of cells is determined for each installation.

39. BATTERY INSTALLATION

The storage battery cells are installed in the battery cabinet, according to the manufacturers directions. A #6 B.R.C. wire is required from the negative "-" terminal of the battery to the negative bus bar on the power panel. A #6 B.R.C. wire is also run from the positive "+" terminal of the battery to the ammeter on the power panel.

40. CHARGING EQUIPMENT

This equipment may be mounted in the battery cabinet though it is frequently wall mounted

especially in the larger sizes which give off considerable heat. Since this is a variable item, the job specification should be consulted. The following section further describes the charging equipment.

41. BATTERY CHARGER

The charging capacity and type of charger needed must be determined for each installation. However, it may be noted here that power circuit, H-35786, requires a self-regulating type charger. When a constant voltage type rectifier is used, the charge alarm relays shown in Fig. 4 of the above drawing are employed. One of these relays gives the charge alarm upon failure of the commercial power supply. A pair gives the alarm if the battery voltage falls to or below 46.5. When a rectifier other than a constant voltage type is employed, the relays above are eliminated, and a charge control unit is added. This charges the battery only for the length of time needed to bring up the voltage.

On the constant-voltage full-float method of operation, the storage battery is constantly maintained at a voltage sufficiently above its normal voltage to prevent its discharge. The charger, copper oxide type, being connected and in operation at all times, will normally carry the exchange load up to the limit of its rated capacity. The storage battery will be used only to carry the load in excess of the capacity of the charger. When the exchange load falls below the capacity of the charger, the battery will begin to receive a small charge.

Should the battery become discharged, it would be necessary to maintain a voltage of approximately 53 on a 23-cell battery (normal condition: 2.15 volts per cell or 49.45 volts for the exchange) until the battery became fully charged. Provision is made on the charger for obtaining this higher voltage. Normally, it will not be necessary to give the battery equalizing overcharges. However, variations among the cells may arise under conditions of discharge such as those mentioned above.

42. EXCHANGE GROUND

The telephone company should provide a permanent low-resistance, central-office ground. It is recommended that this ground be installed and tested in accordance with Bulletin 308, "Central Office Grounds." A #6 B. & S. gauge B.R.C. stranded copper wire is run from the central-

office ground to the main distributing frame, and then to the ground, "+," bus bar on the power panel.

43. MAIN DISTRIBUTING FRAME

Wall type main distributing frames are generally used by exchanges of the sizes included herein. The frames are approximately 1'-6" wide and 1'-3" deep per 100 lines. It should be located so as to keep the cable run to the cable hole in the top panel of the switchboard to a minimum.

44. CABLING AND CABLE RUNWAYS

On this series of switchboards, the cabling is carried on runways in order that there may be great flexibility. The smaller boards such as the 100-line use quite a simple arrangement. A runway extends from the M.D.F. to the common equipment frame. Then a second runway joins the first at right angles by the use of "corner brackets", D-78430. This runs across the top of the common equipment cabinet to the cable opening on the top cover of the line and link

frame. Straight sections of runway are joined together by "straight brackets," D-78431 and the appropriate bolts. The end of the runway near the M.D.F. may be fastened to the wall by "runway feet," H-44197-15. The runway, itself, is often spoken of as cable rack, and consists of two parallel 1-1/2"x3/8" side bars with cross-ties welded on to support the cable. The runway is supported at a convenient height above equipment. Prints H-44229 and H-44229-A contain information for assembling runways while H-64513 gives information on connecting tie cables.

The 200-line board requires considerably more extensive cabling and hence more branches to the runways. This time there are four line and link frames plus a common equipment frame. Again the runway starts from the M.D.F. being fastened to the wall by runway feet, H-44197-15 and lag screws. It crosses to the common equipment frame; a second and possibly a third runway joins at right angles. The second and third runways carry the subscribers' lines to their appropriate line equipment on the line and link frames. Runways along the top of the line and link cabinets carry the line cables, tie cables, and signal cables to the appropriate frame. Information on cabling the 200-line boards can be found on the appropriate drawings mentioned in the job specification.

Switchboard cable is supplied for connecting the M.D.F. to the terminal strips. Reference should be made to the job specification and the drawings listed therein for the quantity of cable supplied, the number of cable runs, and other details. Apparatus units and terminal strips are stamped with designations or numbers so that equipment groups and wiring may be identified. Likewise, information regarding trunking beyond that in Section 17 must be found in the job specification.

45. COMMON EQUIPMENT CABLING

One run of 13 conductor cable takes care of alarm checking and transfer circuits between the common equipment and the line and link frames in the case of the 100-line board. Generator tone, ringing interrupter, timing, and miscellaneous leads are carried in a twelve and/or 22 conductor cable as required. Trunk circuits are in separate cables and require five conductors per circuit.

45.1 Alarm Checking Circuit

The +N, -N, CN terminals associated with the alarm equipment on the common equipment frame terminal block should be jumpered to a trunk or a subscriber's line terminal assigned for this purpose. Line terminal "00" ("200" on 200-line board) is most frequently used. The checking number dialed would be 2001. Subscriber line equipment is disconnected from this number.

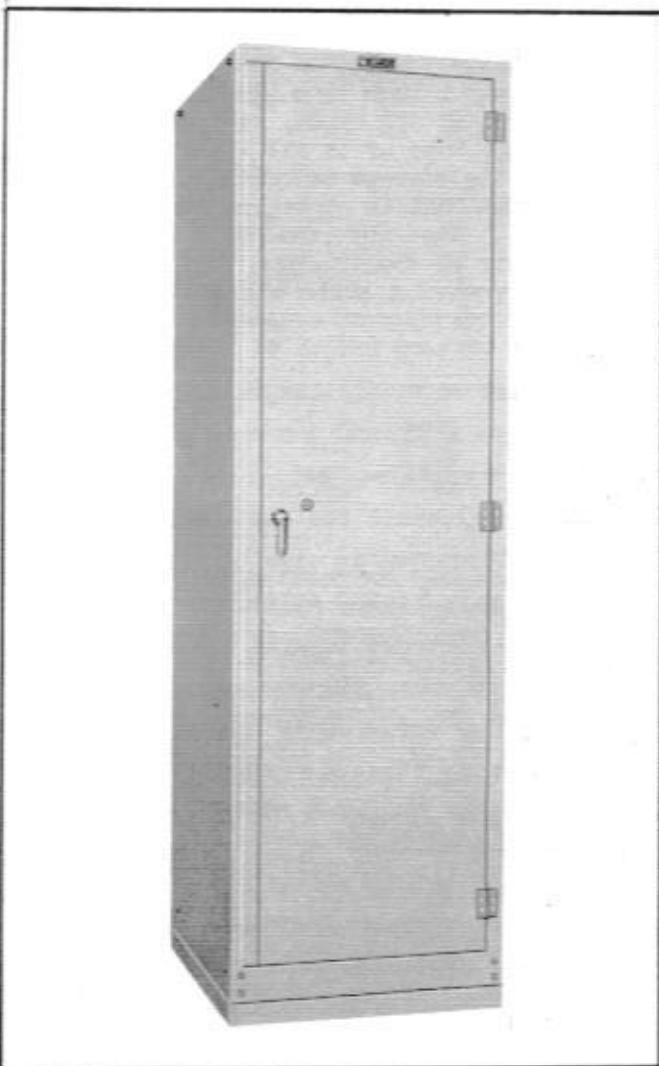


FIGURE 16. COMMON EQUIPMENT CABINET

45.2 Permanent Checking Circuit

Like the above, "permanent" checking terminals ("+", "-", and "C") on the common equipment terminal block are jumpered to a trunk or subscriber's line terminal, "09" (or "209") being commonly used. Line equipment is also disconnected.

45.3 Ringin Converter Remote Transfer

Two subscribers' line terminals must be used for the ringing machine transfer, i.e., when two ringing converters are provided. The terminals CN1 and CN2 on the common equipment terminal block are each jumpered to a "CN" lead associated with a line. Line relays are disconnected from such lines. Satisfactory lines to assign would be the last two of a trunk level as 99 and 90 (dial 2991 and 2901). Circuits for the ringing converter single or duplicate, code or harmonic, with automatic and manual transfer are shown on H-35778. The appropriate wiring diagrams for the board should also be consulted.

46. SUBSCRIBER'S LINE CABLING

The line cabling from the M.D.F. should be terminated at the switchboard terminal strip and connected to the "-" and "+" terminals of the line circuits. Line terminals, on the switchboard terminal strip, which are connected to trunk circuits are not to be otherwise connected.

47. WIRING OF GROUND-RETURN LINES

This wiring will be done at the factory if specified. Line equipment for these lines is the same as for metallic lines except that the positive side of the line is grounded at the terminal block, and connections to the line relay are changed according to the figure on the appropriate linefinder and line equipment drawing. Ground-return lines may be assigned only in the 200 group of the 200-line switchboard and are assigned 20-party bridged-ringing numbers. See "Number Assignment," Section 22. The Universal connector does not reverse battery on ground-return lines.

48. LOCAL BATTERY TELEPHONES

The board is normally wired for common battery and local battery lines using automatic telephones. Local battery and common battery telephones may be assigned numbers on the same level (tens group).

Both local battery lines with converted magneto telephones and with standard automatic magneto telephones may be used. But in the case of the former, on which it is not desirable to reverse battery on the lines, certain wiring should be omitted as per the appropriate linefinder drawing. This removes reverse battery supervision from all lines except the trunks themselves.

Under these conditions, post-pay coin stations, in which a coin is to be collected on local

calls, will have to be assigned numbers in one of the trunk levels--(2)00, (2)90, (2)80, etc., because in these series, battery reversal can be separately provided for the subscriber group on each level. The trunks always receive reverse battery answer supervision. Local battery telephones of the type just mentioned may also be placed on trunk levels provided that reverse battery is not desired on other subscriber lines in the level. Thus, pay stations of the "750" type, requiring reverse battery, may not be used on a level with converted local battery phones. See "Pay Stations," Section 19.

49. P.B.X. TRUNKS

In the 60 and 100-line boards, there is provision for two P.B.X. trunk groups. The 200-line boards provide for three groups. While these may appear on any except the "80," "90," and "00" levels, only one group (maximum of 10 lines) may be on a level. Numbers must start from terminal 1 in the level. A connection on the tens relay must be changed and trunk selecting relays provided to offer this P.B.X. service. Usually the "50" and "60" groups are used. Any number in the group may be used as a night number except the first. Subscribers' lines may be connected to other numbers in the level immediately following the P.B.X. trunk groups.

50. TRUNKS TO OTHER OFFICES

Trunks to and from other offices are terminated on convertible line equipment, available for subscribers' lines or trunks. Thus the capacity for subscribers' lines is reduced by one for each trunk equipped. No provision has, therefore, been made for incoming connectors since calls on trunks are handled by the regular finder-connector links.

The link circuits may be arranged to serve three groups of trunks (four on the 200-line board) having one-digit call numbers ("0," "9," "8," and "7" (200-line only) respectively). The trunk groups are assigned to the "00," "90," "80" and "70" levels of tens-relays. A rotating arrangement is used to prevent the use of any trunk a second time until after the other trunks in the group have been used.

A maximum of 10 trunks in any group may be provided; however, the total number of trunks in the three groups is limited by the mounting space provided for trunk repeaters. This space provides for a total of 10 trunks on the 60-line; 10, on the 100-line; 18, on the 200-line board. These may be divided as necessary among the levels.

Trunks are assigned to the first terminals of a line group so that subscribers' lines may be connected to any unused terminals in the group.

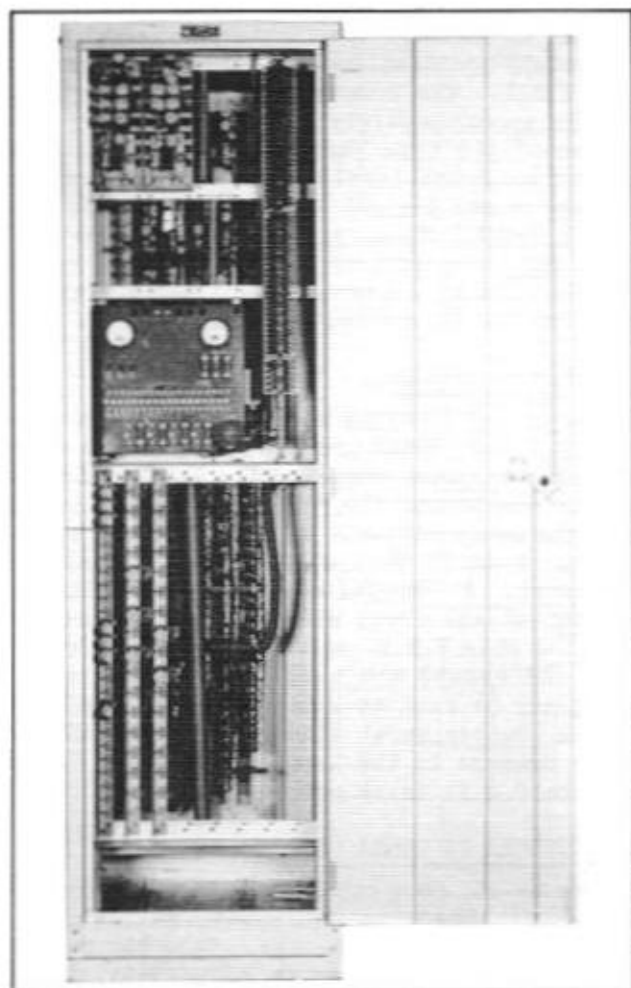


FIGURE 17. FRONT, INTERIOR OF COMMON EQUIPMENT

51. TRUNK EQUIPMENT AT CONNECTING EXCHANGES

The installation of trunk equipment is a variable with each job. In general then, reference for installing and operating data must be made to the job specifications.

52. TRUNK REPEATERS

Repeaters for the 60 and 100 line boards are installed on the lower section, front and rear of the common equipment frame. In contrast the 200-line board provides space for six trunks on the top rear of the common equipment frame and three on each of the four line and link frames, giving space for 18 trunks in all. The trunk repeater units are connected as shown in the appropriate drawings. Trunks mounted on the common equipment frame must be cross connected to the appropriate line terminals on the line and link frames.

52.1 Automatic to Manual Repeaters

For working into a manual exchange, a repeater is employed. The "loop" dialing type is shown

on H-35897. On outgoing calls, such a repeater is seized from the line equipment terminals of the rotor-relay exchange. The repeater sends a splash of generator to signal the manual operator. A momentary short is then held across the trunk to neutralize any charge due to trunk capacitance, preventing the premature operation of relays and the occurrence of clicks to the calling party.

When the operator answers, ringback tone, which the calling party has been receiving, is removed. If the call is from a paystation, paystation tone will be forwarded to the operator. The operator may recall paystation tone by momentarily removing her plug from the jack before her.

An important provision which has been made is that of resignaling the operator by the calling party. The calling party may, without losing the automatic connection, recall the operator, by alternately depressing and releasing the cradle plunger.

Disconnect supervision is given by the calling party upon replacing his handset. This reverses battery over the trunk to the operator. The connection, however, is held until the operator disconnects. Provision has been made for supervision on calls between two manual operators through the switchboard.

Incoming calls from the manual exchange cause the linefinder to locate the calling trunk exactly as it locates a local calling line. When the link seizes the calling trunk, the trunk will be switched through to the link and the operator will receive dial tone. If all links are busy, the operator will not receive dial tone. If desired, the line equipment can be arranged to place an "all-links busy" tone on the line. Dial impulses from the operator are repeated to the link.

When the called station answers, the link reverses battery to the repeater which in turn reverses battery on the trunk to the operator.

The called party may resignal the operator by alternately depressing and releasing the cradle plunger. When the called party disconnects, the operator receives supervision, and upon her releasing, the link is freed.

If a trunk from a manual office becomes "permanent," it will seize a link. After a period of time, the link will lock-out the faulty trunk. Likewise if a subscriber calls the operator, and she fails to answer; the link, the repeater, and the entire connection will be restored to normal after a given interval. Fuse alarm is provided for the repeater.

Automatic to manual repeaters for two way, simplex or composite trunks may be of the type shown on H-35855-X. These repeaters are essentially similar in services to the loop dialing type

described above. Simplex dialing may be employed where advantageous as on long lines. On the other hand, the use of phantom circuits will necessitate this repeater.

52.2 Automatic to Automatic Repeaters

In case it is desired to provide two-way dialing between two automatic offices, an automatic to automatic repeater must be used. As in the case of automatic to manual repeaters, there are three types of circuits. Loop dialing is shown on H-35900; simplex and composite, on H-35854.

In case it is desired to connect two rotor relay exchanges by simplex or composite circuits, the latter drawing is used. Both offices have the same type repeaters. One of the offices, say the second, is connected to a manual exchange by use of the auto to manual repeaters mentioned previously. On outgoing calls from the first office, the switch is seized after the calling party has dialed the appropriate trunk number as "9", additional digits dialed are repeated into the second automatic office. Thus a local subscriber in the second office may be dialed directly from the first. Should the dialing subscriber disconnect first, the local equipment disconnects. However, the trunk remains busy until the equipment at the distant office releases.

If the dialed party disconnects first, battery is reversed to the calling station but entire

connection is held until the dialing party disconnects. See "Networks" Section 18.

In a call to a manual office made through the second or distant automatic office, the digits dialed by the calling subscriber will consist of the trunk number, as "9", to seize this first repeater plus the trunk number, say "0" required to seize the auto to manual repeater in the second office. The manual office will now be signaled unless it is busy; in which case, the busy tone will be returned to the calling party.

If the trunk is not busy and the operator answers, she will receive paystation tone if the call is from a paystation. Reverse battery is not required on a call to an operator, and since paystation calls to operators are usually free, it is necessary to prevent reverse battery in order that the transmitter on post-pay type coin boxes will not be shunted.

Connections on calls through the tandem automatic office to the manual office are under the control of the calling party (H-35854). The calling party may not, therefore, flash the operator without losing the connection.

If the operator calls the first automatic office through the tandem automatic exchange, she will receive answer supervision when the called party answers. Refer to Section 18 for additional "Network" information.

Part V

INSTALLATION TESTS

53. INSTALLATION NOTES

Installation routine tests should be made at the completion of the installation and preparatory to placing the equipment in service. The testing equipment should include two telephones (to be provided by the Telephone Company). These two telephones should be standard dial-type central-battery instruments equipped with normal speed dials, such as are supplied for subscriber service. One telephone should be assigned a permanent line terminal number, in order that it may later be used as an office telephone. The second telephone may be eliminated after the testing has been completed. Ringers should be connected as described in the appropriate Sub-Section of 57. It may be desirable to have these telephones terminate in a cord with clips.

Fuse wire should be used on the fuse panels during the initial testing period, instead of the regular fuses. If any unstandard condition,

such as relays buzzing, develops when the circuits are fused, the fault should be cleared before the tests are started.

54. CALL-THROUGH TEST

Make all links busy except #1 by operating the associated link busy keys. Connect the two test telephones to two line terminals, and dial the number of the second telephone from the first telephone. Check for dial tone, ringing, ring-back tone, and transmission. Repeat the test by dialing the first telephone from the second telephone.

Next, move the telephone connections to two other line terminals, and repeat the tests outlined in the preceding paragraph. Perform this operation on all lines so that calls will be made from and to each line.

These tests insure correct operation from link #1 to each line relay circuit. The complete

call through test should be made with each link to insure perfect continuity throughout the switchboard.

55. LINK FAILS TO FIND CALLING LINE TEST

The links should be further tested by restoring all busy keys and making successive calls from one telephone. The call distributing feature of the distributor circuit causes all links to be used successively.

The allotter circuit is so arranged that when a link fails to connect with the calling line immediately, the call is assigned to the next available link circuit.

Each link circuit should be tested for this operation. Hold relay C-1 (drawing H-35803, H-35780, H-35879, or H-35853) of the normally assigned link circuit in the operated position, and then originate a call. The assigned link should not connect with the calling line, and the allotter circuit should immediately assign the next link which should connect with the calling line. Restore relay C-1 and release the calling line.

56. BUSY TONE TEST

Each link should be tested for busy tone by removing the handset at one telephone and then dialing that telephone from the other telephone. The busy tone test need be made only once with each link.

57. RINGING TESTS

Follow Sub-Section 57.1 for code ringing exchanges and Sub-Section 57.2 for harmonic ringing.

57.1 Code Ringing Tests

To test that all of the ringing codes are extended through all of the links from the code ringing interrupter, it is desirable to ring all codes through each link circuit.

Two ringers should be associated with the office telephone: one ringer connected to the negative side of the line and ground, and the other ringer to the positive side of the line and ground. Each ringer should be designated with the line terminal number assigned to the office telephone, and also with the side of the line to which the ringer is connected. Assuming that the assigned terminal is #83, the ringer connected to the negative side of the line should be designated "83-NEG"; and the ringer connected to the positive side should be designated "83-POS". It may also be desirable to equip the two ringers with distinctive gongs so that either ringer may be readily identified by sound.

The second telephone (for temporary testing use) should be equipped with a ringer bridged across the line. This test telephone should be terminated in cords fitted with spring clips so

that it may be easily connected to any line terminal for testing.

Connect the office telephone to, say, line terminal #83, and the test telephone to any other terminal. Operate the busy keys of all links except circuit #1. This restricts the testing to link circuit #1.

Dial the office telephone from the test telephone, prefixing the digit "3" before the line terminal number and adding the digit "1" to the line terminal number. In other words, the complete number consists of four digits --- 3831. The office telephone ringer connected to the negative side of the line should sound ringing code #1 (one long ring). Release the connection and dial the office telephone again, but in this instance, substitute the suffix 2, giving "3832." The second ringing code (two shorts) should be sounded at the office telephone. Continue calling the office telephone progressively until the suffixes "1" to "0" inclusive have been dialed and the first ten ringing codes tested. See the table of ringing codes in Section 20; also see table in Sub-Section 22.3.

The second ten ringing codes should be tested in a similar manner, with the general exception that the prefix "4" should be used instead of the prefix "3".

The first five ringing codes associated with divided-line ringing should be tested by dialing the office telephone, using the prefix digit "2", plus the two digits of the line terminal (83), plus the ringing suffixes "1" to "5" inclusive in rotation. Thus "2831" would be the first number of the series. The telephone ringer connected to the negative side of the line should sound codes "1" to "5" in accordance with the numbers dialed.

The second five ringing codes associated with divided-line ringing should be tested in the same manner as outlined in the preceding paragraph with the exception that ringing suffixes "6" to "0" inclusive should be dialed. The office telephone ringer connected to the positive side of the line should sound codes "6" to "0" inclusive in accordance with the digits dialed.

The tests outlined in the preceding paragraphs of this sub-section complete the ringing code tests through link circuit #1. Operate the busy key of link circuit #1, and restore the busy key of circuit #2. Repeat the tests. In this manner, all ringing codes may be tested through each link circuit.

57.2 Harmonic Ringing Test

To determine that all ringing frequencies are extended through all of the links, it is desirable to ring the various test ringers through each link. Two sets of harmonic ringers connected for divided ringing should be associated

with the office telephone while a third set bridged across the line should serve the temporary test telephone. Each set consists of five ringers corresponding to the five frequencies of the switchboard equipment. Of the two sets associated with the office telephone, one is connected to the negative "-" line and ground and the other to the positive "+" line and ground. Each set of ringers should be designated with the line-terminal number assigned to the office telephone and also with the side of the line to which the set is connected.

Busy all links except #1 and dial the office phone (line 83) from the test telephone, prefixing digit "2" and adding the digit "1" as a suffix. The office bell corresponding to harmonic #1 should ring. Continue this through digit "0". Suffixes "1" to "5" will ring the set of bells on the "-" line while "6" to "0" will ring corresponding bells on the "+" line. Bridged ringing should then be tested by dialing the temporary phone from the office phone using the suffixes "1" to "5". If provision is made for 10-party semi-selective bridged ringing by one and two-ring combinations this should be tested as well. In other words, all possible ringing combinations are dialed on each link. When the test is completed on the first link, busy it, and restore the busy key of link #2; repeat the test. When duplicate ringing sets are provided, both sets should be used for testing the ringing codes, using one for half the links and the second ringing set for the remaining links.

The frequency of the ringing converters is easily checked by means of a vibrating-reed tester which indicates the frequency of the current under test.

58. REVERTING CALL TEST

To test that the link circuits will provide the proper code combinations on reverting calls, two reverting calls should be made over each link as follows: Connect the office telephone to line terminal "83" as in Sub-Section of 57. Operate the busy keys of all link circuits except circuit #1. This restricts the testing to link circuit #1.

On harmonic boards, no revertive ring will be heard and the word "frequency" should replace "code" in the tests below. In addition, the revertive tick tone, which is received upon either the called or the calling party's removing his handset on a revertive call, should be timed on each link.

Dial "2831" on the office telephone, and then restore the handset. The "negative" ringer of the office telephone should sound code #1 (one long ring); and the "positive" ringer of the office telephone, the revertive ring (one short ring). Lift the handset to stop the ringing, and check that the link circuit is freed from

the line and that the line tests busy. Restore the handset to release the connection.

Dial "2836" on the office telephone, and then restore the handset. The "positive" ringer of the office telephone should sound code #6 (two shorts, 1 long, 1 short rings); and the "negative" ringer of the office telephone, the revertive ring (one short ring). Lift the handset to stop the ringing, and then restore the handset to release the connection.

Operate the busy key of link circuit #1, and restore the busy key of circuit #2. Repeat the tests. In this manner, each link circuit may be tested for reverting call operation. On 200-line boards, these same tests should be run using the prefix "3" in addition to "2". This is necessary to test the 300-line groups.

59. TIMING RELAY TESTS

Operate the busy keys of all link circuits except circuit #1. This restricts the testing to link circuit #1.

Originate a call from one telephone but do not dial a number. The link should be released at the conclusion of the timing period, and the line should be locked out until the handset is restored.

Dial a call from one telephone but do not answer the call at the second telephone. The link should be released at the conclusion of the timing period, and the calling line locked out.

Dial a call from one telephone; answer at the second telephone, restore the receiver at the answering telephone, but do not restore the handset at the calling telephone. The link should be released at the conclusion of the timing period, and the calling line locked out.

If conversation timing is employed, call one phone from the other; answer call, but do not replace either handset. In approximately eight minutes, a tone will be heard, and the connector will release.

Operate the busy key of link circuit #1, and restore the busy key of circuit #2. Repeat the tests. In this manner, the timing relays may be tested with each link circuit.

60. LINE LOCKOUT RELAY TEST

Check that the busy keys of all link circuits are in the normal, or non-busy position, and that none of the links are engaged. The time cut-off relays should not be used for other connections while this test is being made.

Short the "+" and "-" terminals of a line circuit. A link should seize the line. With ground cord, momentarily ground TP-1. The link should release and the lockout relay (RC) of the shorted line should lock. The subsequent non-operation of another link is an indication that the line lockout relay has locked-up and is holding the

start common circuit open. Remove the short circuit. The lockout relay should release and switch the line back into service. Again short the "+" and "-" terminals. A link should seize the shorted line. Remove the short circuit. The test should be applied successively to all of the line circuits.

61. P.B.X. TRUNK TEST

All P.B.X. trunks should be tested by making calls to and from each one over each link. Busy all links except the first. From the office telephone, dial the directory-listed number. The first trunk should be seized; busy the first trunk and again call the directory number. The second trunk should be seized. Busy each successive trunk until all trunks in the group are busy and each trunk tested. With all trunks busy, again dial the directory number; busy tone should be received. Now busy the second trunk; dial the directory number. The first trunk should be seized. Repeat the tests over each line.

62. MANUAL TRUNK CIRCUIT TEST

Connect the office telephone to line terminal, say "83." Operate the busy keys of all link circuits except the first. This restricts the testing to link circuit "1." Dial the trunk code, as "0," and note that the first trunk circuit is selected. Again dial the trunk code, and note that the second trunk is selected. Continue until all trunks have been selected once, in rotation and the first trunk has again been seized. Check each trunk for ringing, ring-back tone, transmission, and disconnect supervision. Operate the busy key of link "1," and restore the busy key of circuit "2." Repeat the tests. In this manner, the trunk circuits may be tested through each link.

Have the manual operator dial the office telephone over each trunk circuit from the manual exchange, checking for ringing, ring-back tone, answering supervision, transmission and disconnect supervision. Operate the busy keys of all link circuits. Test for busy-tone indication at the manual office, if the tone is to be given.

Instruct the operator to call the office telephone using her verification service. The handset of the telephone is left off the cradle, and the operator dials 1-2831 over another trunk. She should be able to talk over this trunk to the busy office phone. Replace the handset on the cradle. The bell on 2831 should ring. Thus both the verification and the camp-on-busy services (Sub-Sections 17.1 and 17.2) are tested. This test should be run-through each link, busying the links as before.

When a second group of manual office circuits is installed, test the second trunk group in a manner similar to that previously outlined in this section for the first trunk group.

63. AUTOMATIC TRUNK CIRCUIT TEST

Trunks to an automatic office should be tested in a manner similar to that outlined in the preceding Section 62, with the general exception that a test number in the distant automatic office should be dialed.

Have someone at the distant test number dial into the rotor relay office. Busy-tone indication will not be received at the distant automatic office when all link circuits in the switchboard are busy. Absence of dial tone is the all-links-busy indication.

64. PAYSTATION AND CLASS OF SERVICE TONE

When paystation lines are provided, and tone condenser equipment is installed on the associated line circuits, check outgoing calls from the paystation lines to determine that the toll operator identifies such calls by means of the tone.

Outgoing calls from lines equipped with "Class of Service" tone should be checked to determine that the operator will receive the tone.

65. INTERCEPTING SERVICE

Unused or recently disconnected lines should be dialed and checked to see if the intercept tone is received.

66. RESTRICTED SERVICE

Check that the service is actually restricted on those lines to be so equipped. Attempt to make calls to the restricted numbers or groups. (See Section 17.6).

67. GROUND-RETURN LINE TEST

Check that ground return lines have been properly assigned and that each such circuit is connected to ground on the positive side. Line-finder drawings detail the changes in line-relay connections.

68. ALARM CIRCUITS TESTS

Dial the alarm checking code (usually 2001) and note that ring-back tone is received as an indication that the switchboard is in normal operating condition. Release the connection.

Cause an urgent alarm condition to exist by connecting the fuse alarm bus bar to negative battery, and then dial the alarm checking code. Busy tone should be received. Release the connection.

Cause a non-urgent alarm condition to exist by removing a heat coil at the M.D.F., and then

dial the alarm checking code. Dial tone should be received. Release the connection.

Open circuit to the charger causing a major alarm to exist. Then dial the alarm checking code. No tone should be received.

Have the operator at the supervising office dial the alarm checking code, and instruct her in the proper interpretation of the tone signals. If an alarm sender is supplied check that it sends an alarm when the above alarm conditions were caused to exist.

If a "permanent" checking number (usually 2091) is provided, cause a line to be locked-out by removing the handset on a telephone. Instruct the operator to dial the "permanent" checking number after four minutes. The line should, by then, become "locked-out" (Section 34). The operator should receive dial tone. If no line is locked-out, she should hear ring-back.

Duplicate ringing machine transfer should be checked by dialing the transfer numbers usually 2901 and 2991. Busy tone should be heard if the converter is operating or has started. (See end of Section 34.)

Part VI

MAINTENANCE

69. MAINTENANCE ROUTINES

Regular routine inspections of the switchboard equipment are not considered necessary. Whenever a maintenance man visits the office, it is suggested that test calls be made from the office telephone or with a hand test set. The installation tests outlined in Part V may also be used by the maintenance man when searching for the cause of service interruptions.

70. ALARM CIRCUIT TESTS

The alarms can be checked from the connecting exchange by dialing the alarm checking code (usually 2001). With the switchboard in normal operation condition, ring-back tone will be heard. If an urgent alarm condition exists, busy tone will be received; and if a non-urgent alarm condition exists, dial tone will be received. The alarm circuit tone signals should be checked occasionally by causing the alarm conditions to exist. See Section 68 for tests and Section 34 for tone indications and their significance. If permanent line checking is

provided, "2091" may be dialed as the test number. Duplicate ringing transfer, if provided, can be effected by dialing two special numbers, usually "2901" and "2991".

71. TRAFFIC REGISTER TEST

The operation of the traffic registers should be observed and recorded at intervals. The operation of all-links-busy register can best be checked by busying the link or trunk circuits with the busy keys. This should be done during light traffic periods.

72. CALL-DISTRIBUTOR TEST

The call-distributing feature of the allotter circuit can be advantageously used to make test calls from the connecting office over a toll trunk. If such calls are made during the evening or night hours, when traffic is light, a number of successive calls will consecutively test all links. Although there is no definite check that all links are tested, the completion of a number of calls gives a reasonable assurance that all links are operating correctly.

INDEX

A

Alarm Circuits	18, 21, 24
Alarm Tests	30, 31
All-Links-Busy Meter	18
All-Links-Busy Tone	14, 26
Allotter	13
Allotter Test	4, 28, 31
Automatic Selection of OG Trunks	8
Automatic Selection of PBX Trunks	6
Automatic to Automatic Repeaters	27
Automatic to Manual Repeaters	26
Automatic Trunk Test	30

B

Basic Relay Switching	2
Battery	
Cabinet	23
Installation	23
Charger	23
Blown Fuse, See "Alarm"	
Blown Heat Coils, See "Alarm"	
Busy Tone	18
Busy Tone Test	28

C

Cabinet	9, 22
Cabling	
Information	24
Subscribers' Lines	25
Trunk	25
Call Allotter	4, 13
Call Allotter, Test	28, 31
Call Not Completed	18
Call Distributor, See "Call Allotter"	
Call-Through Test	27
Camp-On-Busy	14
Camp-On-Line	14
Capacity, Switchboard	10
Charger, Battery	23
Charging Equipment	23
Charging Failure, See "Alarm"	
Class of Service Tone	12, 18
Class of Service Tone Test	30
Code Ringing	
Codes	16
Line Services	15
Tests	28
Coin Stations, See "Pay Stations"	
Common Equipment	10
Common Equipment Cabling	24
Composite Trunks	26, 27

Connector Operations	5
Conversation Timing	18
Conversation Timing Test	29
Converted Magneto Telephones	25
Converter, See "Ringing Converter"	
Counting Relays	10
Cover Assembly	22
Cut-Off Relay	5, 10, 12

D

Delayed Ring	14
Dialing Range	13
Dial Tone	18
Dimensions, Switchboard	10
Distributing Frame, Main	24
Distributor, See "Allotter"	
Duplicate Ringing Transfer	19, 21, 25

E

Equipment	9
Equipment Mounting	10
Exchange Ground	23

F

Finder-Connector Link	2
Finder-Start Relay	4
Free Service	14
Frequencies, Harmonic	16
Frequency Test	29
Fuse Wire	27
Fuse Alarm, See "Alarm"	

G

General (Description)	9
Generator, See "Alarm"	
Ground, Exchange	23
Ground Return Lines	
Number Assignment	17
Test	30
Wiring	25
Group Relays	3
Guard Relays	3, 4

H

Harmonic Converters	16
Harmonic Ringing	16

INDEX

Harmonic Ringing Test 26
 Heat Coils, See "Alarm"

I

Identification of Trunk Calls 14
 Installation 27
 Intercepting Service 12
 Intercepting Service Test 30
 Introduction (To Principles) 1

J

Job Specification 9

L

Line
 Cabling 25
 Equipment 12
 Lock-Out, See "Alarm"
 Lock-Out Relay Test 29
 Relay 4,5
 Service 15
 Standards 13
 Terminals Available 18
 Linefinder Principals 4
 Link Circuits 13
 Link Test 28
 Local Battery Telephones 25
 Local Calls 19
 Local to Toll 20
 Location, Switchboard 22
 Lock-Out Relay 10,12,29
 Loop Dialing 26,27

M

Magneto Telephones 25
 Main Distributing Frame 24
 Maintenance 30
 Manual Trunks, See "Trunks"
 Manual Trunk Test 30
 Method of Operation 19
 Mounting, Equipment 10

N

Networks 14,27
 Networks, Diagram 15
 Night Number, P.B.X. 25
 Number Assignments 16

O

One- and Two-Ring Harmonic Service 16,17
 100-Line Connector 5
 100-Line Switchboards 11,18
 Operation, Method of 19
 Operator Information 20
 Overflow Meter 18

P

Party Lines 15
 Party Lines, Tests 28
 Paystation
 Calls 15,20
 Line Assignments 25
 Tests 30
 Tone 20
 Permanent
 Checking Circuit 25,30
 Checking Number 21
 Lines 13,18
 Peg Count Meter 18,21
 Peg Count Meter Test 33
 Phantom Circuits 27
 Positioning Switchboard 22
 Principles of Relay Switching 2
 Pulse Compensating Feature 13
 Pulsing Relay 5
 P.B.X. Trunks
 Automatic Selection 7
 Installation 25
 Tests 30

R

Radio Suppression 23
 Range, Operating 13
 Registers, Traffic 18
 Relays
 Guard 4,10
 Rotor 1
 Tens 1
 Timing 18
 Units 2
 Relay Switching 2
 Remote Transfer, Ringing Converter 25
 Repeaters, Trunk 26,27
 Resignaling Operator 26
 Restricted Service 14
 Restricted Service Test 30
 Reverse Battery 25
 Reverting Call 19
 Reverting Call Test 29
 Ring-Cut-Off 16
 Ringing
 Code 15
 Converter 16
 Current Protection 16
 Equipment 16
 Harmonic 16
 Remote Transfer 19,25
 Tests 28
 Rotor Relay 1
 Runways, Cable 24

S

Semi-Selective Code Ringing 15,16
 Semi-Selective Harmonic Ringing 16,17
 Services, Subscribers' Line 15
 Simplex Dialing 26,27

