

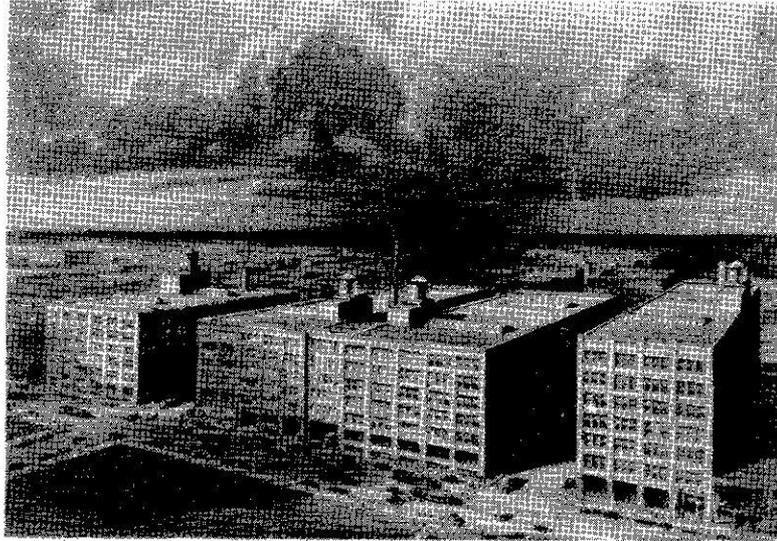
LINE-FINDER SWITCHES

BULLETIN 821

AUTOMATIC  ELECTRIC

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

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Factory and General Offices of Automatic Electric Company, Chicago, U. S. A.

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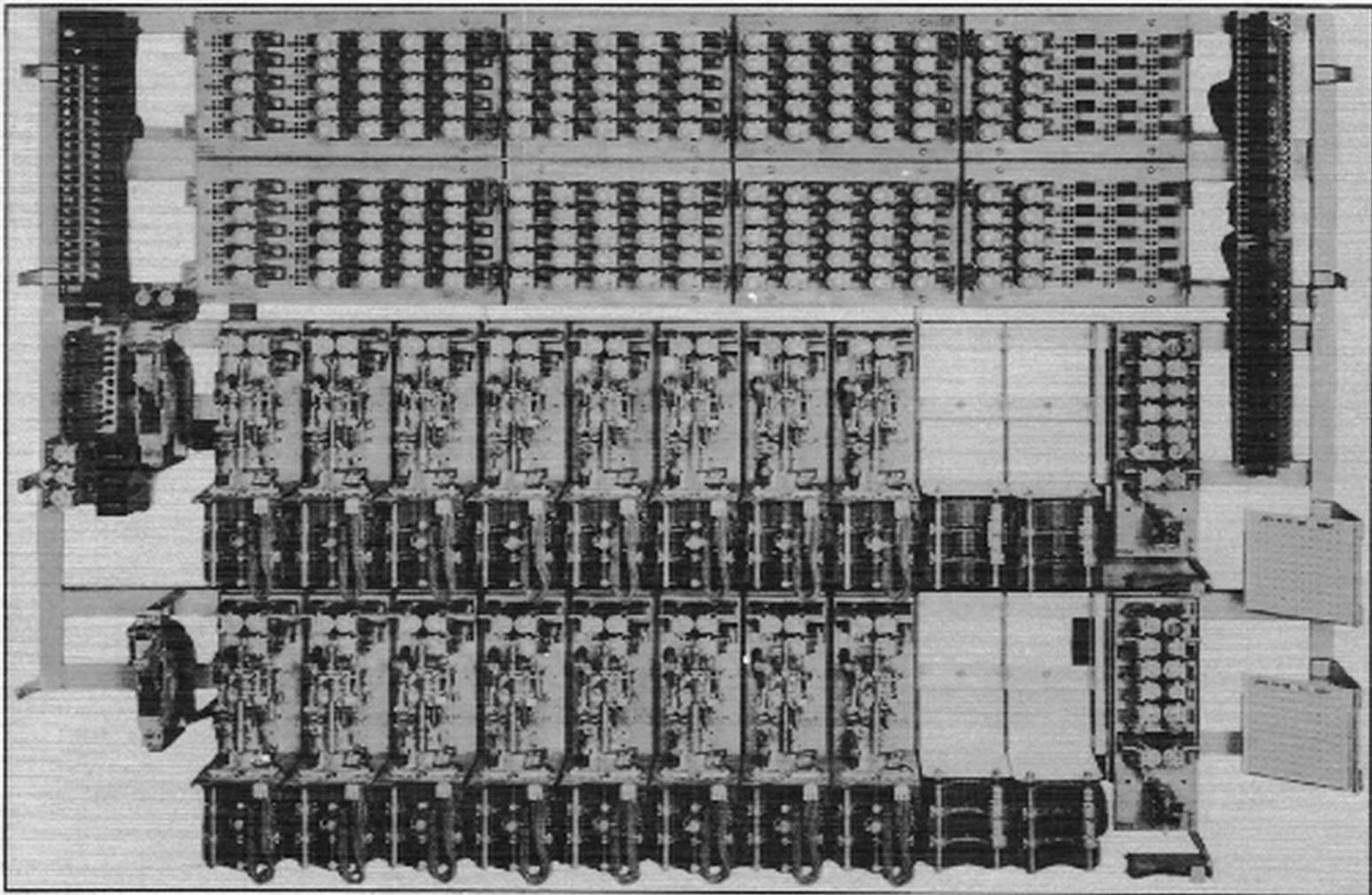
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TYPICAL LINE - FINDER SHELF

Line Equipment At Top -

"A" Finder Group In The Middle, Distributor
At The Left, Group Relays At The Right -

"B" Finder Group At The Bottom -

LINE-FINDER SWITCHES

1. LINE EQUIPMENT

In every type of telephone system there must be an electrical device associated with each line to identify, or mark, the particular line originating a call. In the magneto manual system, this apparatus is a drop; and in the common-battery manual system it is a line and cut-off relay, the former controlling a lamp to attract the operators attention when a call is originated.

2. NON-NUMERICAL SWITCHES

In early Strowger practice, individual connectors were employed for systems of 100 lines or less, and individual selectors for systems over 100 lines. In modern Strowger systems it has been found more economical, both from a viewpoint of initial cost and maintenance, to provide individual line equipment of more simple design and of relatively few functions. This has been made possible by the introduction of a so called "non-numerical" switching device which serves to connect a calling line with an idle selector or connector as the case may be. This non-numerical switching device is termed a "lineswitch" when it is individual to a telephone line and serves "to extend the calling line to an idle selector or connector," (forward selection); and is termed a "line-finder" when it is connected "tail-to-tail" with a selector or connector and serves to "find the calling line," (backward selection).

3. LINESWITCHES

The most simple form of lineswitch is the "Rotary Lineswitch" described in Bulletin #806, it is a single-motion (rotary) "non-numerical" switching device; that is, its operation requires no digit in the call number and no movement of the dial.

A rotary lineswitch is associated with each telephone line and, in operation, is independent of all other lineswitches. This lineswitch automatically connects the associated telephone line, at the time of the initiation of a call, to an idle trunk terminating in a connector (100-line system) or a selector (in a larger system).

Another form of lineswitch is the "Plunger Lineswitch" described in Bulletin #805. This lineswitch is a non-selecting mechanism which

at the time of the initiation of a call, automatically connects the particular line with which it is associated to a pre-selected trunk leading to a connector or selector as the case may be. A number of lineswitches are grouped under the control of a single "Master Switch" and have access to a maximum of ten trunks. It is the function of the common master switch to preselect the next trunk to be used, and to maintain all idle plunger lineswitches "in front of" the preselected trunk.

4. LINE-FINDER SWITCHES, GENERAL

The scheme of backward selection uses a "non-numerical" switching device (termed a "line-finder") which is associated with a trunk, to seek the calling line and connect the trunk to it.

The chief duties devolving upon a line-finder are, to seek out from a group of lines the subscriber's line demanding service, and to connect to it a trunk terminating in the first numerical switch of the switch train. That is, it picks up the calling subscriber's line. The selector (or connector) at the forward end of the connecting link, in response to the dial at the calling station, extends the call in the usual manner employed in establishing Strowger Automatic connections.

A number of line-finders are grouped under the control of a single "distributor" which preselects the next line-finder to be used. This device is sometimes spoken of as an "allotter," or as a distributor which "allots an idle finder to the next succeeding call".

The principal economies realized through the application of the line-finder lie in the simplicity of the equipment directly associated with each subscriber's line. Two relays comprise the equipment which is directly associated with each subscriber's line. They are comparable to those used in common-battery manual systems. With respect to the line-finding operations, the chief duties of the line relays are to "mark" the bank position of the line initiating the call and to cause the allotted finder to hunt the calling line.

Immediately the finder bank is "marked," by the relay equipment associated with the calling line, the allotted idle finder hunts until the calling

LINE-FINDER SWITCHES

line is located, whereupon the finder connects the associated first selector (or a connector in some small installations) to the calling line. When the connection is thus extended, dial tone is transmitted to the calling line.

Simultaneously with the switching through of the calling line to the selector, a cut-off relay associated with the calling line operates to clear the line of attachments, and to disconnect the common start circuit. When the common start circuit is freed, the distributor is caused to allot another idle finder in readiness for the next originating call.

The non-numerical switching device to be used as a line-finder may take various forms, depending upon the size of the system and type of equipment to be used. The operation of a 25-point rotary switch line-finder is described in "Type 32A21 P.A.X.," Bulletin #345; while the operation of a 200-line "all relay" line-finder is described in "Type 36A24 Rotor Relay C.A.X.," Bulletin #672.

5. THE 100-LINE STROWGER LINE-FINDER

In the following discussion it will be assumed that the reader has a working knowledge of the Strowger switch mechanism and bank, such as may be secured by a reading of Bulletin #546.

The Strowger switch, with its ten vertical and ten rotary steps, makes an ideal 100-point finder. Assume a group of 100-lines each having its own individual line equipment together with proper facilities for "marking" (1) the vertical level and (2) the contact within the level; it follows then that the Strowger switch can "find" any calling line within the group by searching over not more than ten vertical steps followed by a search over not more than ten rotary steps.

To complete the picture, let it be further assumed that each of the one hundred line equipments is multiplied thru out the banks of ten Strowger finder-switches; that each finder-switch is tied tail-to-tail with a first selector; and that a single distributor, common to the group of finder-switches, is found to "allot" the next finder to be used.

6. THE 200-LINE STROWGER LINE-FINDER

Let us now visualize a Strowger line-finder switch which retains the customary ten vertical levels but, when rotating, searches over twenty lines; that is, two lines are tested on each of the ten rotary steps. We now have a 200-point finder; and the system will consist of 200-line equipments, 20-finder-selector links and two distributors. Due to traffic reasons explained hereinafter the 20 finders are divided into two groups of 10 finders, designated groups "A" and

"B". Each group is controlled by a distributor.

6.1 Preferential Hunting

Each 200-point finder bank assembly comprises three 200-contact banks and therefore accommodates 200 subscribers' lines, having three conductors each. On the bottom bank are terminated the - and + line conductors of an "odd" hundred lines; on the middle bank are terminated the - and + line conductors of an "even" hundred lines, and the top bank contains the 200 control leads associated with these lines. The lower contacts of each level of the control bank are associated with the line terminated in the lower line bank; and the upper contacts, with the lines terminated in the upper line bank. This arrangement illustrates the actual (or "numerical") grouping of subscribers' lines.

Many students have had difficulty in distinguishing the actual (or "numerical") grouping of the subscribers' lines from the "theoretic" grouping of "appearances" which makes "Preferential Hunting" possible.

For our next consideration let us disregard the actual structure of the finder-switch bank, and visualize merely a Strowger switch which has access to a bank ten levels high with twenty "appearances" in each level.

We will now assume a theoretic "A" group of one hundred "appearances" (Figure 1) and also a theoretic "B" group (Figure 2) of one hundred "appearances," each group being served by a plurality of finder-selector links under the control of an associated distributor.

The one hundred "A" "appearances" occupy the lower five levels in the banks of the "A" group of line-finders, and are normally served by this group. The one hundred "B" "appearances" occupy the lower five levels in the banks of the "B" group of line-finders, and are normally served by this group. Attention is directed to the fact that the levels appear in reverse order, for reasons which later will be apparent.

The one hundred "A" "appearances" also occur in reverse order of levels in the upper five levels of the "B" group of line-finders; while the one hundred "B" "appearances" occur in regular order of levels in the upper five levels of the "A" group of line finders.

Thus it will be seen that the "appearances," although arranged in groups of 200 on the banks of the line-finder, are served in 100 groups under normal traffic conditions, each 100 group having its individual allotment of line finders. However, the 200 grouping is established whenever the traffic in a 100 group becomes abnormal and its allotment of line-finders is momentarily

	B81	B82	B83	B84	B85	B86	B87	B88	B89	B90	B91	B92	B93	B94	B95	B96	B97	B98	B99	B00	
	B61																				B80
	B41																				B60
	B21																				B40
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	
5th level	A81	A82	A83	A84	A85	A86	A87	A88	A89	A90	A91	A92	A93	A94	A95	A96	A97	A98	A99	A00	
	A61																				A80
	A41	Preferred																			A60
	A21	Appearances																			A40
1st level	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	

FIG. 1
THEORETIC APPEARANCES
IN BANK OF
"A" GROUP FINDERS

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	
	A21																				A40
	A41																				A60
	A61																				A80
	A81	A82	A83	A84	A85	A86	A87	A88	A89	A90	A91	A92	A93	A94	A95	A96	A97	A98	A99	A00	
5th level	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	
	B21																				B40
	B41	Preferred																			B60
	B61	Appearances																			B80
1st level	B81	B82	B83	B84	B85	B86	B87	B88	B89	B90	B91	B92	B93	B94	B95	B96	B97	B98	B99	B00	

FIG. 2
THEORETIC APPEARANCES
IN BANK OF
"B" GROUP FINDERS

LINE-FINDER SWITCHES

inadequate. The line-finders of the associated 100 group are then assigned (by means of group distributor equipment) to serve the two 100 groups until the traffic in the overloaded group becomes normal.

The prime advantage of this arrangement of "appearance" grouping is that the conductors of two associated 100 groups are so transposed in the banks of the line-finders that the line-finders of neither group are required normally to hunt in the upper five levels. This results in the establishment of a uniform and satisfactory minimum hunting time, reduces the probability of lines in the lower levels "stealing" a line finder from lines in the upper levels to a negligible factor in case of simultaneous calls, and insures that service to the group will continue even though one distributor should fail.

We will now return to a consideration of the actual (or "numerical") grouping of the lines in the finder banks.

Referring to Figure 3, it will be observed that the numbering scheme actually employed in the finder banks of group "A" follows standard Strowger practice; i.e., "one step up, and one step in" gives access to line 111, or line 211, depending upon which hundred is wanted, and likewise "ten steps up and ten steps in" gives access to line 100 or line 200. The banks of the "A" group of line-finders are multiplied straight; that is, the contacts of one bank are connected to contacts which occupy the same relative position in the next corresponding bank.

The banks of the "B" group of line-finders are also multiplied straight, but it is to be noted that a vertical level reversal is made in the bank multiple between the two groups; thus "one step up, and one step in" gives access to line 101, or line 201, depending upon which hundred is wanted, and likewise "ten steps up, and ten steps in" gives access to line 110 or line 210.

The C leads of lines in the odd hundred group appear on the lower contacts of the control banks, and the C leads of the even hundred lines appear on the upper contacts. The C leads also undergo a level reversal between finder groups (although those of the odd hundred lines remain on the lower contacts and those of the even hundred remain on the upper contacts).

It now becomes apparent that the "A" grouping and "B" grouping of "appearances" does not correspond with the actual (or "numerical") grouping; i.e., the 100 line group, and the 200 line group. In a previous paragraph it was said that the "A" group of finders normally served the 100 "appearances" occupying the lower five levels in its banks; from a study of Figure 3 it will be apparent that the "A" group of "appearances" comprises fifty lines of the 100 numerical group (111-110, 121-120, 131-130, 141-140, and 151-150) and fifty lines of the 200 numerical group (211-210, 221-220, 231-230, 241-240, and 251-250).

The "B" group of "appearances" will be found to comprise fifty lines of the 100 numerical group (101-100, 191-190, 181-180, 171-170 and 161-160) and fifty lines of the 200 numerical group (201-200, 291-290, 281-280, 271-270, and 261-260).

LINE-FINDER SWITCHES

GROUP "A" LINE FINDER BANKS											GROUP "B" LINE FINDER BANKS												
PREFERRED 100 CONTROL LEADS OF GRP. "A"	10th Lev.	201	202	203	204	205	206	207	208	209	200	CONTROL BANKS	211	212	213	214	215	216	217	218	219	210	10th Lev.
		101	102	103	104	105	106	107	108	109	100			111	112	113	114	115	116	117	118	119	110
		291											290		221								220
		191											190		121								120
		281											280		231								230
		181											180		131								130
		271											270		241								240
		171											170		141								140
		261											260		251								250
		161											160		151								150
	251										250		261								260		
5th Lev.	151										150		161								160		
	241										240		271								270		
	141										140		171								170		
	231										230		281								280		
	131										130		181								180		
	221										220		291								290		
	121										120		191								190		
1st Lev.	211	212	213	214	215	216	217	218	219	210		201	202	203	204	205	206	207	208	209	200		
	111	112	113	114	115	116	117	118	119	110		101	102	103	104	105	106	107	108	109	100		
50 OF THE PREFERRED 100 LINES OF GRP. "A"		201	202	203	204	205	206	207	208	209	200	LINE BANKS OF 2ND HUNDRED	211	212	213	214	215	216	217	218	219	210	50 OF THE PREFERRED 100 LINES OF GRP. "B"
		291									290			221								220	
		281									280			231								230	
		271									270			241								240	
		261									260			251								250	
	5th Lev.	251									250			261								260	
		241									240			271								270	
		231									230			281								280	
		221									220			291								290	
	1st Lev.	211	212	213	214	215	216	217	218	219	210			201	202	203	204	205	206	207	208	209	
50 OF THE PREFERRED 100 LINES OF GRP. "A"		101	102	103	104	105	106	107	108	109	100	LINE BANKS OF 1ST HUNDRED	111	112	113	114	115	116	117	118	119	110	50 OF THE PREFERRED 100 LINES OF GRP. "B"
		191									190			121								120	
		181									180			131								130	
		171									170			141								140	
		161									160			151								150	
	5th Lev.	151									150			161								160	
		141									140			171								170	
		131									130			181								180	
		121									120			191								190	
	1st Lev.	111	112	113	114	115	116	117	118	119	110			101	102	103	104	105	106	107	108	109	

FIG. 3 ACTUAL LINE GROUPING IN FINDER BANK

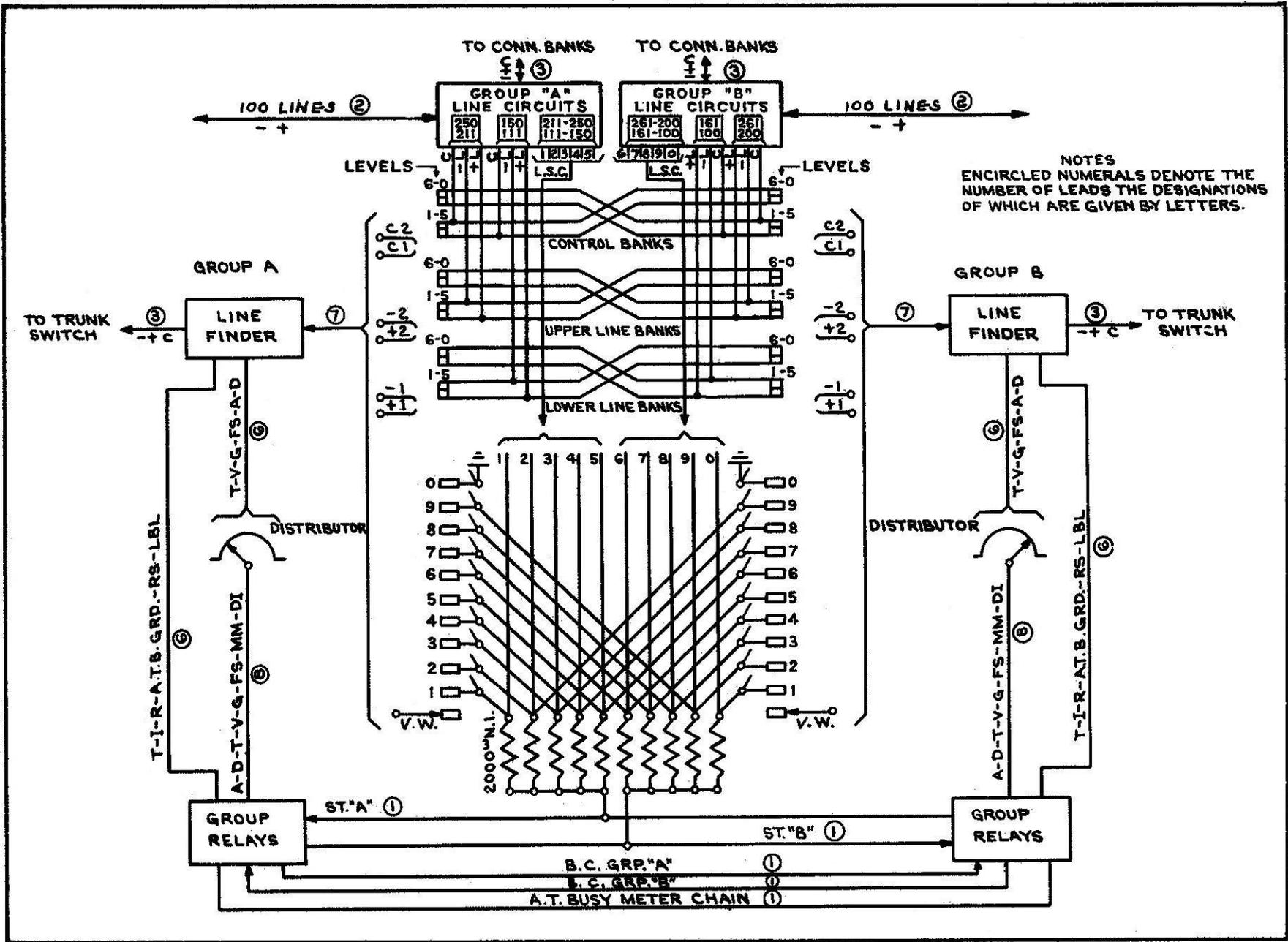


FIG. 4 KEY DIAGRAM OF THE 200-LINE FINDER UNIT

6.2 Fundamental Principle

The fundamental principle of the 200-line finder is illustrated in Figure 4. "A" and "B" groups of finders are shown, with the numerical groups of lines (odd and even hundreds) divided into the "A" and "B" groups preferentially served by the two finder groups. Each line and each C lead shown represents fifty such leads, and each bank level shown represents five bank levels.

Thus, in Group "A", lines 111-150 appear on the lower five levels of the lower line bank, and lines 211-250 appear on the lower five levels of the upper line bank. In Group "B," lines 161-200 appear on the lower five levels of the lower line bank, and lines 261-200 appear on the lower five levels of the upper line bank (with 101-100 and 201-200 on the first levels). Because of level reversal between finder groups, each such set of lines in one finder group appears (in reverse order) in the other finder group on the upper five levels of banks for lines of the same hundred. Appearances of C leads are similar and are likewise reversed.

Thus, all 200 lines and C leads appear in the banks of each finder group. Normally, each group hunts thru only five levels, but if all finders in one group are busy, those of the other group will hunt thru all ten levels.

Two relays comprise the equipment which is directly associated with each subscriber's line. They are comparable to those used in common-battery manual systems. With respect to the line-finding operations, the chief duties of the line relays are to "mark" the bank position of the line initiating the call, to cause the allotted finder to hunt the calling line.

For economy, each group of finders is operated under control of relays common to the group. This is possible because the finders of each group operate one at a time.

Likewise associated with each line-finder group is a distributor which assigns the primary trunks successively to the originating calls. This distributor acts as a preselector, by allotting, after a call is picked up, an idle finder to the next succeeding call.

Immediately the finder banks are "marked," by the relay equipment associated with the calling line, a relay of the common relay group causes the allotted idle finder to hunt first vertically, and then horizontally until the calling line is located, whereupon the finder connects the associated first selector (or a connector in some small installations) to the calling line. When this switch is seized, dial tone is transmitted to the calling line.

Simultaneously with the switching through of the calling line to the trunk, a cut-off relay associated with the calling line operates to clear the line of attachments, and to disconnect the common start circuit. When the common relay group is freed, the distributor is caused to allot another idle finder of the group in readiness for the next originating call.

The rotary position of the calling line is marked by the line relay's placing 1200 ω battery on the individual C lead and its contact in the control banks. The level where the calling line appears is marked by the line relay's placing ground on the "level start common" lead (L. S. C.) connected directly to the proper vertical bank contact. (Vertical bank contacts are multiplied straight from switch to switch within a group and undergo level reversal between groups.) Thus all 20 lines on a given level of both lower and upper line banks mark the same level in the banks, over the same L. S. C. lead.

For example, any of the 20 lines 121-120 and 221-220 can, over L. S. C. 2, mark Level 2 in the "A" group of finders and Level 9 in the "B" group. As all one hundred lines (111-150 and 211-250) must be able to start a Group "A" finder, L. S. C. leads 1-5, after passing thru 2000 ω resistors, are commoned to form Start Lead "A." Similarly, the one hundred lines in Group "B" place direct ground on one of the five L. S. C. leads 6-0, and these five leads likewise pass thru 2000 ω resistors and are commoned to form Start Lead "B," for the "B" group of finders.

Direct ground on the vertical banks is required to stop vertical hunting, while the high-resistance ground on Start Lead "A" or "B" is sufficient to start a finder. (The high-resistance ground placed by branch circuits on other vertical bank contacts will not stop vertical hunting.

6.3 Mechanical Arrangement

In the foregoing discussion of fundamental principles, the components of the 200-line finder were introduced; namely the "line relays," the "line-finders," the group "distributor," and the "group relays." These four components operate in conjunction with each other, without action on the part of the calling subscriber other than the removal of the receiver from the hook-switch. Each component has certain definite functions to perform in the operation of the system as a whole. A brief description of their mechanical arrangement should be of material assistance in understanding the functions devolving on each of them.

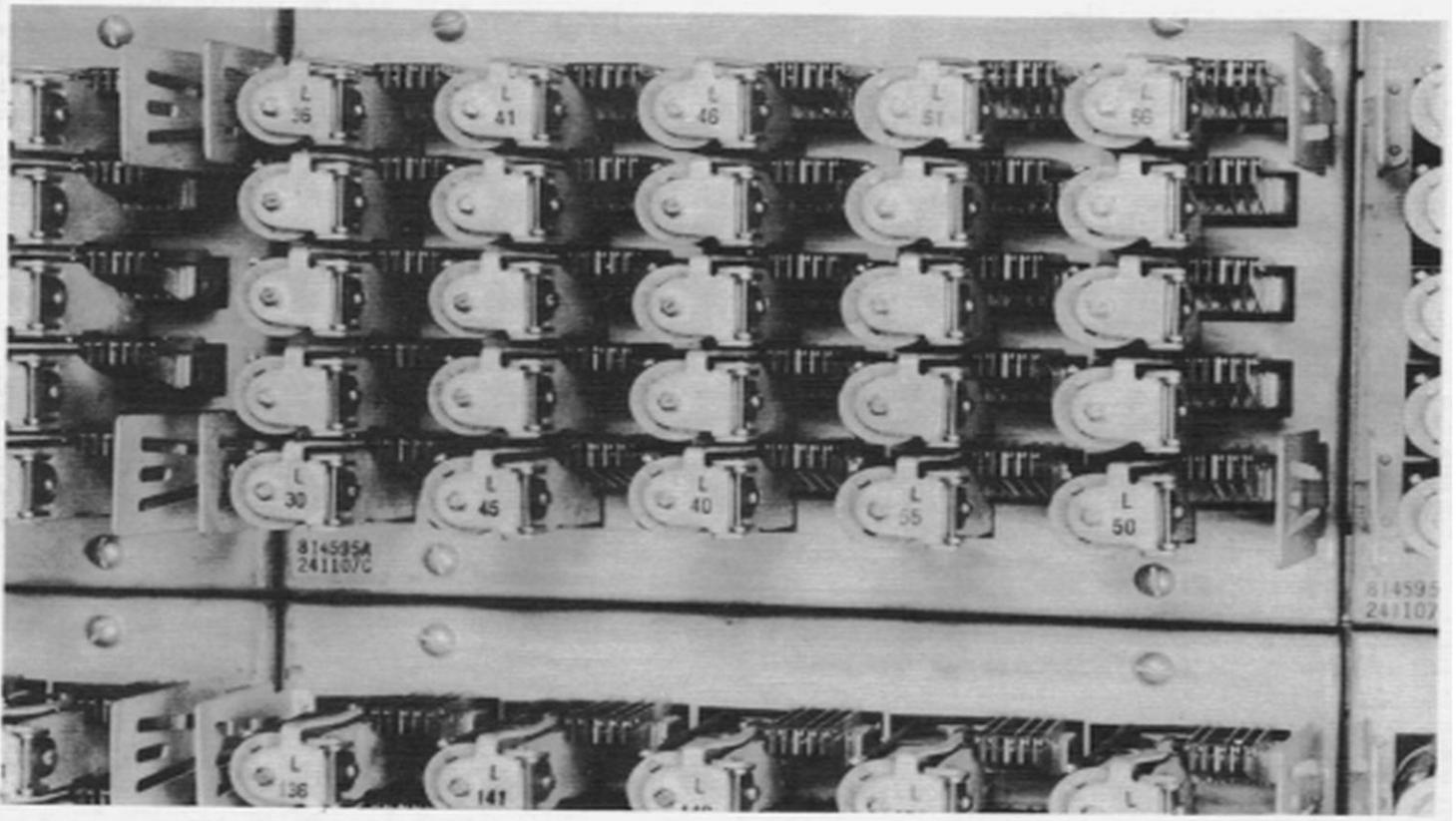


Fig. 5. Combined "Line" and "Cut-off" Relays.

6.31 Line Relays

Associated with each line are a "line" and a "cut-off" relay. Figure 5 shows combined line and cut-off relays (three-winding relays that perform the functions of the more usual two relays). When message rate service is rendered, a message register, or meter, is associated with lines requiring this service.

6.32 Line-Finder

The line-finder proper is a two-motion Strowger switch, quite similar in appearance to the more familiar selector commonly employed in Strowger systems. A view of a typical 200-line finder is shown in Figure 6. It comprises a group of relays mounted on a base upon which also is mounted a frame supporting a shaft and a ratchet mechanism for raising and rotating the shaft. Affixed to the lower end of the shaft are four sets of wipers (one single-conductor and three two-conductor), termed the "vertical," "lower line," "upper line," and "control" wipers.

The vertical and rotary stepping magnets, and the magnet which releases the ratchet mechanism and permits the shaft to return to normal when the connection is released, are mounted within the switch frame.

The line-finder is a non-numerical switch; that is, both its vertical and rotary (stepping) motions are automatic. The number of vertical steps the shaft and wiper rise, depends on the "marking" of the vertical bank, or commutator. The number of rotary steps the shaft takes to the right, depends on the position of the marked control bank contact in that level.

A vertical interrupter circuit causes the vertical magnet (through its armature and pawl engaging a ratchet known as the "vertical hub") to elevate the shaft step-by-step to the "marked" level. Immediately the vertical stepping is completed, a rotary interrupter circuit causes the rotary magnet to rotate the shaft automatically until the marked control bank contact is engaged by the wipers. The automatic rotary motion is transmitted to the shaft by means of the rotary-armature pawl engaging a ratchet known as the "rotary hub."

These motions cause the three sets of two-conductor wipers to engage contacts of a semi-cylindrical bank. Referring to Figure 6, it will be observed that the bank contacts are arranged in three groups; the uppermost of the three is termed the "control bank"; the middle bank, the "upper line bank"; and the lower one, the "lower line bank." The multiple arrangement of these banks was described in Section 6.1.

To the right of the semi-cylindrical banks is the vertical bank, or commutator, comprising a single row of contacts. This vertical bank, and the associated wiper, enables the finder to locate the level of the line initiating a call, without the necessity of testing the individual bank contacts of the lower levels. The upper ten vertical bank contacts correspond to the ten levels of the semi-cylindrical banks, and the bottom contact is a normal position for the wiper. While the shaft is being stepped vertically, the vertical wiper engages the commutator bank contacts. At the first rotary step, the vertical wiper disengages from the bank.

The release of the shaft is accomplished by means of a release magnet which, when energized, operates the "release" armature. This armature

striking a projection of the double-dog, disengages both the vertical dog and the rotary dog from their ratchets. This permits the restoring spring to return the shaft in a counterclockwise direction to disengage the wipers from the bank contacts. The shaft hub is then freed from the stationary dog, whereupon the shaft drops to normal.

6.33 Group Relays

Each group of line-finders has a set of "group relays" associated with it. It comprises a number of control relays mounted on a baseplate equipped with a multi-contact jack.

These relays control the actions of the finders, and cause the distributor to operate and allot the next idle finder after a call has been picked up by the finder previously allotted. They also cause an alarm to be given in case of faulty operation.

6.34 Distributor

The distributor may be considered an adjunct to the group relays, since it connects these relays successively to the finders of the group. As previously mentioned, an idle finder is pre-allotted by the group distributor.

The distributor is a rotary switch mechanism employing a semi-cylindrical bank which has six levels of twenty-five contacts each. A pair of double-ended wipers rotates over each level of contacts. The wipers are engaged with the bank at all times; that is, when one end of the wipers is leaving position twenty-five, the other end is approaching position one. By rotating through a half circle, the wipers successively step over all twenty-five sets of contacts.

The driving mechanism comprises a ratchet wheel, mounted on the wiper shaft, which is engaged by a pawl pivoted to the armature of a motor magnet. When the motor magnet is energized, the pawl is withdrawn from the ratchet wheel so that it can engage the next tooth when the motor magnet is de-energized. A retractile spring, tensioned against the motor-magnet armature, causes the pawl to engage the ratchet tooth and step the wipers to the next position as the motor magnet releases.

6.4 Functions

The major functions of the various elements of 200-line finder are outlined in the order in which they occur. Some of these functions, however, will involve several elements.

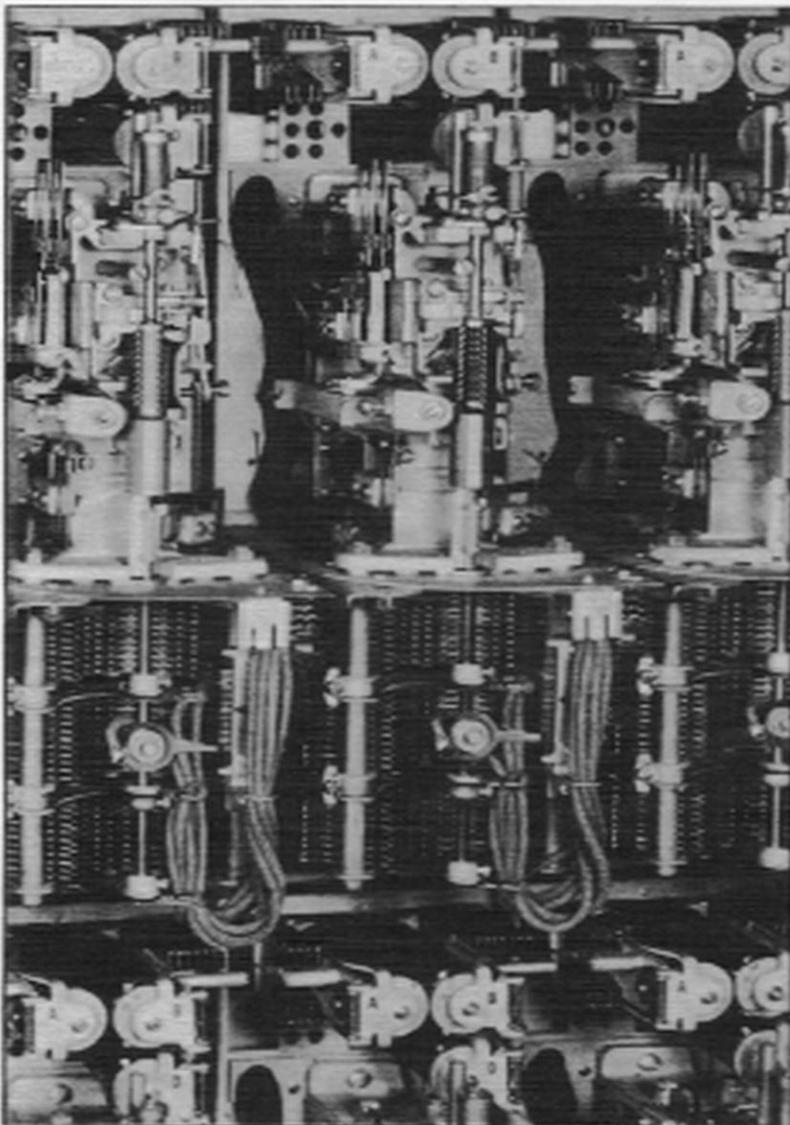


FIG. 6.
TYPICAL 200- LINE FINDER SWITCH

LINE-FINDER SWITCHES

6.41 Line Relays

6.411 Outgoing Calls

On outgoing calls the functions of the line relays are:

- (a) To mark the level in the commutator banks.
- (b) To mark the line in the control banks.
- (c) To cause the group relays to operate the allotted finder.
- (d) To free the line of attachments when the finder seizes it.

6.412 Incoming Calls

The only function of the line relays on incoming calls is:

- (a) To free the line of attachments.

6.42 Line-finder

- (a) To elevate the wipers to the marked level.
- (b) To rotate the wipers onto the terminals of the calling line.
- (c) To determine which of two lines is demanding service.
- (d) To connect the associated trunk to the calling line.
- (e) To cause the cut-off relay of the calling line to operate and clear the line of attachments.
- (f) To busy the calling line at the connector bank.
- (g) To advance the group distributor.
- (h) To release at the termination of the call.

6.43 Group Relays

- (a) To seize the allotted finder at the initiation of a call.
- (b) To provide a pulsing circuit for the vertical magnet of the finder.
- (c) To stop vertical stepping of the finder when the vertical wiper engages the marked commutator contact corresponding to the level in which the calling line appears.
- (d) To provide a pulsing circuit for the rotary magnet of the finder.

- (e) To cause the distributor to disengage from the finder when the calling line is seized.
- (f) To advance the distributor to the next idle finder.
- (g) To transfer the start lead to the adjacent group of finders in case of faulty operation.
- (h) To signal an attendant if an associated finder fails to release.

6.44 Distributor

- (a) To connect the group relays to any one of the finders of the group.
- (b) To disengage from the allotted line-finder when the calling line is seized, and allot the next idle finder of the group.

7. CIRCUIT OPERATION OF THE 200-LINE STROWGER LINE-FINDER

Illustration "A", which is inserted at the rear of this bulletin, shows in schematic form, a typical circuit of the 200-line-finder unit. The circuits of the line relays, line-finder, group relays, and distributor are shown in duplicate. This is done in order that the circuit connections between the groups, and to the common signalling equipment may be more readily traced. However, it is to be understood that the circuit operations for the components of group "B" are identical to those of group "A". In the circuit description, however, only one circuit group generally need be considered.

The line equipment in a finder system usually consists of two relays, a "line" and a "cut-off" relay. Under certain circumstances a single relay circuit is used, the one relay combining both the line and cut off functions. (See Fig. 5). Under still other circumstances a three relay circuit may be used, the relays being "line," "cut-off" and "lock out." (See Fig. 7). The following description covers a three relay circuit because, if the reader understands the more complicated circuit, the operation of the other two will be self evident.

8. DETAILED DESCRIPTION

8.1 General

The finders in this system are divided into two groups, each having distributor and group relays.

Normally the group relays and distributor of each group allot the finders of their associated group to handle the calls of that group. However, in case trouble occurs in the group or all the finders are busy in that group, the associated

group relays will transfer the call or calls to the other group.

In Illustration "A," the lines, C leads and bank levels are symbolized as in Figure 4 (see Sec. 6.2 for explanation). Only one line equipment is seen in each group, but all lines have identical equipment. This circuit also shows (as Figure 4 does not) how leads from twenty line relays are multiplied to make one L. S. C. lead.

In the following explanation, group "A" will be considered entirely, the operation of group "B" being exactly the same. Note that the line finder is designated "Line Finder (Fig. 5)"; the distributor as "Distributor (Fig. 4)"; and the group relays as "Group Relays (Fig. 3)." In the following explanation "Relay B5" will refer to the line finder relay while "Relay B3" will refer to the group relay bearing that letter.

8.2 Seizure

When the calling subscriber closes the loop, relay L is energized and makes the line busy for incoming calls; prepares the stopping circuit for the finder; grounds the start lead; and marks the vertical bank contact corresponding to the level to which the calling line is connected.

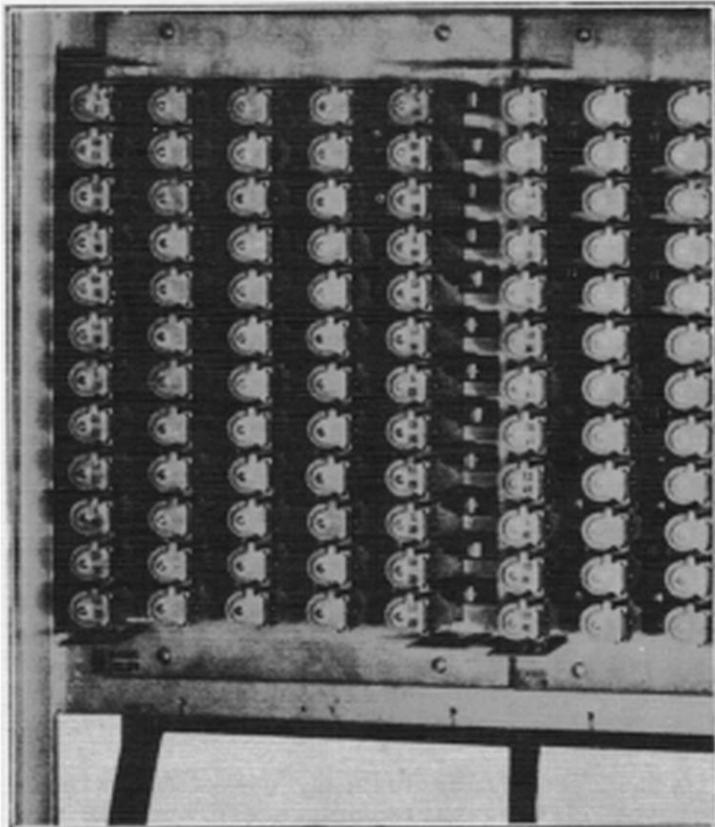


FIG. 7.
"Line", "Cut-off" and "Lock-out" Relays.

8.3 Start

Relay C3 operates; closes circuit to P3 in series with motor magnet; and grounds ST. SIG. lead thru lamp.

Relay P3 operates (but not the motor magnet); grounds the F. ST. lead; prepares its locking circuit; connects the guard lead to the motor magnet; prepares the circuit to the finder VERT lead; prepares the circuit to the TEST-1 lead; closes circuit to B3; and maintains N3 operated.

Relay B3 operates and closes circuit to H3 (S.O.).

H3 operates and locks; provides locking ground for P3; places ground on the Grd. 5-"A" lead; closes #1 winding of F3 and energizes the 500w biasing windings of J3 and K3 in series. (J3 and K3 do not operate but will do so very rapidly when the other winding is energized.)

Relay F3 operates and locks to the F. ST. lead; provides multiple ground to P3; opens the circuit to B3; and connects ground to #1 windings of J3 and K3.

Relay B3 releases, but its weighted armature intermittently energizes H3 for a period, thus preventing the release of slow-release H3.

Relay B5 operates from ground on F. ST. lead; closes the circuit to the VERT. MAGNET; prepares a circuit to the ROT. MAGNET; places ground on the C lead; removes ground from the A.T.B. GRD. lead; closes TEST-2 lead; and places 500w across the "+" and "-" lines to seize the associated selector, which returns ground on the C lead.

8.4 Vertical Movement

The VERT. MAGNET operates; elevates shaft; closes its interrupter springs. The shaft movement releases the VON springs (which are operated when the switch is at normal).

Relay A3 follows the INT pulses, and, when operated, breaks the circuit to the vertical magnet. This action continues until the vertical wipers reach the level marked by ground. On this level, after INT springs open, D3 operates its "X" contacts, due to ground on the vertical wiper, TEST-1 lead, #1 winding of D3 to A3. A3 is held operated and therefore the circuit to the vertical magnet remains open.

Relay D3 operates fully thru its #2 winding; transfers the circuit from VERT to ROT lead; opens the initial circuit of P3; connects TEST-1 lead to #1 winding of K3; opens its #1 winding, thus opening the circuit to A3.

Relay A3 releases; extends ground to the rotary magnet.

8.5 Rotary Movement

The rotary magnet operates and closes its interrupter contacts.

Relay A3 operates from the ground on INT lead and breaks the circuit to ROT magnet. This action continues until one of the C wipers find the contact marked by 1200w battery.

When the wipers reach the contacts to which the subscriber's line is connected, the C2 or C1 wiper, depending upon whether the subscriber's line appears in the upper or lower bank, encounters battery thru C0 which closes the circuit to the #1 winding of K3 or J3, respectively, producing a field which is in the same direction as the field already produced by the #2 winding of the same relay.

If the subscriber's line is on the upper bank, K3 operates; opens the rotary magnet circuit; and closes the circuit to relay A of the finder.

Relay A5 operates; connects the -, + and C trunks to the upper bank; connects its winding to the C trunk; places ground on the GUARD lead to make the finder busy; opens the circuit to the winding of D; opens the incomplete release circuit; and opens the rotary circuit.

If the subscriber's line is on the lower bank, J3 operates; opens the rotary magnet circuit; and closes the circuit to relay D of the finder.

Relay D5 operates; connects the -, + and C trunks to the lower bank; connects its winding to the C trunk; places ground on the GUARD lead to make the finder busy; opens the circuit to the winding of A; opens the incomplete release circuit; and opens the rotary circuit.

In case both C1 and C2 contacts of the same rotary position have battery connected, both J3 and K3 relays will operate, but the K3 relay, in operating, will open the circuit to relay D, and thus the upper bank contacts will have preference in switching.

The circuit to the A and D relays is taken thru the interrupter relay springs. This arrangement prevents the switch-thru operation taking place until such time as the rotary magnet in the finder has restored.

Relay C0 of the line circuit operates; provides a locking circuit through its "X" springs; removes L and ground from the line; and closes the circuit to L0 (described in Sec. 12). After the operating ground is removed by the group relays, C0 is held operated over the C lead by ground from a succeeding switch.

Should the C-2 or C-1 wiper pass over a contact on which positive booster-battery is present (for operating a meter associated with that line and contact) the #1 winding of K3 or J3 would be energized, were it not for the fact that the rectifiers in series with these relays offer high resistance to current in such direction.

8.6 Distributor Selects Next Idle Finder

Ground on the GUARD lead closes the circuit to the distributor motor magnet over the MM lead and short circuits P-3. The distributor motor magnet operates; opens the circuit to P-3; and prepares to step the wipers of the distributor one step.

Relay L of the line circuit restores and removes ground from the start lead.

Relay C3 restores if no other call has been originated in the group; opens part of the starting circuit to P-3; and removes ground from the ST. SIG. lead.

Relay P-3 restores; removes ground from the F. ST. lead; removes ground from winding #2 of F-3; transfers the GUARD lead to the MOT. MAGNET interrupter springs; opens the circuit to the MOT. MAGNET; opens its locking circuit; removes the switching ground; removes ground from H-3 through the vibrating armature springs of B-3; and removes ground from #2 winding of D-3.

Relay D-3 restores; prepares the circuit for P-3; and prepares the VERT. pulsing and TEST-1 circuits.

Relay H-3 restores; opens #1 winding of F-3; opens the biasing circuit of relays K-3 and J-3; prepares an incomplete circuit for E-3; and removes ground from the Grd. 5-"A" lead.

Relay F-3 restores; places ground on the starting circuit of P-3; prepares the starting circuit of B-3; and removes ground from #1 windings of J-3 and K-3.

Relay B5 restores; opens the 500w shunt across the line; places multiple ground on the GUARD lead; and opens the VERT. ROT. TEST-2 leads.

The distributor motor magnet restores; advances the wipers of the distributor to the contacts associated with the next finder; extends the GUARD lead to the distributor motor magnet; and prepares the starting circuit to P-3.

If the next finder is busy, one of the wipers of the distributor encounters ground on the GUARD lead upon being advanced to the contacts associated with the next finder. Ground on the

GUARD lead closes the circuit over the DI lead, through the distributor interrupter spring, to the distributor motor magnet, also short circuiting the winding of P-3 to prevent its operation should C-3 operate due to another call being made before the distributor has found a free finder.

The distributor motor magnet operates; prepares to advance the wipers of the distributor to the next finder; and opens its own circuit. The distributor motor magnet restores and advances the wipers to the succeeding finder. If this finder is also busy, the circuit will again be closed to the distributing motor magnet and the above sequence followed.

When the idle finder is found by the distributor, the circuit is no longer closed to the distributor motor magnet and there is an absence of ground on the winding of P-3 thus allowing it to reoperate if there is another call.

Should there be more than one subscriber's line relay holding ground on the START lead, C-3 will remain operated and the sequence when one of the lines is found is the same as above.

8.7 Releasing

Upon completion of the call, ground is removed from the C lead by a succeeding switch, whereupon --

Relay A5 or D5 restores; completes the circuit of the RLS magnet; and opens the -, + and 0 trunks.

Relay C0 of the line circuit restores and re-connects L across the line.

The CN lead of the line circuit becomes un-guarded and ready to receive incoming calls.

The release magnet operates in series with G-3.

Relay L0 restores.

Relay G-3 operates; lights the RLS lamp and gives alarm if the switch does not restore after a certain interval, grounds the P C METER lead, causing the operation of a meter (if used) which records the total number of calls handled by the associated group of finders.

When the shaft and wipers of the finder return to normal, the VON springs operate; open the circuit to the RLS magnet; remove ground from the GUARD lead, making this finder free to the associated distributor and group relays; connect a multiple ground to the ATB GRD lead; and connect the C lead to the GUARD lead. The RLS magnet restores. G-3 restores and removes ground from the RLS LAMP and P C METER leads.

9. GROUP RELAY CHANGE OVER

9.1 Failure in Vertical or Rotary Stepping

In case a call is originated and the finder fails to reach its destination the call will be transferred to the partner group.

Relay H-3 has been held operated by the vibrating contacts of B-3. Since the amplitude of this vibration is gradually decreasing, H-3 will finally release.

Relay H-3, upon restoring, closes #1 winding of E-3; opens #2 winding of D-3 (if operated); opens the #1 winding of F-3 and the biasing windings of J-3 and K-3; removes a multiple ground from P-3; and removes ground from the Grd. 5-"A" lead.

Relay D-3 releases (if operated).

Relay E-3 operates; closes its locking circuit to the ATB GRD lead of the partner group; removes the ATB GRD lead from N-3; removes N-3 relay from the partner group; short circuits P-3; and grounds the MOT. MAGNET.

Relay P-3 restores; opens the circuit to relay B-5; opens the circuit to #2 winding of F-3; opens the circuit to N-3; opens the circuit to #1 winding of E-3; and transfers the GUARD lead to the MOT MAGNET interrupter springs.

Relay F-3 restores and prepares ground for P-3.

Relay N-3 restores; opens the circuit of C-3; opens the circuit of the MOT MAGNET; closes the ATB chain; transfers the start circuit to the partner group; and opens the circuit of the Grd. 5-"B" level, removing ground from this lead to allow a group "B" finder to search above level 5 for a line in the "A" group.

Relay C-3 restores; opens the start circuit of P-3; and removes ground from the ST. SIG. lead.

Relay B-5 restores; the RLS magnet operates and releases the finder; the MOT MAGNET steps on and opens its interrupter springs. Locking the F-3 relay under control of the P-3 relay insures that the proper length of kick-off pulse is sent to the MOT MAGNET.

Relay E-3 is held operated until all finders are busy in the other group or until the other group transfers as explained above or until manually released by momentarily operating the busy key of either group. In case all trunks are busy in the other group, E-3 will release after H-3 is opened and N-3 on re-operating transfers the call to the next finder in the same group. N-3 on restoring transfers the start circuit.

LINE-FINDER SWITCHES

9.2 The Finder Fails to Find the Subscriber's Line

During the rotary searching of the finder, should the finder fail to encounter battery through the subscriber's bridge cut-off relay on the C-1 and C-2 wiper, the shaft and wipers would be rotated to the eleventh position. When the wipers reach the eleventh rotary position, the CAM SPRINGS operate and place ground on the GUARD lead, closing the circuit to the distributor motor magnet, which in turn advances the distributor wipers to the contact of the next finder. P-3 releases, its circuit being opened by the MOT MAGNET interrupter springs.

During the vertical searching of the finder, should the finder fail to find ground on the level on which the calling line appears, it will raise its shaft and wipers to the fifth level. Since this level is grounded from a make contact of H-3 through the contacts of N-3 of Group "B", the finder will cut in on this level, rotate to the eleventh rotary position, and release, as described in the paragraph above.

9.3 All Finders Busy in a Group

When all the finders in a group are busy, ground is removed from the ATB GRD lead of that group when P-3 restores after the last free finder in the group has completed its operation. N-3 restores; transfers the start circuit from C-3 of that group to the corresponding relay in the other group; opens the circuit to P-3; closes the ATB CHAIN lead within that group; and opens the circuit of the Grd. 5-"B" to level 5 of the vertical banks of the Group "B" finders. (The operation of the other group from here on is the same as explained above.)

10. TESTING

To test the group of finders controlled by this circuit a connection is made between springs #1 and #2 of the test jack. Ground on test spring #2 is thereby extended to the start circuit. As explained, this circuit finds an idle finder and causes it to search over the vertical bank. When the shaft and wipers of the finder reach the fifth vertical contact (unless the finder wipers have encountered a line making a legitimate call while searching over the vertical bank), ground ordinarily connected to this contact causes the finder to rotate the shaft and wipers over the contacts of the fifth level. Under control of its CAM SPRINGS (unless the finder wipers encounter a line making a legitimate call while searching over the fifth level), the finder releases after searching over the level and causes the distributor to connect this circuit to the next idle finder. The next idle finder is likewise caused to search over its

fifth level and release. This action continues as long as the springs #1 and #2 of the test jack are connected. A finder coming up on a legitimate call will search for that call and when it has completed its operation, the distributor will start the next idle finder which will follow the above sequence.

Springs #3 and #4 of the test jack are connected to a test line and when a short is placed across these springs, the finder which has been allotted by the distributor will seize this line, and the distributor will step to the next idle finder. Removing the short between springs #3 and #4 allows the finder to release.

Each finder is provided with a BANK test jack which permits determining whether an operated finder is connected to a line in its upper bank, or its lower bank. If the lower bank is in use, D is operated, and short circuiting the BANK test jack grounds the LEL lead, to light a LOWER BANK lamp associated with the alarm lamps. If the upper bank is in use, D is normal, and short-circuiting the BANK test jack does not light the LOWER BANK lamp.

11. CALLS TO THE SUBSCRIBER'S LINE

When a call is made to the subscriber's line, the connector associated with the dialing line tests the dialed line over the CN lead.

If the dialed line is busy, ground on the C lead from the succeeding switch in the train causes the connector to give the dialing-party busy tone.

If the dialed line is free, ground through a winding of the "cut thru" relay of the connector over the CN lead, closes the circuit to the winding of CO.

Relay CO operates; places ground on the C contact in the finder banks to make the dialed line busy; clears the line of attachments, preparing the circuit for ringing the dialed station.

12. LOCKING OUT A "PERMANENT" LINE

The line lockout feature is a means of locking out a line when a "permanent" occurs on the line. It also provides means to permit the release of the switch train on a reverting call and supply transmission battery to the calling and called party. This feature can only be provided if the entire exchange is equipped with the line lockout relays. The operation in both cases will be the same.

When a call is made or if a permanent occurs on the line, relays L and CO will operate as explained previously. Relay LO operates when CO

NOTE:
 FINDER GROUP "A" NORMALLY SERVES LINES 111-150 & 211-250
 FINDER GROUP "B" NORMALLY SERVES LINES 161-100 & 261-200
 EITHER FINDER GROUP SERVES ALL 200 LINES IF ALL FINDERS
 IN OTHER GROUP ARE BUSY.

NOTES:
 "A" - CONTACTS "X" OPERATE FIRST.
 "B" - L.S.C. 1 COMMON TO LINES 111-110 & 211-210

L.S.C. 2	"	"	121-120 & 221-220
L.S.C. 3	"	"	131-130 & 231-230
L.S.C. 4	"	"	141-140 & 241-240
L.S.C. 5	"	"	151-150 & 251-250
L.S.C. 6	"	"	161-160 & 261-260
L.S.C. 7	"	"	171-170 & 271-270
L.S.C. 8	"	"	181-180 & 281-280
L.S.C. 9	"	"	191-190 & 291-290
L.S.C. 0	"	"	101-100 & 201-200

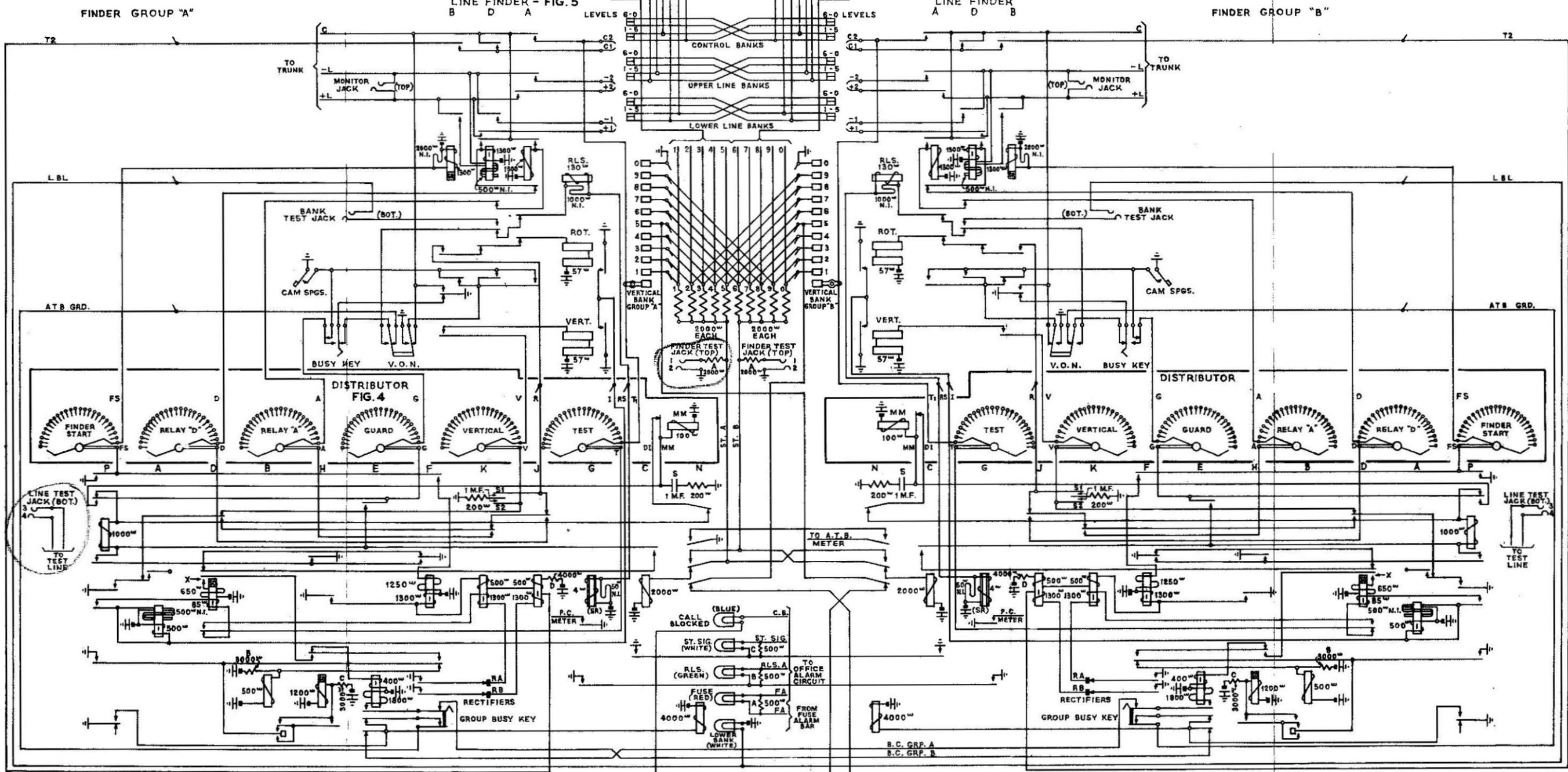
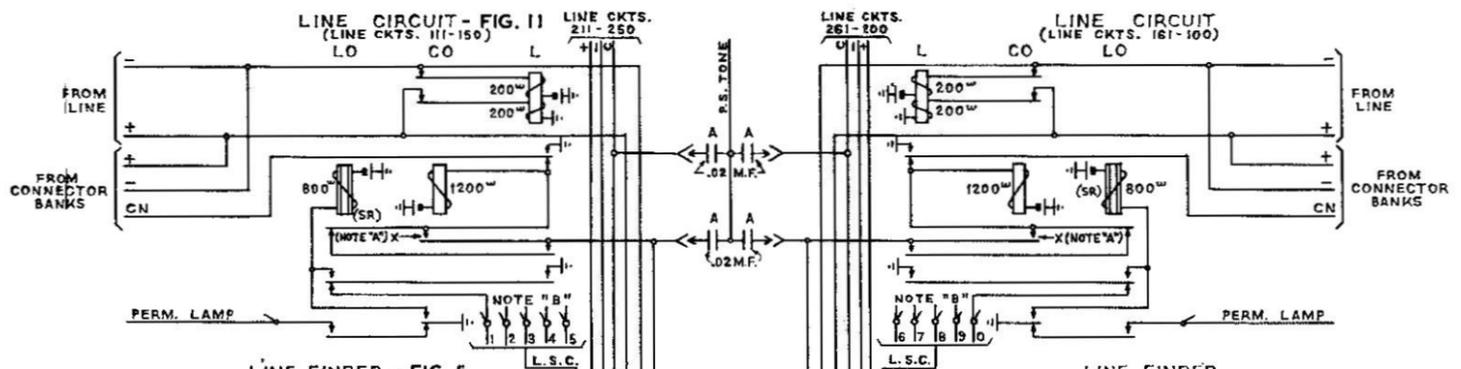


ILLUSTRATION "A"
 CIRCUIT OF THE 200 LINE FINDER UNIT

operates; opens the operating circuit to CO; prepares its own holding circuit to the springs of L; prepares the circuit to the PERM LAMP signal; and opens the incomplete start circuit to the finders.

After the distributor has stepped to the next finder, the only ground holding CO operated is that received over the C lead from a succeeding switch. When this ground is removed by a succeeding circuit, CO releases; connects L to the line loop; opens its locking circuit; and closes the PERM LAMP lead to complete an alarm circuit. If there is a permanent on the line, or if either called or calling party has lifted his receiver after reverting ringing, the loop circuit will be closed to L. L operates; closes the holding circuit to slow-release LO; and grounds the CN lead to make this line busy in the connector banks. LO remains operated and keeps the L. S. C. open to prevent this line from starting a finder.

When the short is removed from the line, letting L restore, LO releases and the equipment returns to normal.

13. BUSY KEYS

The BUSY KEY on the finder when operated transfers the GUARD lead from the C lead to ground

thereby making this switch busy; and removes a multiple ground from the ATB chain associated with that group of finders.

The BUSY KEY in that group relay circuit when operated, opens the circuit to N-3, which upon restoring transfers the calls to the other group and opens the locking circuit to E-3.

14. SPARK SUPPRESSION

The non-inductive windings of the release magnet of the finder prevent excessive sparking at the VON springs when they open the release circuit. A condenser and a resistance in series, connected between ground and a contact of D-3 prevent excessive sparking at contacts of A-3 during vertical pulsing of the finders. The non-inductive winding of A-3 prevents excessive sparking at the interrupter spring contacts of the vertical and rotary magnets of the finder during vertical and rotary pulsing. The condenser and resistance in series, connected between ground and a terminal of the distributor motor magnet, prevent excessive sparking at the motor magnet interrupter springs. A condenser in series with a resistance connected to a contact of J-3 prevents excessive sparking at the contacts of A-3 during the rotary pulsing of the finder and at the springs of K-3 and J-3 when they operate to seize the calling line.

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