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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

LINEFINDER EQUIPMENT

STEP-BY-STEP DIAL CENTRAL OFFICE EQUIPMENT

DEPARTMENT OF THE ARMY • MAY 1950

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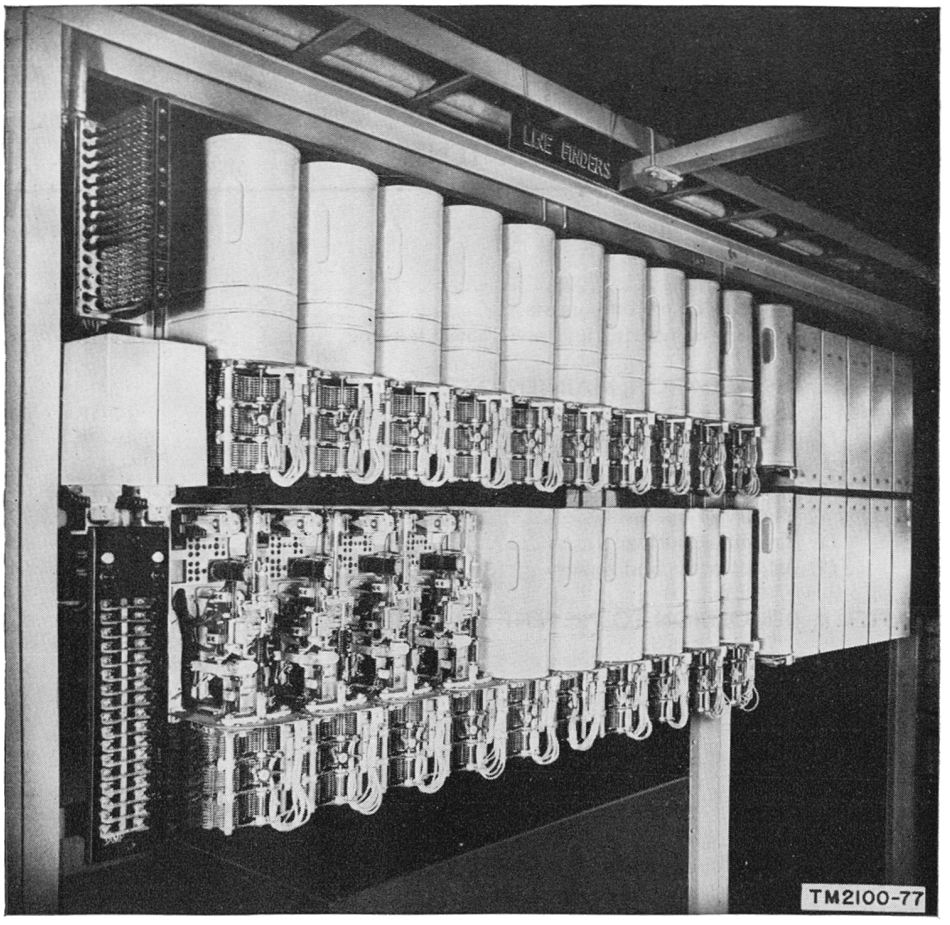

Figure 1. Typical 200-point regular linefinder shelf.

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. Scope

These instructions are published for the information and guidance of the personnel to whom this matériel is issued. They contain information on the theory, operation, and organizational maintenance of the matériel as well as a description of the major units and their functions in relation to other components of the matériel. They apply only to a *typical* installation of 200-point linefinders and associated equipment used in Army step-by-step dial central offices. For details concerning a *specific* linefinder installation refer to the applicable manufacturer's specifications, schematic and wiring diagrams, circuit descriptions, and maintenance data.

2. Appendix

This manual is one of a series of technical manuals covering step-by-step dial central office equipment. These manuals and other current references, including supply catalogs, technical manuals, and other available publications applicable to the matériel, are listed in the appendix.

3. Forms and Records

a. The following forms will be used for reporting unsatisfactory conditions of Army matériel and equipment:

DD Form 6 (Report of Damaged or Improper Shipment).

DA AGO Form 468 (Unsatisfactory Equipment Report).

(1) DD Form 6 (Report of Damaged or Improper Shipment) will be filled out and forwarded as prescribed in SR 745–45–5.

(2) DA AGO 468 (Reports Control Symbol CS GLD–247) (Unsatisfactory Equipment Report) will be filled out and forwarded to the Office of the Chief Signal Officer as prescribed in SR 700–45–5.

b. Use other forms and records as authorized.

Section II. DESCRIPTION OF COMPONENTS

4. General

When it is necessary to make a telephone call from a dial central office, the handset of the telephone is lifted from its cradle, and, almost immediately, the steady buzz of dial tone is heard. This tone indicates that the central office equipment is ready for the calling party to dial the directory-listed number of the party desired. Transmission of dial tone means that the equipment on a linefinder shelf has operated independently of any action on the part of the calling party except for lifting of the receiver. The equipment has extended the line loop through to a first handset, a two-motion stepping switch which responds to dial pulses. See TM 11–2100 for the basic theory of stepping switches, and TM 11–2105 for a detailed explanation of selectors.

5. Linefinder Shelf

The primary purpose of a linefinder shelf is to provide each calling telephone terminating thereon with access to a number of trunk lines leading to selectors (or connectors). It duplicates the functions performed by the answering cords and multipled jacks of a manual switchboard. A linefinder shelf equipped to service 200 lines, with 20 simultaneous calls in progress, is equivalent to a 200-line manual switchboard provided with 20 cord circuits.

a. A linefinder shelf (fig. 1) consists of all the equipment required to connect any of its associated calling telephones to a selector or connector which will receive the pulses dialed by the calling party. However, the action of a linefinder is not under the control of the telephone user. Instead, when

the calling party lifts the handset from the cradle, the contacts in the linefinder banks associated with the calling telephone are marked. Other units on the shelf then cause the linefinder to raise and rotate its wipers over its contact banks automatically until the wipers reach the marked contacts. These units then cause the linefinder to extend the calling line to a selector or connector. Just as a manual switchboard requires more than one answer cord if more than one call is in progress at the same time, a linefinder shelf requires more than one linefinder. If, for example, it is determined that 20 calls will be in progress on the shelf at one time, the shelf will be equipped with 20 linefinders. This makes control equipment necessary, to determine which linefinder will service a given call.

b. The components of a linefinder shelf are as follows:

(1) Linefinders (par. 6).
(2) Line and cut-off relays (par. 7).
(3) Group relay assemblies (par. 8).
(4) Distributors (par. 9).
(5) Start and level-marking resistors (par. 10).
(6) Fuse panels (par. 11).
(7) Terminal blocks (par. 12).
(8) Shelf jacks (par. 13).

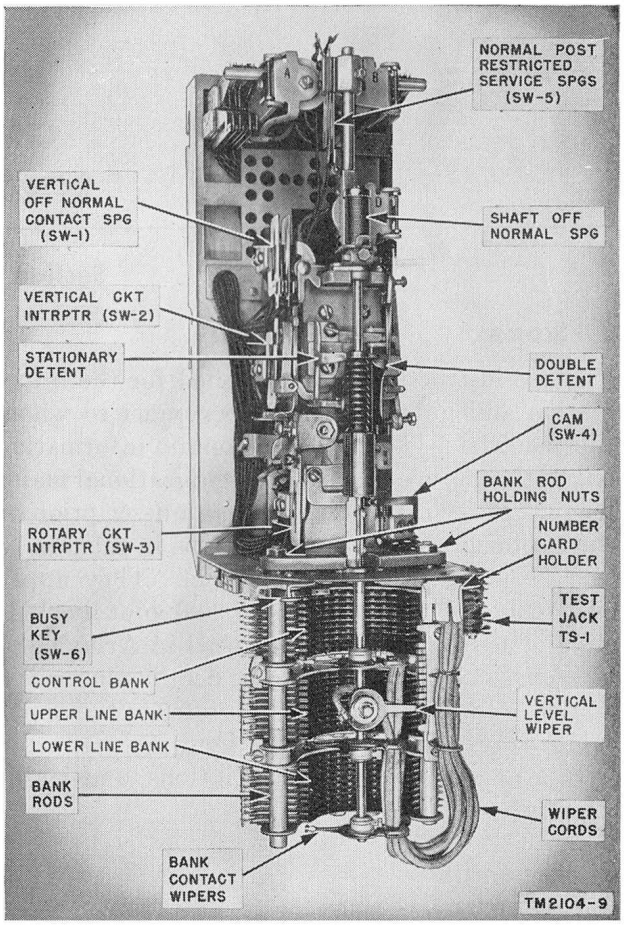

Figure 2. 200-point linefinder.

6. Linefinders

A linefinder is a two-motion stepping switch, which operates automatically when a calling party closes his telephone cradle switch. Unlike a selector it is not operated by dial pulses. It is operated by a group of relays which, in proper sequence, automatically close the circuits which cause a particular linefinder action, and automatically open those same circuits when the associated linefinder action is completed. This type of switch is referred to as a nonnumerical switch. Each linefinder is directly connected to one particular selector or connector, by means of cables and through cross connections at the distributor frame. The action of a linefinder and its controlling relays extends the loop of the calling telephone to the selector or connector associated with the linefinder. A linefinder may be either 100 point or 200 point, depending on the number of lines it serves.

a. A typical 200-point (or 200-line) linefinder has the usual basic mechanism for two-motion stepping switches, consisting of vertical, rotary, and release magnets, shaft, wipers, detents, and ratchets.

(1) Several auxiliary contact spring assemblies are used in the linefinder (fig. 2). These spring assemblies are designated the vertical off-normal (SW–1), the vertical circuit interrupter (SW–2), the rotary circuit interrupter (SW–3), the cam (SW–4), and the normal post (SW–5). The linefinder switch base mounts three control relays: A, B, and D. A removable metal cover protects the relays and switch mechanism.
(2) A 200-point linefinder has 3 contact banks mounted under the switch base. The control bank is mounted directly under the switch base and contains 10 levels each with 20 contacts. The contacts are mounted in pairs, one directly under the other; these contacts are separated by an insulator. Directly under the control

bank are two similar banks known as the upper and lower line banks. The control leads for 200 lines terminate on the 200 contacts of the control bank. The + and − leads of 100 lines terminate in the 100 pairs of contacts in the upper line bank and those of 100 other lines in the contact pairs of the lower line bank. The 100 control bank contacts mounted above the insulators are associated with the + and − contacts in corresponding positions in the upper line bank. The control bank contacts mounted below the insulators are similarly associated with the contacts in the lower line bank. Three wiper arms are mounted on the switch shaft. Each arm is comprised of two insulated wiper contacts mounted so that one contact wipes the upper set of contacts of a level as the other contact wipes the lower set of the same level. When the shaft raises these arms to one of the 10 levels, the control bank-wiper contacts search both sets of contacts on that level. At the same time the contacts of the line bank-wiper arms wipe the associated line bank contacts.

(3) A set of vertical level-marking contacts, called the vertical bank or vertical commutator, is mounted at the right side of the contact banks. A single-contact wiper, mounted at a right angle to the other wipers, traverses the vertical commutator during vertical motion of the shaft. The shaft thus has one single-contact and three dual-contact wipers. A total of seven wiper cords are used to connect the wipers. The wiper cords terminate on a terminal strip and test jack assembly.

b. The linefinder operates under control of the group relays and the distributor linefinder shelf. The distributor preselects a linefinder in readiness for an originating call. The line relay of the calling line marks one of the linefinder's control bank contacts with negative battery to indicate which line is originating a call, and marks one of the linefinder's vertical bank contacts with ground to indicate the bank level of the line appearance. The group relays control the vertical and rotary stepping, until the wipers of the linefinder find the marked contacts.

(1) A pulsing (or interrupting) circuit causes the VERT MGT (vertical magnet) to operate, raising the linefinder switch shaft step-by-step until the vertical wiper reaches the level marked by ground in the vertical bank. This stops the vertical stepping and starts the rotary pulsing (or interrupting) circuit. This circuit causes the RTY MGT (rotary magnet) to operate. The shaft is rotated step-by-step until the control bank wipers rest on the control bank contact marked by negative battery and the line bank wipers rest on the corresponding − and + line bank contacts of the calling line.

(2) This connection is extended automatically from the linefinder bank contacts to the selector associated with the linefinder. The selector transmits dial tone to the calling party.

(3) Upon completion of a call and release of the switch train, the RLS MGT (release magnet) of the linefinder operates, restoring the wipers and switch shaft to normal.

c. A 100-point linefinder is similar in construction and operation to the 200-point linefinder, but contains only one line bank with 100 pairs of + and − contacts, and only 100 control lead contacts in the control bank. Some control banks contain 100 single contacts, others, as in the 200-point linefinder, contain 100 pairs with each contact electrically connected to the other of its pair. In all 100-point linefinders, however, the contacts of the control bank wiper arms are electrically interconnected to make a one dual-surface wiper. The line bank wiper arm and contact assembly is similar to that used in the 200-point linefinder. Four wiper cords are used to connect the wipers of a 100-point linefinder; two for the line wiper, and one each for the control and vertical wipers. Relay A used in the 200-point linefinder is not required in the 100-point linefinder, which has only two relays, B and D, functioning exactly like the corresponding relays in the 200-point linefinder.

d. Twenty linefinders will adequately handle the calls made from 200 lines under normal traffic conditions. If the normal traffic for a particular linefinder shelf is heavier than the normal traffic usually handled by a 200-point linefinder shelf, additional linefinders are installed. Since the frames used in assembling the standard linefinder

shelf are designed to accommodate a maximum of 20 linefinders per shelf together with their controlling equipment, the additional linefinders are installed on an adjacent but separate frame. The resulting assembly is referred to as an *overflow shelf*. The linefinders installed on this adjacent frame are multiplied with the original 20 on the shelf to make additional trunks to selectors available to the calling parties. Although the linefinders of the overflow shelf are frequently referred to as *overflow linefinders* they are not installed primarily for the purpose of handling peak loads. (For information on the method of handling peak loads refer to sec. III.) The term "overflow" refers to the fact that more than 20 linefinders overflow the frame used in a 200-point linefinder shelf assembly. The frames used in assembling overflow shelves are made to accommodate 10 or 20 linefinders. However, the actual number of linefinders used on a particular overflow shelf is determined by the difference between the number of calls ascertained to be normal for that shelf and the number of calls normally handled by a 200-point linefinder shelf.

7. Line and Cut-off Relays

One combined line and cut-off relay (usually called line relay) is provided on the linefinder shelf for each telephone line to be served by the shelf. The manufacturer frequently refers to this relay as line equipment, since in some applications two or three relays were required, individual to each line, to perform the functions handled by the one relay.

a. The line relay is designed for two-step operation. Its coil has three windings of 550, 600, and 1,850 ohms resistance. The contact pile-up has two pairs of make contacts and three pairs of break contacts. Line relays are assembled on mounting bases in groups of 20 or 40, to facilitate final assembly by the manufacturer. A typical group of 20 relays, from which the protective metal cover has been removed, is shown in figure 3. Wiring between the line relays and the other linefinder equipment is completed during assembly of the shelf. A terminal block (par. 12) is provided for connecting the telephone lines to the line relays.

b. In schematic diagram and circuit explanations, the line relay is designated **L.** Its circuit is incorporated into the schematic diagram (fig. 28).

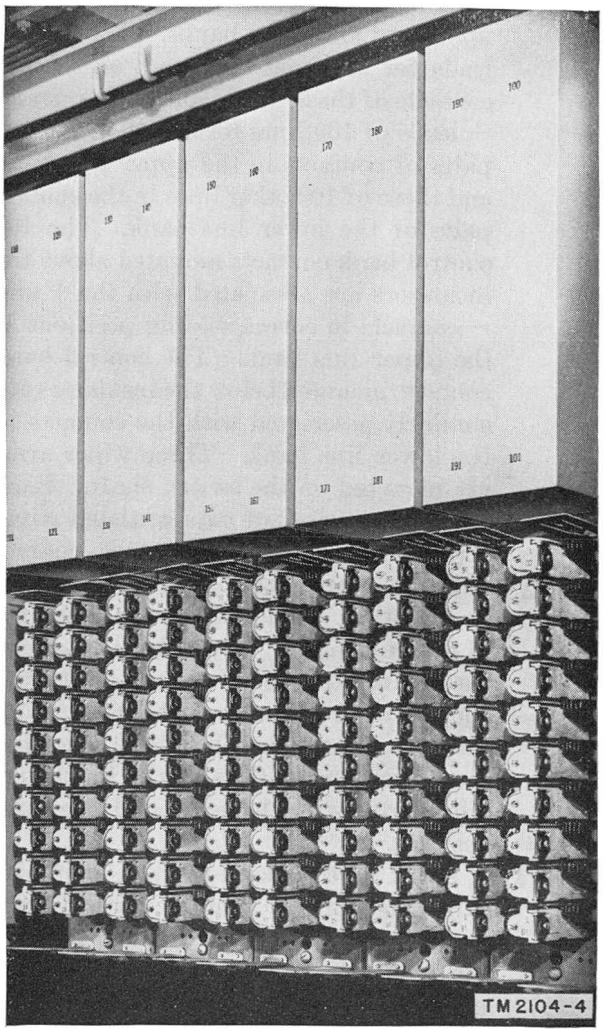

Figure 3. Line and cut-off relays.

As its full name implies, the line and cut-off relay has two functions.

(1) In its first-step operation it functions as a line relay when the handset of the associated line is removed from its cradle. At this time, the three windings of the relay are in series, bridged across the telephone line. The *combined* resistance of these windings permits current through the windings to develop a magnetic field strong enough to close its make contacts, but not strong enough to open its break contacts. Closing the make contacts places ground on a contact at a specific level in the vertical bank (or commutator) and connects negative battery to a control lead contact in that same level. This closes a loop circuit through the

relay to the linefinder, starts the linefinder searching for the marked line, and initiates the connections to subsequent equipment in the dial central office.

(2) In its second-step operation the line relay has a cut-off function. It frees its windings from the loop, and releases the group relays and distributor from the call after a linefinder completes a connection through to a selector. The cut-off function also occurs on incoming calls when a connector seizes the line. This seizure removes the bridged coils of the line relay and prevents a linefinder from starting and searching when the receiver is removed in answering the call. In its second-step operation, only the 600-ohm winding is connected across the central office battery. Thus, more current flows, and the relay operates fully, opening its three pairs of break contacts (fig. 16).

8. Group Relay Assemblies

The term "group relays" refers to an assembly of 12 control relays (fig. 4) mounted on a base plate. The assembly is equipped with two multicontact jacks (figs. 21 and 28). Also mounted on the base plate are five resistors, three capacitors, and two rectifiers. A removable metal cover protects the assembly. An extension frame bolted to the base plate mounts a busying switch, card holder, and test jack for the assembly. A linefinder shelf has two such group relay assemblies, designated A and B. Under normal operating conditions, each of the assemblies controls one-half of the linefinders mounted on the shelf.

a. The 12 relays are designated on the equipment and in circuit explanations as A–3, B–3, C–3, D–3, E–3, F–3, G–3, H–3, J–3, K–3, N–3, and P–3. The group relays control the action of a linefinder by providing pulsing circuits for its VERT and RTY MGT, and by stopping its vertical movement at the marked contact in the vertical bank corresponding to the level in which the calling line appears. The group relays cause the associated distributor (par. 9) to operate and allot a new idle linefinder after one previously allotted has seized a calling line. Under abnormal conditions, one group relay assembly transfers calls normally handled by the linefinders under its control to the other group relay assembly, and starts an alarm circuit.

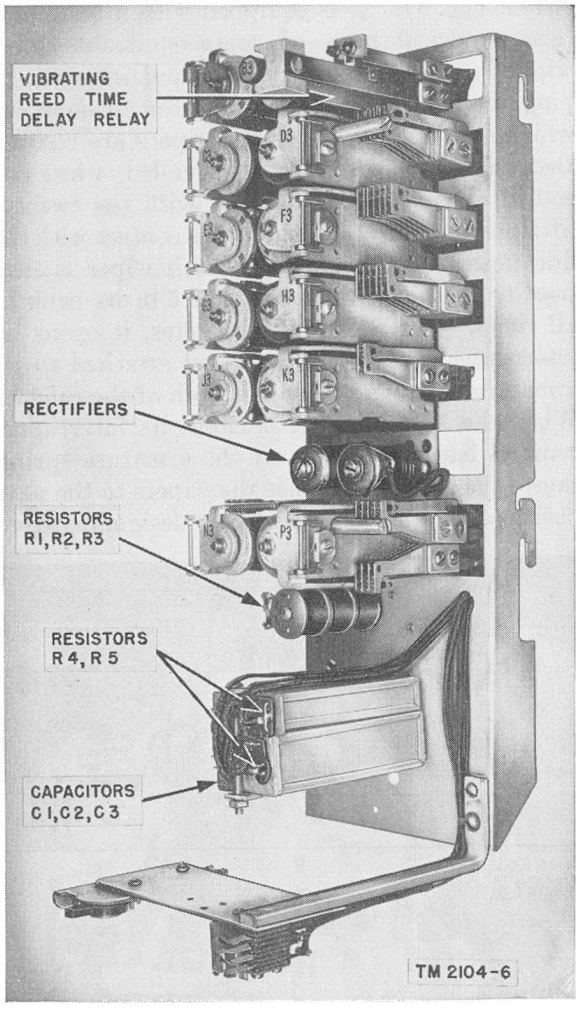

Figure 4. Group relay assembly.

b. The group relay assembly includes two rectifiers (RA–1 and RA–2), which permit current to flow in only one direction through the windings of relay K–3 and J–3, respectively. Resistor R–1 (2,000 ohms) is a start resistor in the test jack circuit. Resistor R–2 and R–3 (3,000 ohms each) are noninductive resistors placed across the windings of B–3, and H–3, respectively; resistor R–4 (200 ohms), associated with capacitor C–1 (1 mf), and resistor R–5 (200 ohms), with capacitors C–2 and C–3 (1 mf each), are spark-suppression resistors.

9. Distributors

A linefinder shelf has two distributors, designated A and B. One is associated with each group relay assembly and the linefinders it controls.

a. The distributor is a 25-point rotary stepping

switch (fig. 5). It is equipped with a bank of 6 semicylindrical rows of contacts, double-ended wipers, a motor magnet (MM) and rotary stepping mechanism, and an indicator to show on which of the 25 positions the wipers are resting. Because the wipers are double-ended, when one end of a wiper breaks contact with the twenty-fifth position the other end makes contact with the first position. Consequently, each wiper is electrically connected to some contact in its bank at all times. When the MM operates, it opens its interrupter contacts, and a pawl attached to its armature is drawn across one tooth of the ratchet. When the MM releases, it closes its interrupter contacts and the tension of the armature spring causes the pawl to advance the wipers to the next position. The six bank levels are designated from left to right as guard, finder-start, vertical, test–1, relay D, and relay A. A metal cover is bolted over each distributor.

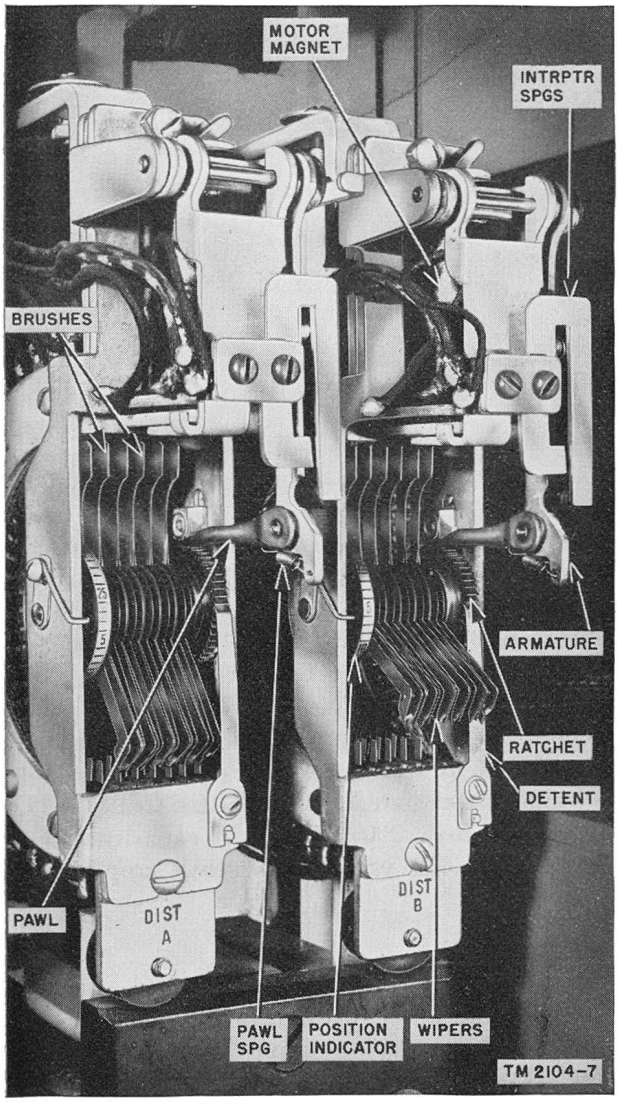

Figure 5. Distributors.

b. Linefinders are assigned positions on the distributor banks in accordance with the number of linefinders mounted on the shelf (par. 16). The distributor preselects an idle linefinder to handle the next originating call. When a linefinder, preallotted by the distributor, has seized a calling line, the distributor disengages its wipers from the bank position occupied by this linefinder, rotates them to find an idle linefinder, and allots this idle linefinder to handle the next call. If a linefinder is busy, its contact on the guard level in the distributor is grounded, causing the distributor to step its wipers to the next contact. If the distributor has a position to which no linefinder is assigned, the contact on the guard level of that position is permanently grounded, so that the wipers rotate past that position.

10. Start and Level-Marking Resistors

A linefinder shelf contains 10 start and level-marking resistors (R–6 through R–15) of 2,000 ohms each. They are assembled in two groups of five, similar to resistors R–1, R–2, and R–3 (fig. 4) and mounted on the rear of the shelf. They are connected to the vertical bank contacts of the linefinders (fig. 8). When the first-step operation of a line relay places ground on one of the linefinder's vertical bank contacts, the ground is extended to the rest of the vertical bank, but through 4,000 ohms series resistance. This resistance is high enough to prevent ground on contacts, other than the one originally marked, from interfering with vertical searching.

11. Fuse Panels

a. The regular linefinder shelf has a combined fuse and lamp panel (fig. 25). Seventeen 3-ampere fuses are provided as follows: one for every 20 line relays, one for every 5 regular linefinders, one for each group relay assembly and associated distributor, and one for miscellaneous purposes. Four lamps are provided as follows: a white lower bank lamp (LB), a white start signal lamp (ST SIG), a green release lamp (RLS), and a red fuse alarm lamp (FA). When a fuse blows, a delay circuit is energized (fig. 12); this causes an alarm buzzer to sound and the fuse alarm lamp to glow. See TM 11–2108 for a detailed explanation of the alarm and supervisory signal circuits.

b. The overflow shelf has a small fuse panel equipped with one 3-ampere fuse for every five linefinders mounted on the shelf (fig. 26).

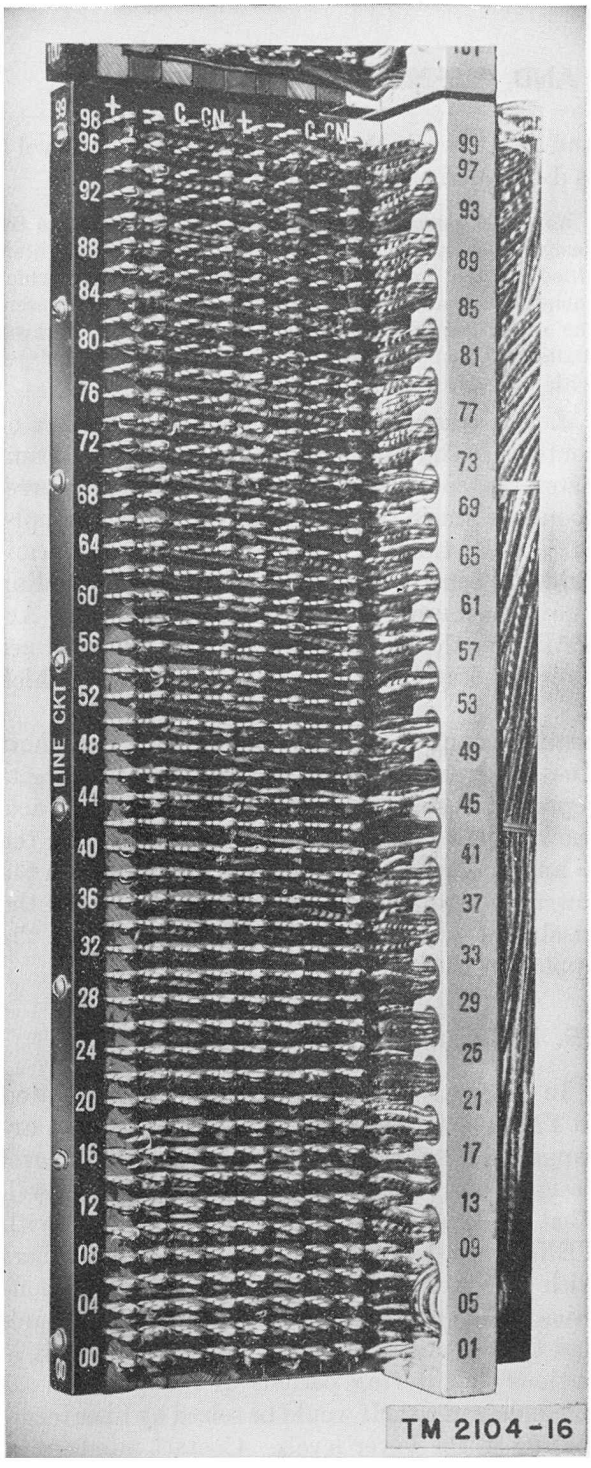

Figure 6. Line terminal board.

12. Terminal Boards

The regular shelf has two line terminal boards and one trunk terminal board. The overflow shelf has one trunk terminal board. These boards permit interconnection between sets of permanent wiring placed at the factory or added by the installer.

a. The two line terminal boards on the regular shelf (fig. 6) contain 8 rows of 50 double-ended terminals each (8 by 50 boards). Each board provides terminating facilities for 100 line circuits. Three conductors per circuit (+, −, CN) are cabled from the connector banks via the CDF (combined distributing frame). At the CDF the + and − conductors are also cross-connected to the outside cable pairs. The line relays and linefinder banks are interconnected at the boards. Figures 6 and 18 show the circuit designations.

b. The trunk terminal board on the regular shelf (figs. 1 and 30) contains 10 rows of 30 double-ended terminals each (10 by 30 board). It provides terminating facilities from the 20 regular linefinder circuits, and four-conductor (+, −, C, EC) cabled connections to the first selectors via the TIDF (trunk intermediate distributing frame). It also provides facilities for connecting the leads from the distributors, group relays, and start and level-marking resistors to the overflow linefinders, and for connecting the supervisory (signal) leads to the overflow linefinders, other shelves, and the power board.

c. The trunk terminal board on the overflow shelf (fig. 27) contains 4 rows of 10 double-ended terminals each (4 by 10 board). If more than 10 overflow linefinders were provided on the shelf, a 4 by 20 terminal board would be used. This board provides terminating facilities for the overflow linefinder circuits, and four-conductor (+, −, C, EC) cabled connections to the first selectors via the TIDF.

13. Shelf Jacks

The linefinders and group relay assemblies are designed so that the basic units can be removed from the shelf without disturbing any wiring connections. Mating connectors (jacks) are provided with the plug portion (switch jack) mounted on the switch unit and the receptacle portion (shelf jack) mounted on the shelf. All connections to the basic unit are made through the

jacks. The contact springs of the shelf jack seat against the contact projections of the switch jack, maintain electrical continuity for the various control leads to and from the units. Some springs in the shelf jacks are so constructed that they will close when the switch jack is removed and connect the leads, which indicate to the associated equipment that the unit is busy. See TM 11–2103 for further information on these jacks. Figures 19, 20, and 21 show the terminal arrangement and wiring of the shelf jacks for regular linefinders, overflow linefinders, and group relay assemblies.

Section III. CONTACT NUMBERING AND PREFERENTIAL HUNTING

14. Linefinder Banks

Paragraph 6*a* outlines the arrangement and purpose of the linefinder's line and control bank contacts. This paragraph explains actual contact numbering, straight multiplying, and reverse multiplying for preferential hunting.

a. Under the standard scheme of bank contact numbering for two-motion stepping switches, with 100 contacts per bank, the contacts are arranged in 10 levels, with 10 contacts per level. The levels are designated 1–0 (or first through tenth) from bottom to top. The contacts on each level are numbered clockwise. Consequently, the first contact on level 1 is contact 11, the fifth is contact 15, and the tenth is contact 10. The first contact on level 4 is contact 41, and the tenth is contact 40. The first contact on level 0 is contact 01, the seventh is 07, and the tenth is 00.

b. The upper and lower line banks mentioned in paragraph 6*a* are 200-contact banks. Each of the 10 levels contains two rows of contacts, paired and insulated from one another. There are 20 contacts per level, arranged in 10 pairs. These contacts are the terminals for the − and + conductors (or ring and tip) of 10 lines. Accordingly, the upper contact in each pair is designated −, and the lower contact is designated +. The numbering explained in *a* above is used but the numbers designate pairs instead of individual contacts. The first contact pair on level 1 is designated as −11 and +11, while the tenth contact pair on level 0 is designated as −00 and +00. The lower line bank contains 100 pairs of contacts numbered from 00–99, appearing in the order described in *a* above.

c. The upper line bank contains 100 pairs of contacts terminating the − and + conductors of an additional 100 lines. To distinguish them from the 100 lines in the lower line bank, those in the upper line bank are numbered 100–199. The contact pairs are designated as before. The first contact pair on level 1 is designated as −111 and +111, while the tenth contact pair on level 0 is designated as −100 and +100.

Note. The contact numbers, 00–199, correspond to the designations stamped on the line relay covers and stencilled on the line terminal blocks. The digits which comprise a contact number do not necessarily represent the digits comprising the last two, or the last three, digits of the number assigned to the telephone associated with that specific contact paid (par. 28*d*).

d. The control bank also contains 100 pairs of contacts. The upper contact in each pair terminates the control conductor (C) for the corresponding line in the upper line bank (for example, 111), while the lower contact in each pair terminates the control conductor for the corresponding line in the lower line bank (for example, 11). Accordingly, the contacts in the control bank are designated as $\frac{111}{11}$, $\frac{112}{12}$, and so on, to show which control conductors terminate there. The short lines between the upper and lower sets of digits represent insulators. Each of the 100 contacts shown below the insulators is associated with the + and − contacts bearing the same number in the lower line bank; those contacts shown above the insulators are associated with contacts in the upper line bank.

15. Preferential Hunting

In the system of contact numbering illustrated in TM 11–2100, the bank contact numbers are arranged so they are parallel in sequence to the level designations, except for the 0, or tenth level. That is, level 1 contains contact numbers with TENS digit 1, level 2 contains contact numbers with TENS digit 2, etc., up to level 10 which contains TENS digit 0. If all linefinders in a bank had their contacts arranged in this manner, it is obvious that during periods of heavy traffic all linefinders in a shelf would be seized by lines terminating in the lower levels. Contact numbers in the upper levels would not be served until the

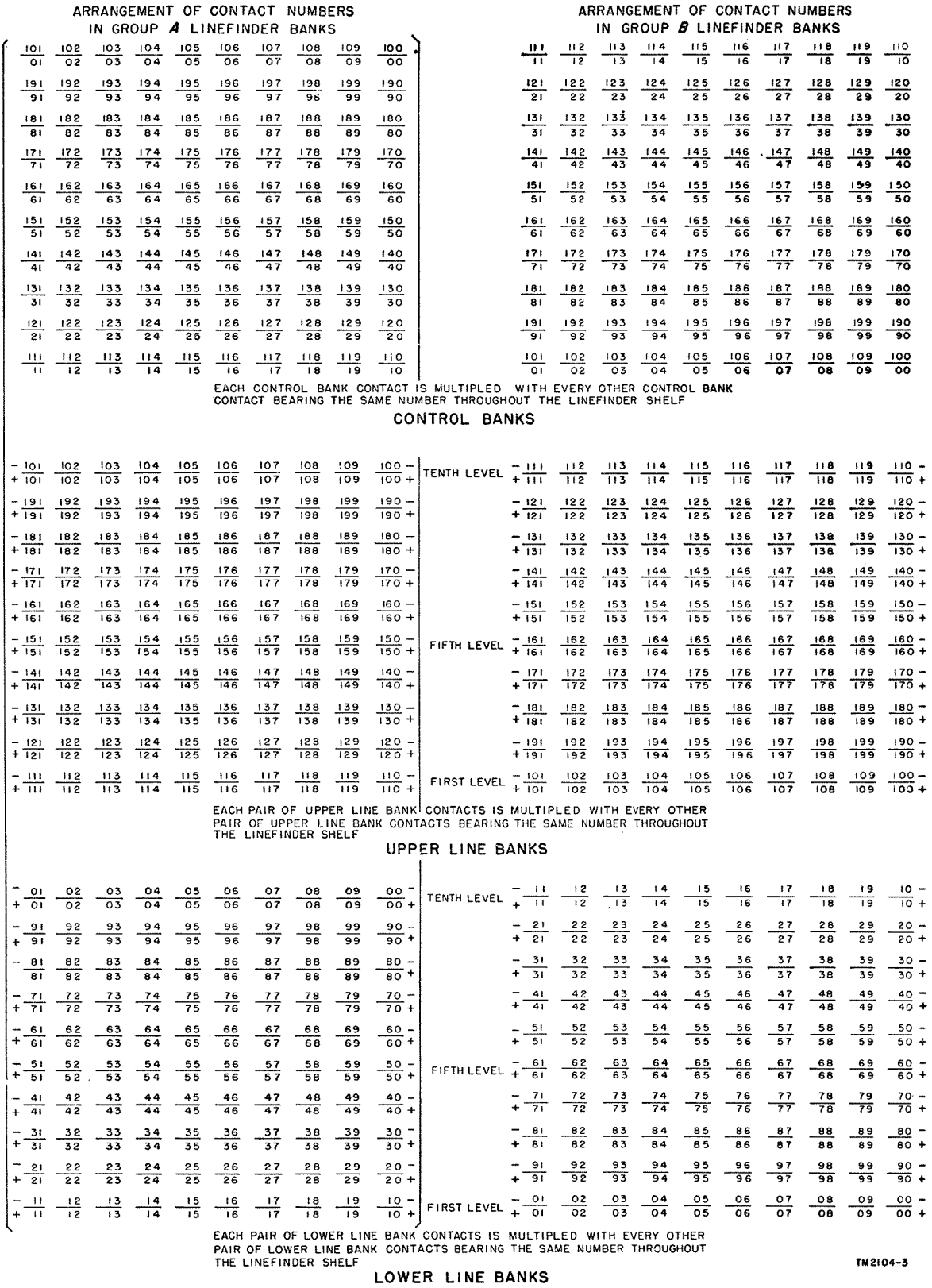

Figure 7. Linefinder bank contact numbering arranged for preferential hunting.

traffic through the lower levels had decreased. In order that a linefinder shelf may give similar service to all of the telephone lines terminating in its banks, some system of grouping contact numbers on contact banks and of grouping individual linefinders in a linefinder shelf is required. Linefinders and contact numbers so grouped are said to be arranged for preferential hunting (fig. 7).

a. To provide for preferential hunting, the 20 regular linefinders of a shelf are divided into groups A and B. Each group of linefinders is controlled by a separate distributor and relay group designated A and B, respectively. Group A linefinders are numbered 1 to 10, inclusive; group B linefinders are numbered 11 to 20, inclusive.

b. The contact numbers in group A linefinders are assigned so that the TENS digits are in sequence with the level designations (figs. 7 and 8). The contact numbers in group B linefinders are assigned so that the TENS digits are in reverse order to the level designations, that is, contact numbers with TENS digit 1 are assigned to level 10, those with TENS digit 2 to level 9 etc., down to those with TENS digit 0 which are assigned to level 1. Figure 7 shows the method of assigning contact numbers to linefinders in groups A and B. The sequence of numbering across the

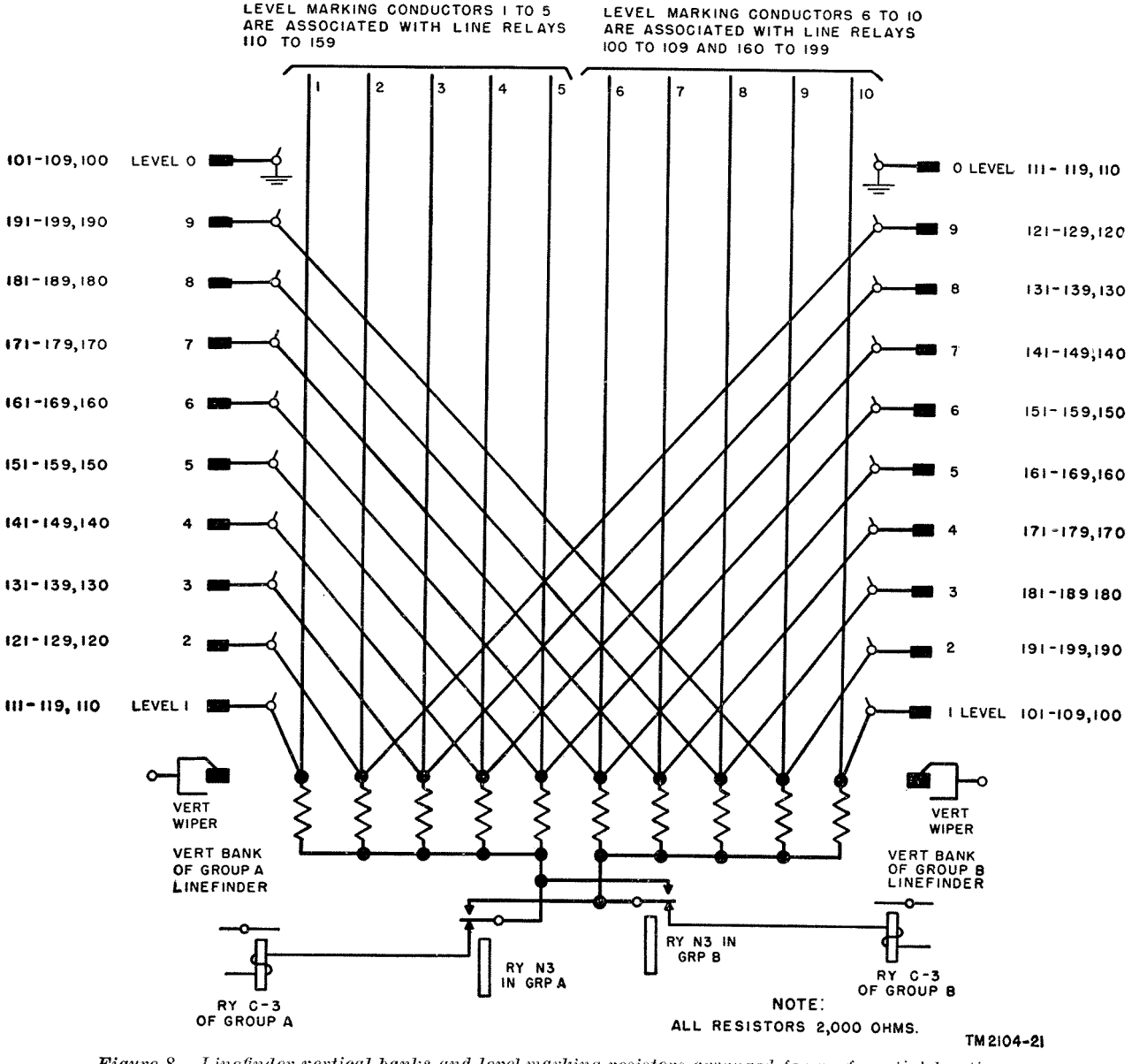

Figure 8. Linefinder vertical banks and level-marking resistors arranged for preferential hunting.

levels is the same in both groups. Note that in figure 7 the contact numbers which appear in the upper five levels of group A linefinders, appear in reverse order as to levels in the lower five levels of group B linefinders, and vice versa. Thus it is possible by proper circuit arrangement, described later, to serve all contact numbers from the lower five levels. This reduces the time required for a linefinder to locate and seize the calling line.

c. The bank contacts of linefinders in both groups are multipled. Contact 101 of linefinder 1 has a fixed circuit connection with contact 101 of every other linefinder in groups A and B. Each contact number is similarly multipled to the contact bearing the corresponding number in all the other linefinders on the linefinder shelf. However, as described in *b* above, the contacts in group B banks are assigned to levels in reverse order. Therefore, although a fixed circuit connection exists, for example, between each contact number 177 in both A and B groups, contact 177 appears in level 7 of all group A linefinders, but in level 4 of all group B linefinders. It is this system, referred to as reverse multipling, that restricts preferential hunting to the five lower levels during normal traffic conditions. If figure 8 is compared with figure 7, it will be noted that the same series of contact numbers is assigned to level 2 of group A linefinders as is assigned to level 9 of group B linefinders. The following example illustrates the effectiveness of preferential hunting. Assume that a calling party closes the circuit which marks control bank contact number 122. (As is explained in chapter 3, under normal traffic conditions, the group A distributor and the group B distributor has each selected one vacant linefinder from its group to receive an incoming call.) Note in figure 8 that contact 122 marks the idle group A linefinder vertical bank at level 2, while contact 122 marks the vertical bank of idle group B linefinder at level 9. The circuits of figure 8 also show that relay C–3 associated with the group A linefinder will close and start the operation of the group A relays. This occurs because the signal which marks contact 122 in the preselected group B linefinder is not transmitted to the starting relay of the group B linefinders, but is transmitted over the same path as the signal from contact 122 in the preselected group A linefinder. If, however, a calling party marks contact 175, level 7 of the vertical bank in the group A linefinder will be marked and level 4 of the vertical bank in the group B linefinder will be marked. This signal will be transmitted to relay C–3 of the preselected group B linefinder starting the operation of the group B relays. An analysis of figure 8 will show that any contact marked in one of the upper five levels one group will have only the effect of being marked in one of the lower five levels in the other group. Note, however, that this occurs only under normal traffic conditions.

d. Both group A and group B linefinders are further prevented from operating above level 5 under normal traffic conditions by grounding level 5 through ground lead 5A and 5B, respectively. This causes the linefinder of either group to restore upon reaching level 5, if the calling party replaces the handset on the cradle before the linefinder seizes the line. If level 5 were not grounded, the switch would rise to level 10 before restoring. This would increase the time required to ready the linefinder for another call.

e. When traffic becomes abnormally heavy the upper five levels are opened to service. Assume that all linefinders in group A are busy. When the last group A linefinder is busied, relay N–3 (fig. 8) restores (par. 26), and ground is removed from level 5 of the group B linefinders. An analysis of figure 34 will show that ground is applied to level 5 of the group B relays only when relay N–3 of the group A relays is operated. When relay N–3 of group A restores it removes ground from level 5 of the group B linefinders. (In a like manner ground is applied to the group A linefinders by operation of relay N–3 in the group B relays.) At an instant when all linefinders in group A are busy assume that a calling party marks contact 145. This appears in the lower five levels of the group A linefinders (fig. 8), but all group A linefinders are busy, N–3 of group A has restored, and the signal is routed to relay C–3 of the group B relays. Contacts numbered 145 also appear in level 7 of the group B linefinders. This is in the upper five levels of the group B linefinders, but ground has been removed from level 5. Therefore, the line terminating in contact 145 will be seized by the first idle linefinder in group B. By a similar operation of circuits, when all group B linefinders are busy, the upper 5 levels of group A linefinders are opened to receive calls normally handled in the lower five levels of group B linefinders.

f. The system of grouping the components of a linefinders shelf, numbering and multipling contacts between groups, and reverse multipling of

levels between groups results in more rapid seizure of lines by the linefinders in a shelf. In any group of 100 lines, those terminating on contacts numbered 50 to 99 have the same preference of seizure as those terminating on contacts numbered from 0 to 49. This is true under normal or abnormal traffic conditions. More rapid seizure for all lines is assured during normal traffic conditions by providing for service to all lines terminating on a shelf in the lower 5 levels of the linefinders.

16. Numbering of Distributor Contacts and Overflow Linefinders

Paragraph 6*d* explains the purpose of overflow linefinders. This paragraph explains the method of assigning overflow linefinders to groups **A and** B of regular linefinders, and the method of assigning distributor contacts to both overflow and regular linefinders.

a. If it is determined that 25 simultaneous calls will constitute the normal traffic through a linefinder shelf, 5 overflow linefinders will be added. Three of these will be multiplied as group A linefinders and two as group B linefinders. If this arrangement is compared with the description of preferential hunting in paragraph 14, it will be noted that under normal traffic conditions (when ground is applied to level 5 of group A and B linefinders, respectively) 13 linefinders are available to the 50 pairs of contacts appearing in any of the lower 5 levels of group A linefinders, and 12 line-

DISTRIBUTOR GRP A				
DIST CONT NO.	NO. FINDERS IN SHELF			
	10	13	15	20
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	4
5	5	5	5	5
6	6	6	6	6
7	7	7	7	7
8	8	8	8	8
9	9	9	9	9
10	10	10	10	10
11	BUSY	21	21	21
12	BUSY	22	22	22
13	BUSY	23	23	23
14	BUSY	BUSY	24	24
15	BUSY	BUSY	25	25
16	6	6	6	26
17	7	7	7	27
18	8	8	8	28
19	9	9	9	29
20	10	10	10	30
21	1	1	1	1
22	2	2	2	2
23	3	3	3	3
24	4	4	4	4
25	5	5	5	5

DISTRIBUTOR GRP B				
DIST CONT NO.	NO. FINDERS IN SHELF			
	10	12	15	20
1	11	11	11	11
2	12	12	12	12
3	13	13	13	13
4	14	14	14	14
5	15	15	15	15
6	16	16	16	16
7	17	17	17	17
8	18	18	18	18
9	19	19	19	19
10	20	20	20	20
11	BUSY	26	26	31
12	BUSY	27	27	32
13	BUSY	BUSY	28	33
14	BUSY	BUSY	29	34
15	BUSY	BUSY	30	35
16	16	16	16	36
17	17	17	17	37
18	18	18	18	38
19	19	19	19	39
20	20	20	20	40
21	11	11	11	11
22	12	12	12	12
23	13	13	13	13
24	14	14	14	14
25	15	15	15	15

NOTE:
COLUMN 3 SHOWS CONTACT NUMBERING FOR THE TYPICAL INSTALLATION DESCRIBED IN THIS MANUAL.

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Figure 9. Distributor bank contact assignment.

finders to the 50 pairs of contacts in any of the lower 5 levels of group B linefinders. Underpeak or overload traffic conditions, all 25 linefinders are theoretically available to any one set of contacts in any level of either group. Note that overflow linefinders are not restricted in function to handling peak loads as their name implies, but function as if they were one of the regular linefinders of the group with which they are associated.

b. As explained in paragraph 15*a*, linefinders in group A are assigned numbers 1 to 10, inclusive, those in group B, 11 to 20, inclusive. The frames (frequently referred to as overflow shelves) installed for mounting overflow linefinders are manufactured in two sizes, to accommodate either 10 or 20 linefinders. However, the number of linefinders initially installed on such a frame may be less than the total capacity of the frame. When it is expected that a linefinder shelf will eventually require 10 overflow linefinders, the numbers 21 through 25 are reserved for group A overflow linefinders, and numbers 26 through 30 are reserved for group B overflow linefinders (fig. 10). If it is expected that 20 overflow linefinders will eventually be required, the numbers 21 through 30, and 31 through 39 are similarly reserved for the overflow linefinders of groups A and B, respectively. In the typical installation described in this manual, 5 linefinders have been installed on a frame designed to hold 10 (fig. 10). In accordance with the numbering system described, the three overflow linefinders associated with group A regular linefinders have been assigned numbers 21, 22, and 23, whereas numbers 24 and 25 remain unassigned pending future installations. The same procedure has been observed in assigning numbers 26 and 27 to group B overflow linefinders.

c. Note that in figure 9 the group A linefinders 1 through 10 are assigned to distributor contacts 1 to 10, respectively. In the typical installation described in this manual, overflow linefinders 21, 22, and 23 are connected to distributor contacts 11, 12, and 13, respectively. Contacts 14 and 15 are grounded on level A, and are reserved for additional overflow linefinders which may be installed. When the distributor reaches these two grounded contacts, each affects distributor action in the same manner as the contact of a busy linefinder; the wipers step past them. A similar system of assigning distributor contact numbers is followed for group B linefinders as shown in figure 9. Distributor contacts 16 through 20 are multipled with contacts 6 to 10, respectively, and contacts 21 through 25 are multipled with contacts 1 to 5, respectively (fig. 30). The distributor wipers step across two contacts connected to each regular linefinder and one contact connected to each overflow linefinder for each 180° of rotation. This arrangement of distributor contacts does not necessarily indicate the sequence in which the linefinders will be selected to handle calls, because the distributor wipers step past any contact connected to a busy linefinder.

d. Figure 9 shows the method of assigning distributor contacts to linefinders in shelf installations which differ in the number of overflow linefinders. Column 1 shows the distributor contact assignment for a shelf with no overflow linefinders, and columns 2, 3, and 4 show distributor contact assignment for installations with 5, 10, and 20 overflow linefinders, respectively.

CHAPTER 2

INSTALLATION, MAINTENANCE, AND OPERATION

Section I. INSTALLATION AND MAINTENANCE

17. Physical Location

a. Each regular linefinder shelf is shipped as a complete unit by the manufacturer. Each overflow shelf is similarly assembled and shipped as a unit. The wiring of these shelves is completed through the cable lengths to terminals which may be attached directly to the line terminal boards and trunk terminal boards, respectively. Figure 10 shows the equipment layout on the typical linefinder shelf, which is described in this manual. The shelf wiring for the installation of the full complement of overflow linefinders is completed by the manufacturer. Five cable runs are provided with each complete (regular and overflow) linefinder shelf. These are designated as runs 2A, 41A, 41B, 50A, and 51A. The latter two runs are not shown in figure 10. Cable run 2A connects the line relays to the station lines. Cable runs 41A and 41B connect the regular and overflow linefinders, respectively, to their associated selectors, via the TIDF. Cable runs 50A and 51A connect the linefinder shelf to the power board for power and supervisory wiring, respectively. For detailed instructions on installation, refer to TM 11–2102.

b. Frames to mount regular and overflow linefinder shelves are erected by the installing personnel. Frames for the installation described in this manual are designed to accommodate 2 regular linefinder shelves, each containing 20 linefinders. The overflow linefinders which comprise part of the respective shelves are mounted on an adjacent overflow frame. These two adjacent frames, the two linefinder shelves mounted on them, and the associated control equipment constitute a bay. The bays are designated LF–1, LF–2, and so on as required. Figure 31 shows the floor plan of a typical 3,200-line office. Bays LF–1 through LF–8 are shown installed and the space reserved for future installation of bays LF–9 through LF–12 is indicated. Since each bay contains facilities for 400 lines the installation shown in figure 31 has an ultimate capacity of 4,800 lines. The table below shows the arrangement of shelves and groups in each bay. Note that the two complete linefinder shelves in a bay are designated A and B. Shelf A is mounted above shelf B (the reverse of groups A and B in each shelf).

Linefinder Designations in Bay LF–1

Shelf	Linefinder Nos.		Group on shelf
	Overflow	Regular	
LF–1A	26–27	11–20	B
	21–23	1–10	A
LF–1B	26–27	11–20	B
	21–23	1–10	A

18. Maintenance

a. Maintenance consists of a series of PM (preventive maintenance) inspections of linefinder equipment designed to eliminate major breakdowns and unwarranted interruptions in service. PM inspections coupled with regularly scheduled equipment tests will improve the operating efficiency of the equipment and will reduce the amount of time required for major repairs.

b. Refer to TM 11–2103 for descriptions of maintenance practices, lubrication, and scheduling of routine tests. No other specific maintenance instructions are required for linefinder equipment.

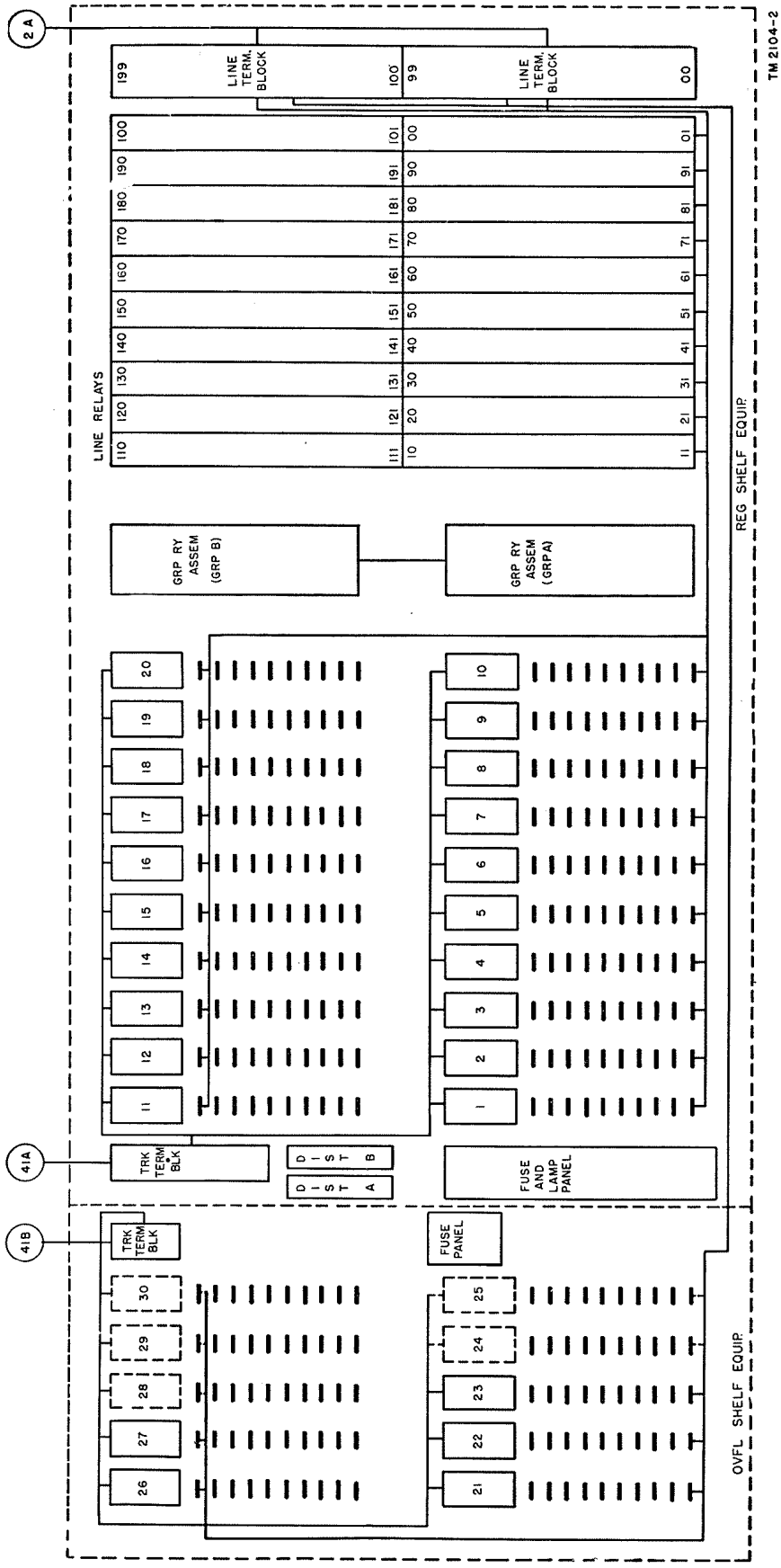

Figure 10. Location of linefinder shelf components.

Section II. OPERATING INSTRUCTIONS

19. General

a. Preoperational Procedures. The installer must perform certain strapping at the terminal boards and at the shelf jacks to adjust the method of operation of the equipment to conform to the specifications for the central office. The manufacturer's specification outlining the method of operation has suffix number 792. Special notes to the installer pertaining to linefinder equipment are listed in a specification having suffix number 722.

(1) At the trunk terminal board of each regular shelf, the installer must strap the ST SIG (start signal alarm) terminal to the RLS (release alarm) terminal, so that both circuits will provide alarm signals in the event of operating faults (fig.30).

(2) When it is so specified, the installer must strap terminals 11 and 17 at the upper shelf jack (PL–2) of the group relay assembly for group A (fig. 21).

b. Operating Tests. Procedures for operating tests of the linefinder equipment are given in TM 11–2103. Perform tests on each linefinder on every shelf before placing equipment in operation. If any units do not operate properly, remove them from the shelf and perform any necessary inspection and adjustment as outlined in TM 11–2103.

c. Wiring Diagrams. Figures 18 through 27 and 29 and 30 illustrate wiring diagrams for the circuits described in this manual. Study the wiring diagrams, note all installer's wiring, and check both the installer's wiring and the shop wiring of each unit which operates improperly.

20. Adjustments for Restricted Service

a. Refer to paragraph 29 for a circuit explanation of restricted service operation. Restriction is effected by adjustment on both linefinder and selector levels. Each linefinder line bank level serves 10 lines. However, the shaft raises the wipers for both line banks so that restriction on one level effects 20 lines. Restricted and unrestricted lines must not be connected to the same levels.

b. To restrict a level, a tooth of the normal post cam on each linefinder on a shelf must be adjusted to operate the normal post contact assembly (fig. 11). Use a special cam adjusting tool recommended by the equipment manufacturer. Adjust each tooth by bending it 90° from its original position. Raise the shaft manually to see that the normal post contacts are operated at the desired restricted service level or levels. Remember that reverse multiplying exists between groups A and B on the linefinder shelf. Refer to figure 8 to find the level in group B corresponding to the level in group A. For example, if level 4 in group A is to be restricted, level 7 in group B must also be restricted. Make sure that the cams in the associated first selectors are also adjusted for restricted service on the specified trunk levels.

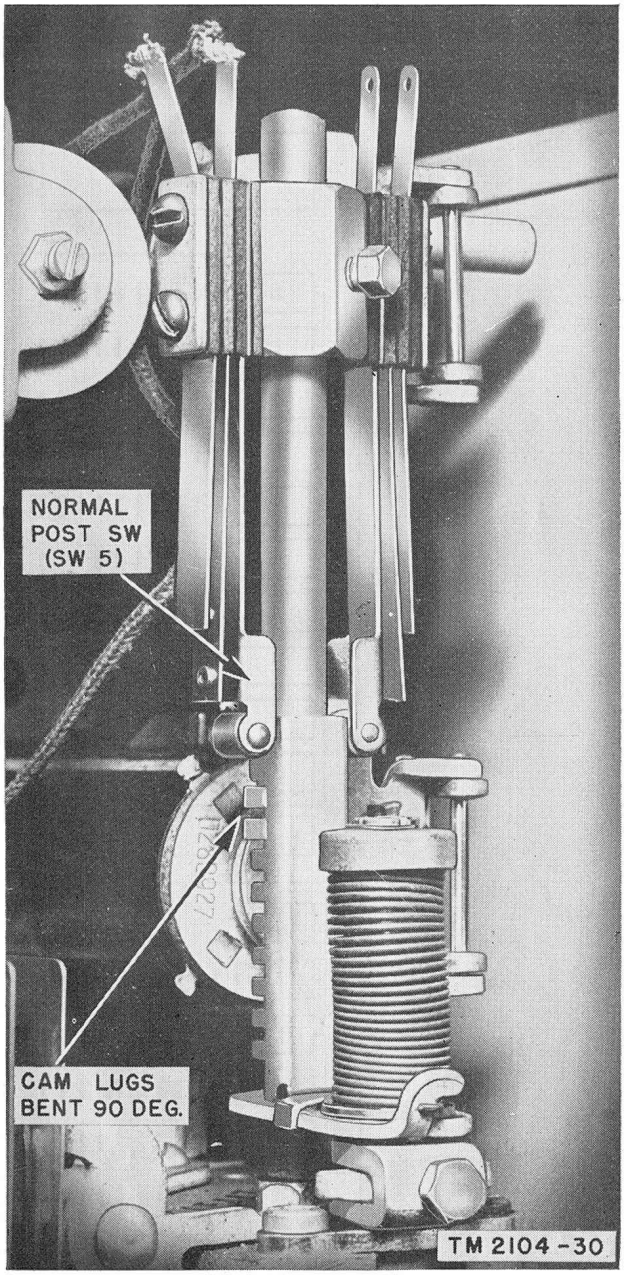

Figure 11. Adjustment for restricted service.

CHAPTER 3

REPAIR INSTRUCTIONS

Section I. THEORY OF OPERATION

21. General

As stated in paragraph 4, the units on a linefinder shelf extend the line of a party originating a call through to a selector which returns dial tone. At the completion of the call, a linefinder disconnects the calling line from the remaining switching equipment. Each of the 200 lines served by a linefinder shelf is directly associated with a line and cut-off relay mounted on the shelf. Each line relay can be connected through the group relays and distributor to any linefinder on the shelf. The group relays and distributor preselect or allot a particular linefinder to find and seize the next line originating a call. The seizure of a trunk to a first selector by a linefinder is completely automatic. The circuits which cause this to occur, however, are simple direct-current circuits which are closed or opened in proper sequence by relays. The action of the relays is supplemented by mechanical action. By alternately opening and closing circuits through the windings of electromagnets the linefinder shaft is raised and rotated to the desired position one step at a time. Although the operation of the linefinder is fundamentally simple, the schematic diagram appears complicated because of the number of circuits involved. Paragraphs 22 through 26 trace in detail each of the simple direct-current circuits shown in figure 28 in the order in which they are closed (completed) or opened. Figure 28 indicates that the wipers of the linefinder have been stepped to the second contact of the second level, and that the line associated with bank contact 22 has been extended. The individual relays, however, are shown in their normal (unoperated) condition, except relay N–3 which is normally operated. When tracing these linefinder circuits, it is necessary to visualize the condition of each relay (operated or restored) at any given instant during the sequence.

22. Operating Sequence at Start of a Call

See figure 28 for the operating sequence at the start of a call. The operating sequence discussed in the following paragraphs is for the equipment in group A only. Group B equipment operates in an identical sequence.

a. Relay N–3. When a linefinder shelf is installed, connected, and ready for operation, the circuit through relay N–3 is completed. Therefore, relay N–3 remains in its operated position constantly, except as explained in paragraph 15. The circuit, which holds N–3 operated prior to the operation of a linefinder in its group, runs from negative battery through the winding of relay N–3, through contacts 3 and 4 of relay E–3, through contacts 3 and 4 of SW–7 (busying switch), over the ATB GND (all trunks busy ground) lead, through contacts 2 and 3 of the VON switch (VON switch not operated), through contacts 1 and 2 of SW–6 (busying switch), and through contacts 3 and 4 (not operated) of relay B to ground. Note that the ATB GND lead is multipled with the VON switch of all the linefinders in a group. Therefore, when any one or more linefinders in a group is idle (its VON switch not operated) the circuit to N–3 is complete and N–3 will remain operated.

b. Relay L. (Relay N–3 is operated at this point in the sequence of relay operation.) When a calling party removes the handset from the cradle, a circuit is completed from negative battery through the 600-ohm and 1,850-ohm windings of relay L, through contacts 7 and 8 of relay L, over the − side of the loop to the calling telephone, over the + side of the loop, through break contacts 5 and 6 of relay L (line relay), and through the 550-ohm winding of relay L to ground. The magnetic field developed by the current flowing through these three windings is sufficient to attract the heel piece of the relay armature only

that distance which will cause the X contacts of relay L (contacts 1, 2, 3, and 4), to close.

c. RELAY C–3. (Relay N–3 and X contacts of relay L are operated at this point in the sequence of relay operation.) When relay L closes its X contacts, the operating circuit of relay C–3 is completed from negative battery through the winding of relay C–3, through contacts 4 and 5 of relay N–3, through the start and level marking circuit, through contacts 3, 4, 9, and 10 of relay L to ground. When relay C–3 operates, it closes the operating circuit of relay P–3 and closes a circuit through contacts 1 and 2 to the start signal lamp, causing the filament of the start signal lamp to glow, and partially completes a circuit over which the delayed alarm will operate if the linefinder fails to function properly.

d. RELAY. P–3. (The following relays are operated at this point in the sequence of relay operation: relay N–3, X contacts of relay L, and relay C–3.) When relay C–3 operates, it closes the operating circuit of relay P–3, which runs from negative battery through the winding of the MM, through interrupter contacts 1 and 2 of the MM, through contacts 6 and 7 of relay N–3, through the winding of relay P–3, through contacts 3 and 4 of relay C–3, through contacts 9 and 10 of D–3, and through contacts 4 and 5 of F–3 to ground. When relay P–3 operates, it completes or partially completes the following circuits:

(1) The operating circuit of relay B of the linefinder. This circuit runs from negative battery through the winding of relay B, over the finder start lead, through level B distributor contacts, through the distributor wipers, through contacts 4T and 5T of relay P–3 to ground.

(2) The operating circuit of relay B–3 which runs from negative battery through the winding of relay B–3, and through resistor R–2 (a parallel shunt), through contacts 1 and 2 of relay F–3, and through contacts 4B and 5B of relay P–3 to ground.

Note. Relay B of the linefinder and relay B–3 of the group relays both operate immediately after P–3. Each of these relays, B and B–3, start separate but concurrent sequential relay operations. Relay B starts the relay action causing vertical and rotary stepping of the linefinders; relay B–3 starts a timing circuit which causes the call to be transferred to the partner group of linefinders if the linefinder fails to function properly.

(3) Partially completes a circuit to ground from its own winding through contacts 7T and 6T to contact 6 of relay F–3.

(4) Provides an additional circuit to ground from the winding of relay N–3 through contacts 2B and 3B of relay P–3. This circuit to ground from the winding of relay N–3 is required only when a linefinder is the last in its group to operate. In this event, when relay B of the linefinder operates, it removes the only remaining circuit to ground from the winding of N–3 through the ATB GND (*a* above). This additional ground holds relay N–3 operated until the call is completed after which relay N–3 is restored as described in paragraph 24.

(5) Partially completes the circuit which arrests vertical motion when the vertical bank wiper reaches the marked vertical bank contact. This partially completed circuit runs from the vertical bank wiper over the test 1 lead, through the level D contacts and wipers of the distributor, through contacts 6 and 7 of relay D–3, through the 85-ohm winding of relay D–3, through contacts 8T and 9T or relay P–3, and through the winding of relay A–3 to negative battery. The ground potential which completes this circuit is applied to the circuit when the vertical wiper seizes the marked vertical bank contact.

(6) Partially completes the circuit to the VERT MGT. This circuit runs from ground through contacts 6B and 7B of P–3, through break contacts 2 and 3 of relay A–3, through contacts 3 and 4 of D–3 to contact 11 of relay B of the linefinder.

(7) Prior to the operation of relay P–3 a partially completed circuit runs from negative battery through the winding of the distributor MM, through interrupter contacts 1 and 2 of the distributor MM, through contacts 6 and 7 of relay N–3, through break contacts 1T and 2T of relay P–3 to the level A (guard lead) wipers of the distributor. When relay P–3 operates, this partially completed

circuit runs from negative battery through the MM winding, through contacts 3T and 2T of relay P–3 to the level A wipers of the distributor.

e. Relay B. (The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of L, relays C–3, and P–3.) Relay P–3 completes the operating circuit of relay B (*d* (1) above). When relay B operates, it opens, completes or patrially completes the following circuits:

(1) Completes the operating circuit of the VERT MGT (*d* (1) above), through its contacts numbered 10 and 11, through the windings of the VERT MGT to negative battery.

(2) Partially completes the operating circuit of the RTY MGT. This circuit runs from negative battery through the windings of the RTY MGT, through contacts 3B and 4B of relay A, through contacts 3B and 4B of relay D, through contacts 8 and 9 of relay B, over the rotary lead, through contacts 1 and 2 of relay J–3, through contacts 1 and 2 of relay K–3 to contact 5 of relay D–3.

(3) Opens the circuit which held relay N–3 operated before the call was started. (N–3 does not restore (subpar. *d* (4) above). This circuit passed through contacts 3 and 4 of relay B.) Partially completes a circuit to the connector or selector over the C lead by placing ground potential on the C lead, through contacts 4 and 5 of relay B. Partially completes the circuit from the lower control bank wiper, through contacts 6 and 7 of relay B, over the test—2 lead, through the windings of relay J–3, through contacts 8 and 9 of relay F–3 to ground.

(4) Opens its contacts 1 and 2. A circuit from the guard lead to ground would be completed when the VON switch operates if contacts 1 and 2 of relay B had not opened. Opening contacts 1 and 2 prevents grounding of the guard lead at this point in the sequence. A grounded guard lead would cause the distributor wipers to step off the distributor contacts associated with the operating linefinder and disconnect it from the group relays.

(5) Places the 500-ohm noninductive winding of relay D across the loop to the first selector or connector, by closing contacts 12 and 13.

f. Vertical Magnet. (The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of relay L, relays C–3, P–3, and B.) When relay B operates, it completes the operating circuit of the VERT MGT (*e* (1) above). When the VERT MGT operates, it raises the wiper assembly one step and completes the operating circuit of relay A–3. This circuit runs from negative battery through the winding of relay A–3, over the interrupter lead, through contacts 1 and 2 of the VERT MGT.

g. Von Switch. (The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of relay L, relays C–3, P–3, B, and VERT MGT.) The mechanical movement of the linefinder switch caused by the first operation of the VERT MGT operates the VON switch. The VON switch contains two sets of break-before-make contacts. When the VON switch is not operated (the linefinder is in its idle position) the C lead to the selector or connector is connected to the guard lead of the linefinder. This connection runs from the guard lead through contacts 3 and 4 of SW–6, through contacts 1 and 2 of relay B (not operated), through contacts 5 and 6 of the VON switch to the C lead. If a short occurs in the trunk between the first selector (or connector) and the linefinder, a circuit will be completed from the guard lead of the linefinder to ground. This will also occur if the selector fails to remove ground from the C lead as a result of malfunction. In this event the distributor wipers will find the linefinder marked busy and step past it to the next idle linefinder. When a linefinder is seized and operated, the VON switch opens this circuit which passes through its contacts 5 and 6. A circuit to ground from the winding of relay N–3 (*a* above) is completed through contacts 2 and 3 of the VON switch when it is not operated. Note, however, that this circuit passes through the ATB lead which is multipled to contact 3 of the VON switch of all the linefinders in the group. Therefore, if the operating linefinder is the last linefinder in a group to operate, the circuit to ground from the winding of relay N–3 is broken and N–3 restores (par. 15*e*). When the VON switch operates, it also completes a connection to ground through its contacts 4 and 5. This ground con-

nection is used alternately by several circuits during operation of the linefinder and is noted in the applicable circuit descriptions. The VON switch also closes its contacts 1 and 2 through which the operating circuit of the RLS MGT is completed when the call has been concluded.

h. Relay A–3. (The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of relay L, relays C–3, P–3, B, VERT MGT, and VON switch.) The operating circuit of relay A–3, which is completed by the operation of the VERT MGT runs from negative battery through the winding of relay A–3, over the interrupter lead, and through contacts 1 and 2 of the VERT MGT to ground. When relay A–3 operates, it opens its break contacts 2 and 3, thus opening the operating circuit of the VERT MGT (*d* (6) above). This permits the VERT MGT to restore. But the operation of the VERT MGT closed the contacts which complete the operating circuit of relay A–3. Therefore, when the VERT MGT restores, relay A–3 restores. When A–3 restores, it again completes the operating circuit of the VERT MGT and the VERT MGT operates. Each time the VERT MGT operates, the wiper assembly is raised one step. This alternate operation of relay A–3 and the VERT MGT continues until the vertical bank wipers seize the marked vertical bank contact.

i. Relay D–3. (The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of relay H, relays C–3, P–3, B, and the VERT MGT.) When the vertical wiper seizes the marked vertical bank contact a circuit through the 85-ohm winding of relay D–3 is completed. This circuit runs from negative battery through the winding of relay A–3, through contacts 8T and 9T or relay P–3, through the 85-ohm winding of relay D–3, through contacts 6 and 7 of relay D–3, through level D of the distributor, over the test–1 lead to the marked vertical bank contact and through contacts 3, 4, 9, and 10 of relay L (the *X* contacts) to ground. Note that relay A–3 also operates momentarily, because its operating circuit is in series with the 85-ohm winding of D–3.

j. Relay D–3 Full Operation. The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of relay L, relays C–3, P–3, B, A–3, and *X* contacts of D–3. At this point in the sequence, relays H–3 and F–3 will be operated and the contacts of relay B–3 will be vibrating. The operation of these relays occurs concurrently with the vertical and rotary stepping (*n* through *q* below). When relay D–3 closes its *X* contacts, it completes a circuit through its 650-ohm winding which causes D–3 to operate fully. This circuit runs from negative battery through the 600-ohm winding of relay D–3, through contacts 1 and 2 (the *X* contacts of relay D–3) through contacts 2 and 3 of relay H–3, through contacts 2 and 3 of relay F–3, through contacts 4B and 5B of relay P–3 to ground. When relay D–3 operates fully it completes, partially completes, or opens the following circuits:

(1) Opens the operating circuit of the VERT MGT (*e* (1) above) which passed through its 3 and 4 contacts.

(2) Causes A–3 to restore by causing the VERT MGT to restore.

(3) Completes the circuit to the RTY MGT (*e* (2) above), which runs from negative battery through the winding of the RTY MGT, through contacts 3B and 4B of relay A and 3B and 4B of relay D, through contacts 8 and 9 of relay B, through contacts 1 and 2 of relay J–3, through contacts 1 and 2 of relay K–3, through contacts 4 and 5 of relay D–3 (closed by full operation of relay D–3), through contacts 2 and 3 of relay A–3, and through contacts 6B and 7B of relay P–3 to ground.

(4) Opens the circuit through its own 85-ohm winding (*i* above), which passed through 6 and 7 contacts.

(5) Opens the initial operating circuit of relay P–3 (*d* above) which passed through its 9 and 10 contacts.

Note. When D–3 opens the circuit to the VERT MGT, the VERT MGT restores; consequently A–3 restores.

k. Rotary Magnet. (The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of relay L, relays C–3, P–3, B, and D–3.) When relay A–3 restores, it completes the circuit to RTY MGT as described in (*j* (3) above). When the RTY MGT operates, it closes an operating circuit of relay A–3. The circuit which operated A–3 following the operation of the VERT MGT and was completed to ground through contacts 1 and 2 of

the VERT MGT, is now completed to ground through contacts 1 and 2 of the RTY MGT. (Note that the VERT MGT has completed its function and restored.) When A–3 operates it opens the operating circuit of the RTY MGT, and the RTY MGT restores. However, when the RTY MGT restores, it opens the operating circuit of A–3; A–3 restores, and again completes the operating circuit of the RTY MGT. The alternate operation of the RTY MGT and relay A–3 continues, moving the linefinder's wipers one rotary step for each operation of the RTY MGT, until the wipers seize the marked control bank contact.

l. Seizure of Marked Control Bank Contact and Operation of Either Relay J–3 or K–3 and Full Operation of Relay L. (The following relays are operated at this point in the sequence of relay operations: relay N–3, *X* contacts of relay L, relays C–3, P–3, D–3, and the VERT MGT.) At this point relays H–3 and F–3 will have been operated as described in *n* through *q* below. It is possible for each of the two control bank contacts at one position in the linefinder banks to be electrically marked at the same instant, if the two telephones associated with these contacts are lifted simultaneously from their respective cradles. It is assumed in the discussion of relay J–3 and relay K–3 which follows that only one of the control bank contacts is marked. If the upper control bank contact is electrically marked with negative battery, the operating circuit of relay K–3 is completed from negative battery through the 600-ohm winding of relay L, through contacts 1 and 2 of relay L, to the upper control bank contact, through the upper control bank wiper, over the test–1 lead, through level D of the distributor, through contacts 7 and 8 of relay D–3, through the winding of relay K–3, and through contacts 9 and 10 of relay F–3 to ground. If, however, the lower control bank contact is marked, the operating circuit of relay J–3 will be completed instead of that of K–3. This circuit runs from negative battery through the 600-ohm winding of relay L, through contacts 1 and 2 of relay L, through the lower control bank contact, through the lower control bank wiper, through contacts 6 and 7 of relay B, over the test–2 lead, through the windings of relay J–3, and through 7 and 8 of relay F–3 to ground. The circuit to the RTY MGT is opened when either relay J–3 or K–3 operates because the operating circuit of the RTY MGT passes through contacts 1 and 2 of both of these relays in series. Therefore when relay J–3 or K–3 operates, the RTY MGT restores. (Note, however, that when the RTY MGT operates for the last step, it closes the circuit to relay A–3, then relay A–3 operates and restores; this has no effect on the other components of the circuit.) The operating circuit of relay J–3 or K–3 passes through the winding of relay L causing relay L to operate fully. Full operation of relay L removes the line relay windings from the loop circuit and removes ground from the CN lead to the connector. Ground is replaced on the CN lead by the selector when relay A or D, which operate concurrently with the full operation of the line relay, complete the circuit through the C lead to the selector. Full operation of the line relay also opens the initial operating circuit of relay C–3, which passed through its contacts 9 and 10 to ground. C–3 does not restore, however, because of a holding circuit completed when relay H–3 operates (*o* (1) below).

Note. In the event that both the upper and lower control bank contacts are marked with negative battery at the same instance, both relay J–3 and relay K–3 will operate. Relay A of the linefinder will receive preference, however, because the operating circuit of relay D is complete only when contacts 1 and 2 of K–3 are in the unoperated or restored condition. Therefore, when relay K–3 operates it opens the operating circuit of relay D. The loop of the telephone which marks the lower banks of the linefinders will not be extended until the group relays have extended the loop of the telephone which marks the upper banks and have been connected to the next idle linefinder by the stepping of the distributor.

m. Relay A or Relay D. (The following relays are operated at this point in the sequence of relay operation: relays N–3, L, C–3, P–3, B, D–3, and J–3 or K–3.) If the lower control bank wiper is marked and relay J–3 operates, relay D operates. The circuit is completed from negative battery through the winding of relay D, through break contacts 1T and 2T of relay A, through level E of the distributor, through contacts 2 and 3 of relay J–3, through contacts 1 and 2 of relay K–3, through contacts 4 and 5 of relay D–3, through contacts 3 and 4 of relay A–3, through contacts 6B and 7B of relay P–3 to ground. The operating circuit of relay D is completed through make contacts 4 and 5 of relay D–3 when relay D–3 is in its operated position. Relay D–3, being one of the group relays, will restore after the linefinder has extended the loop of the calling telephone to the selector or connector, but relay D must remain

operated for the duration of the call. Therefore, when relay D operates it completes its own holding circuit. This circuit runs from negative battery through the winding of relay D, through contacts 4T and 5T of relay D to the C lead. Ground potential is maintained on the C lead for the duration of the call by each switch in the switch train and finally by the connector. When relay D operates it also completes, partially completes, or opens the following circuits:

(1) Extends the + and − sides of the loop of the calling telephone to the selector through its own contacts 7B and 8B, and 5B and 6B, respectively.

(2) Completes a circuit which runs from negative battery through the 600-ohm winding of relay L, through contacts 1 and 2 of relay L, through the lower control bank contact, through the lower control bank wiper, through contacts 6T and 7T of relay D over the C lead and through components of the associated selector or connector to ground (TM 11–2105).

(3) Opens a partially completed operating circuit of relay A to assure that relay A will not operate. This partially completed circuit runs through contacts 1B and 2B of relay D.

(4) Partially completes the circuit which causes the distributor MM to operate. This circuit, when completed, runs from negative battery through the winding of the distributor MM, through contacts 2T and 3T of relay P–3, through the level A wipers and contacts of the distributor, over the guard lead, through contacts 3 and 4 of SW–6, through contacts 8T and 9T of relay D, and through contacts 4 and 5 of the VON switch to ground. Prior to the operation of A or D the circuit from the guard lead to ground was open.

(5) Opens a partially completed circuit to the RLS MGT which passes through contacts 1T and 2T, and partially completes the test circuit which is used to determine whether a call in progress is in the upper or lower line bank. This test circuit, when completed by the insertion of a coin or screw-driver blade in the lower test jack, runs from negative battery through the filament of the lower bank lamp to one contact of the lower test jack, through the inserted shorting tool or coin, to the opposite side of the test jack, from the opposite side of the test jack through the contacts 2T and 3T of relay D, through contacts 1 and 2 of the VON switch, through contacts 1 and 2 of SW–6, and through contacts 3 and 4 of relay B to ground. (This circuit is not actually completed until relay B restores, but relay D completes the connections from the lower bank lamp to the contacts of relay B which apply ground.)

(6) Opens the circuit to the RTY MGT (*j* (3) above).

Note. If the upper control bank wiper is marked, relay K–3 operates and relay A of the linefinder operates. Relay A completes the same circuit for the upper line bank as relay D does for the lower line bank (fig. 35).

n. Relay B–3. (Operation of relay B–3 occurs concurrently with that described beginning with *e* above. The following relays are operated at this point in the sequence of relay operation: N–3, *X* contacts of relay L, relays C–3, and P–3.) The circuit analysis contained in *a* through *m* above describes the action of the group relays and linefinder relays which actually extend the loop through to the first selector. Immediately following the operation of relay P–3, a concurrent train of relay operation, beginning with relay B–3, is started which times the operation of the linefinder. Relay B–3 operates when its operating circuit is closed by the operation of relay P–3 (*d* (2) above). Relay B–3 closes the operating circuit of relay H–3 which runs from negative battery, through the winding of relay H–3 and shunt resistor R–3, through contacts 1, 2, and 3 of relay B–3, and through contacts 4B and 5B of relay P–3 to ground.

o. Relay H–3. (The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of relay L, relays C–3, P–3, and B–3.) Relay H–3 partially completes its own holding circuit from negative battery through its own winding, through its 8 and 9 contacts to double-contact 2 and 4 of relay B–3, through contacts 4B and 5B of P–3 to ground. Relay H–3 also completes, partially completes, or opens the following circuits:

(1) Completes a circuit which applies ground potential to the fifth level of all linefinders in its own group, thus preventing

the linefinders from operating above the fifth level until H–3 or N–3 of the opposite group restores. This circuit runs from negative battery through the winding of relay C–3, through contacts 4 and 5 of relay N–3 of its own group, over the start lead of its own group, through the level 5 start and level marking resistor of its own group, through contacts 8 and 9 of relay N–3 of the partner group, and through contacts 10 and 11 of relay H–3 of its own group to ground.

(2) Completes the operating circuit of relay F–3 which runs from negative battery through the 1,300-ohm winding of relay F–3, and through contacts 4 and 5 of relay H–3 to ground.

(3) Completes another circuit to ground from the winding of relay P–3. This circuit runs from the winding of relay P–3 through contacts 6T and 7T of relay P–3, and through contacts 6 and 7 of relay H–3 to ground.

(4) Opens a partially completed circuit to relay E–3 to prevent relay E–3 from operating when relay F–3 operates. This circuit runs from negative battery through the 400-ohm winding of relay E–3, through contacts 1 and 2 of relay H–3 (when H–3 is not operated), through contacts 2 and 3 of relay F–3 (when F–3 is operated), and through contacts 4B and 5B of relay P–3 to ground.

p. Relay F–3. (The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of L, relays C–3, P–3, B–3, and H–3.) Relays F–3 operates when relay H–3 completes its operating circuit as described in *o* (2) above. Relay F–3 completes, partially completes, or opens the following circuits:

(1) Completes its holding circuit through its 1,250-ohm winding, which runs from negative battery through this winding, through contacts 11 and 12 of relay F–3, and through contracts 4T and 5T of relay P–3 to ground.

(2) Opens the initial operating circuit of relay F–3 (*c* above), which passed through contacts 4 and 5 of relay F–3 when F–3 was not operated. Completes another circuit to ground from the winding of relay P–3 which runs from the winding of relay P–3 through contacts 6T and 7T of P–3, through contacts 5 and 6 of relay F–3 to ground.

(3) Opens the operating circuit of relay B–3 (*n* above) which passes through contacts 1 and 2 of relay F–3 when F–3 was not operated.

(4) Partially completes the operating circuits of relays J–3 and K–3, (*l* above) which pass through contacts 7 and 8 and contacts 9 and 10, respectively, of relay F–3.

q. Relay B–3 Restores. (The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of relay L, relays C–3, P–3, B–3, and F–3.) When relay F–3 restores, it opens the operating circuit of relay B–3 as described in *m* (3) above. When relay B–3 restores, it starts its weighted armature vibrating. The armature makes alternate contact with the two points of contacts 2 and 4 of relay B–3, thus completing intermittently, the circuit which holds relay H–3 operated. This circuit runs from negative battery through the winding of relay H–3 and resistor R–3, through contacts 8 and 9 (operated) of relay H–3, through contacts 2 and 3 of relay B–3, and through contacts 4B and 5B of relay P–3 to ground. The vibrating contacts of relay B–3 are set to vibrate with sufficient amplitude to maintain the holding circuit for a period of approximately 3½ seconds. Under normal conditions the linefinder will operate, seize the marked contact, and extend the loop of the calling telephone to the selector in this time interval.

Note. The sequence of relay operation described in *a* through *p* above assumes normal operation of the linefinder up to and including the actual extension of the loop to the selector. The sequence of group relay operation and restoration which normally follows after the loop has been extended is described from *o* above through *z* below.

r. Distributor Motor Magnet Operates. (This step occurs immediately following the operation of relay D or relay A. The following relays are operated at this point on the sequence of relay operation: relays N–3, L, C–3, P–3, B, J–3, or K–3, D or A, H–3, F–3, and D–3. The VERT MGT, relay A–3, and RTY MGT have completed their respective functions and restored. Relay B–3 has restored, but assuming normal functioning of the linefinder, its armature will be vibrating.) When relay A or D operates it completes a circuit through the winding of the distributor MM

as described in *m* (4) above. Note that a circuit had been completed through the winding of the MM in series with the winding of relay P–3 (*d* above). However, the current flowing through the MM winding when it is in series with P–3 is not sufficient to cause the MM to operate. When the MM operates it opens the circuit between P–3 and negative battery. At this point in the relay sequence the circuit from negative battery to the winding of P–3 runs from negative battery through the winding of the MM, through contacts 1 and 2 (the interrupter contacts) of the MM, through contacts 6 and 7 of relay C–3 to the winding of relay P–3. (The circuit from relay P–3 to ground had been completed through several paths described in the foregoing subparagraphs.)

s. Relay P–3 Restores. (The following relays are operated at this point in the sequence of relay operation: relays N–3, L, C–3, B, H–3, D–3, A or D, J–3 or K–3, and F–3.) Relay P–3 restores when its operating circuit, which passes through the interrupter contacts of the MM, is opened by the operation of the MM. When P–3 restores it opens the circuit which caused operation of the MM. This operating circuit of the MM (*m* (4) above) runs from negative battery through the winding of the distributor MM, through contacts 2T and 3T (operated) of relay P–3, through the level A wipers and contacts of the distributor, over the guard lead, through contacts 3 and 4 of SW–6, through contacts 8T and 9T of relay D (operated), and through contacts 4 and 5 of the VON switch to ground. However, as relay P–3 restores, contact 2T breaks with contact 3T and makes with contact 1T. Closing contacts 1T and 2T of relay P–3 partially completes another circuit through the winding of the MM (*t* below). When relay P–3 restores it also opens the following circuits:

(1) Opens the operating circuit of relay B (*d* (1) above) which passed through the (operated) contacts 4T and 5T of P–3, permitting B to restore, and opens the full operating circuit of relay D–3 (*j* above).

(2) Opens the circuit which holds relay H–3 operated (*o* above) which passed through contacts 4B and 5B of P–3, permitting H–3 to restore.

(3) Opens a circuit from ground to the winding of relay N–3 which passed through contacts 2B and 3B of P–3. Note, however, that relay N–3 does not necessarily restore since its circuit is complete through the ATB GND lead which is multipled to ground through the VON switch and through the unoperated contacts 3 and 4 of relay B of any idle linefinder in its group. If, however, the operating linefinder is the last of its group which is idle when the call is cut through to the selector, the holding circuit of relay N–3 will be opened, when contacts 2B and 3B of P–3 break, and N–3 will restore.

(4) Opens a section of what had been the operating circuit of relay A–3, which passed through contacts (operated) 8T and 9T of P–3. Since the circuit to relay A–3 had previously been opened when the vertical and rotary stepping was completed, opening these contacts has no further effect.

(5) Opens a section of what had been the circuit which operated the *X* contacts of relay D–3. This circuit had been previously broken when D–3 was fully operated; therefore, opening these contacts when P–3 restores has no effect.

t. Distributor MM Restores. When relay P–3 restores, it opens the operating circuit of the MM as described in *s* above. As the MM restores, it causes the distributor wipers to rotate one step and also closes its interrupter contacts. When the distributor has been moved forward one step, it breaks the following circuits between the group relays and the linefinder which has just completed operation, and partially completes these same circuits between the group relays and the linefinder associated with the next set of distributor contacts:

(1) The operating circuit of relay B of the linefinder which passes over the finder start lead. (Note that relay B actually restores, when P–3 restores.)

(2) When the MM restores it closes its interrupter contacts 1 and 2. This action may, or may not, complete a circuit through the winding of the MM. This circuit runs from negative battery through the winding of the MM, through contacts 1 and 2 of the MM, through contacts 6 and 7 of relay N–3, through contacts 1T and 2T (restored) of relay P–3, through the level A wipers and contacts of the distributor, over the guard lead of the linefinder to which the wipers have

stepped, through contacts 3 and 4 of SW–6 of the linefinder, to contact 2 of relay B of the linefinder. If the linefinder to which the wipers have stepped is idle, its relay B will be restored and the circuit may be traced through contact 1 of relay B, through contacts 5 and 6 of the VON switch to the C lead. However, the C lead of an idle linefinder to the selector is not grounded; the circuit to the winding of the MM is not complete; the MM does not operate again and the distributor wipers remain on the distributor contact of this idle linefinder. If the linefinder to which the wipers have stepped is busy, the circuit will be completed from contacts 3 and 4 of SW–6, through contacts 8T and 9T of relay D (if D is operated), or through 7T and 8T of relay A (if A is operated), through contacts 4 and 5 of the operated VON switch of the busy linefinder to ground. If the circuit through the winding of the MM is thus completed, the MM will operate again, and, in so doing, open its operating circuit which passes through its own interrupter contacts; then the MM restores, stepping the wipers to the next set of distributor contacts. The identical conditions apply to the circuit through the linefinder associated with the next set of distributor contacts. If it is idle the distributor wipers remain on its distributor contacts; if it is busy the wipers are stepped forward by operation and restoration of the MM as described above. Thus the distributor will continue to step its wipers from linefinder to linefinder until an idle one is found, provided that at least one linefinder in the group is idle.

(3) The VERT MGT lead over which the circuit to the VERT MGT is completed.

(4) The lead to relay D of the linefinder, over which the initial operating circuit of relay D is completed. (Relay D provides its own holding circuit.)

(5) The lead to relay A of the linefinder, over which the initial operating circuit to relay A is completed. (Relay A provides its own holding circuit.)

(6) The test–1 lead over which the circuit to relay K–3 is completed. If relay K–3 had been operated, this stepping of the distributor wipers opens its operating circuit and K–3 restores. (Note that J–3 does not restore at this point if it had been operated, because its circuit does not pass through the distributor wipers.)

u. Relay B of the Linefinder Restores. (The following relays are operated at this point in the sequence of relay operation: relays N–3, L, C–3, H–3, D–3, F–3, and relay A or D.) Note that a concurrent series of relay restorations occur at the instant relay B restores, beginning with relay H–3. When relay B restores it opens or completes the following circuits:

(1) Opens the circuit which had functioned as the operating circuit of the VERT MGT and the RTY MGT, which passed through its contacts 10 and 11, and contacts 8 and 9, respectively. These circuits had been previously opened.

(2) Completes a multiple circuit to ground from the guard lead. This circuit runs from the guard lead through contacts 3 and 4 of SW–6, through contacts 1 and 2 of relay B and through contacts 4 and 5 of the VON switch to ground. This circuit marks the distributor contacts as busy for the duration of the call (until the linefinder restores its VON switch).

(3) Opens the circuit which first connected ground potential to the C lead. This circuit ran from the C lead through contacts 4 and 5 of relay B to ground. Note, however, that ground is applied to the C lead by the next switch in train (selector or connector) as soon as either relay D or A operates (TM 11–2105). When contact 4 breaks with contact 5 it makes with contact 3, thus partially completing the circuit to the lower bank lamp (*m* (5) above).

(4) Opens the operating circuit of relay J–3 (if relay J–3 had operated) which passes through its 6 and 7 contacts (*l* above), permitting J–3 to restore.

(5) Removes the 500-ohm noninductive shunt winding of relay D from the + and − sides of the loop by opening contacts 12 and 13.

v. Relay H–3 Restores. (The following relays are operated at this point in the sequence of relay

operation: relays N–3, L, C–3, D–3, F–3, A or D, and relay J–3, or K–3.) Relay H–3 restores when its holding circuit is opened by restoration of relay P3 (*p* above). When relay H–3 restores it opens, completes, or partially completes the following circuits:

(1) Opens the circuit from the winding of relay C–3 to ground which held C–3 operated after its initial operating circuit was opened by the operation of relay F–3. The holding circuit of C–3 thus opened (*o* (1) above), passed through contacts 10 and 11 of H–3.

(2) Opens the contacts through which its own holding circuit had passed before B–3 restored (*j* above). This passed through contacts 8 and 9 of H–3.

(3) Opens its contacts 2 and 3 through which the operating circuit of relay D–3 passed before P–3 restored, and closes its contacts 1 and 2 through which the operating circuit of relay E–3 would pass if relay P–3 had not restored. (For the operation of relay E–3, see paragraph 25.)

(4) Opens its contacts 6 and 7 through which one of the multiple ground circuits to P–3 had previously passed.

(5) Opens the operating circuit of relay F–3 (*o* (2) above).

w. Relay D–3 Restores. (This occurs immediately after the restoration of relay P–3. The following relays are operated at this point in the sequence of relay operation: relays L, A or D, and relay F–3). The restoration of relay D–3 has no effect on the circuits of the group relays or the linefinder because all of the circuits which pass through its contacts have been previously opened when other relays in the group restored.

x. Relay C–3 Restores. (Relays L, A or D, and relay F are operated at this point in the sequence of relay operation.) The holding circuit of relay C–3 (*o* (1) above) is opened when relay H–3 restores. When relay C–3 restores, it opens the circuit to the ST SIG lamp which passes through its contacts 1 and 2, and opens its contacts 3 and 4 through which the initial operating circuit of P–3 passed before F–3 operated. If another call has been originated in the group relay, C–3 will not restore as indicated. This other call will cause the line relay of this second calling telephone to operate its *X* contacts, completing a circuit to relay C–3 through the start and level marking resistors. This circuit, which would prevent relay C–3 from restoring, may or may not pass through the same start and level marking resistor as the previous call. Note also that although relay C–3 remains operated, relay P–3 cannot operate until after relay F–3 restores since the initial operating circuit of relay P–3 passes through contacts 4 and 5 of relay F–3 (restored) to ground. Since relay F–3 is the last relay of the group relays to restore (except for C–3) the group relays will be ready to handle the next call when F–3 restores.

y. Relay F–3 Restores. (Relays L, A or D of the linefinder are operated at this point in the sequence of relay operation.) Relay F–3 restores when its operating circuit is opened by H–3. The restoration of relay F–3 has no effect on the circuits of either the group relays or the relays of the linefinder since all circuits passing through its contacts have been previously opened by the restoration of other relays.

z. All Group Relays Restored. As each group relay restores after the loop has been extended to the selector, its contacts return to the positions held at the start of the call. The circuits of the group relays are thus returned to the condition in which they were at the start of the call. When all group relays have restored they are ready to handle another call through the linefinder to which they have been connected by the distributor. Relay A or D of the linefinder (which has operated) and relay L, the line relay, do not restore until the calling party replaces the handset on the cradle. Note, however, that the linefinder which has been discussed throughout this paragraph is no longer connected to the group relays because the distributor wipers have stepped to the next idle linefinder.

Note. The foregoing subparagraphs which describe the restoration of the linefinder and group relays indicate the sequence in which each relay restores and the circuits affected by the restoration of each relay. Note, however, that several relays restore concurrently. The restoration of relay P–3 simultaneously opens the circuits to relay B of the linefinder, the vibrating contacts of B–3 and thus to H–3, to relay D–3, and to the MM. The circuit to relay K–3, if it has been operated, is opened concurrently in two places; once by the restoration of relay B, and once by the stepping of the distributor wipers. The restoration of relay H-3 simultaneously opens the operating circuits of relay C–3 and relay F–3.

23. Operating Sequence at Termination of Call

When the calling party replaces the handset on the cradle, the loop circuit is opened to the last switch in train. This last switch in train will be the connector if the call has been extended to the connector. It will be the selector, however, to which the loop has been extended if the calling party replaces the handset before the loop has been extended to a connector. When the loop circuit is opened, a relay of this last switch in train restores, removing ground from the C lead.

a. Relay A or Relay D and Relay L Restore. The circuit, which holds relay A or relay D and relay L operated, (par. 22*m*) obtains ground from the C lead. When the last switch in train removes this ground, relay A or relay D and relay L restore.

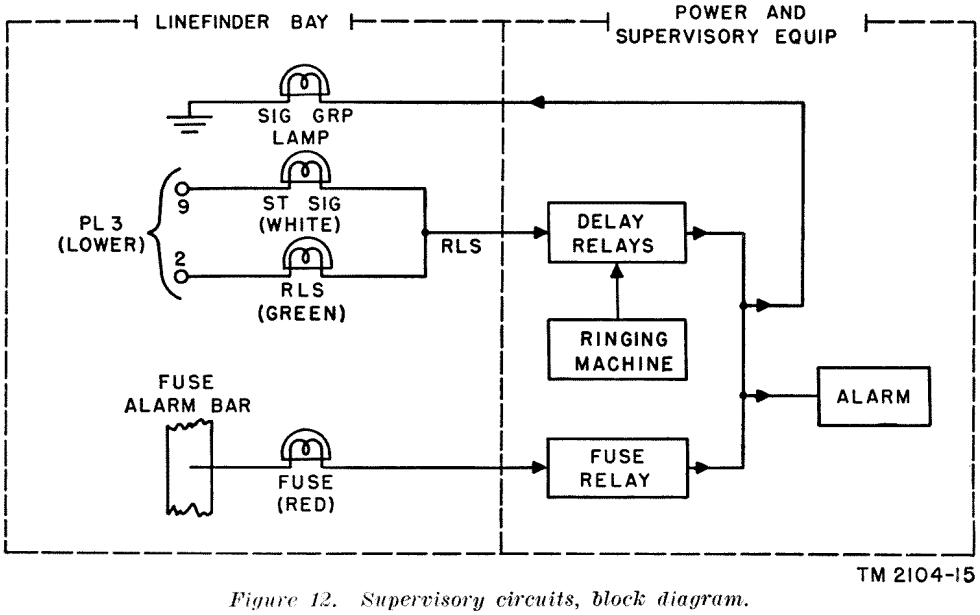

Figure 12. Supervisory circuits, block diagram.

b. Relay G–3 and RLS MGT Operate. When either A or D restores, a circuit is completed which runs from negative battery, through the winding of relay G–3, through the winding of the RLS MGT, through contacts 1B and 2B of relay A, through contacts 1T and 2T of relay D, through contacts 1 and 2 of the VON switch (par. 22*g*), through contacts 1 and 2 of SW–6, and through contacts 3 and 4 (restored) of relay B to ground. When the RLS MGT operates, the movement of its armature causes the detents to be withdrawn from the vertical and rotary ratchets on the linefinder shaft. The tension in the rotary off-normal spring causes the shaft and bank wipers to return to the normal rotary position. When the shaft is in this position, a channel in the vertical ratchets permits the switch to drop by its own weight to its normal vertical position. When relay G–3 operates, it applies ground potential to the RLS lamp lead through its contacts 1 and 2 and partially completes a circuit to the RLS alarm. If the RLS mechanism fails to restore the linefinder to normal in a predetermined interval, a delay relay cycle causes a buzzer to sound at the power board, causes the signal group lamp (aisle pilot lamp) for a row of linefinder bays to glow, and causes the green RLS lamp on the fuse and lamp panel of the particular shelf to glow (fig. 18). Refer to TM 11–2108 for a full explanation of this circuit. The operation of relay G–3 also closes a circuit to the P-C (peg-count) meter through contacts 3 and 4. If a P-C meter is used, it registers that a call has been made. Although shelf wiring for a P-C meter is installed by the manufacturer, the meter itself is not used in many military installations.

c. Von Switch Restores, G–3 and RLS MGT Restore. (Relay G–3 and RLS MGT are operated at this point in the sequence of relay operation.) When the linefinder shaft drops to its normal position it causes the VON switch to restore. When it restores it opens its contacts 1 and 2 through which the circuit to the RLS MGT and relay G–3 was completed. When their circuits are thus opened the RLS MGT and relay G–3 restore.

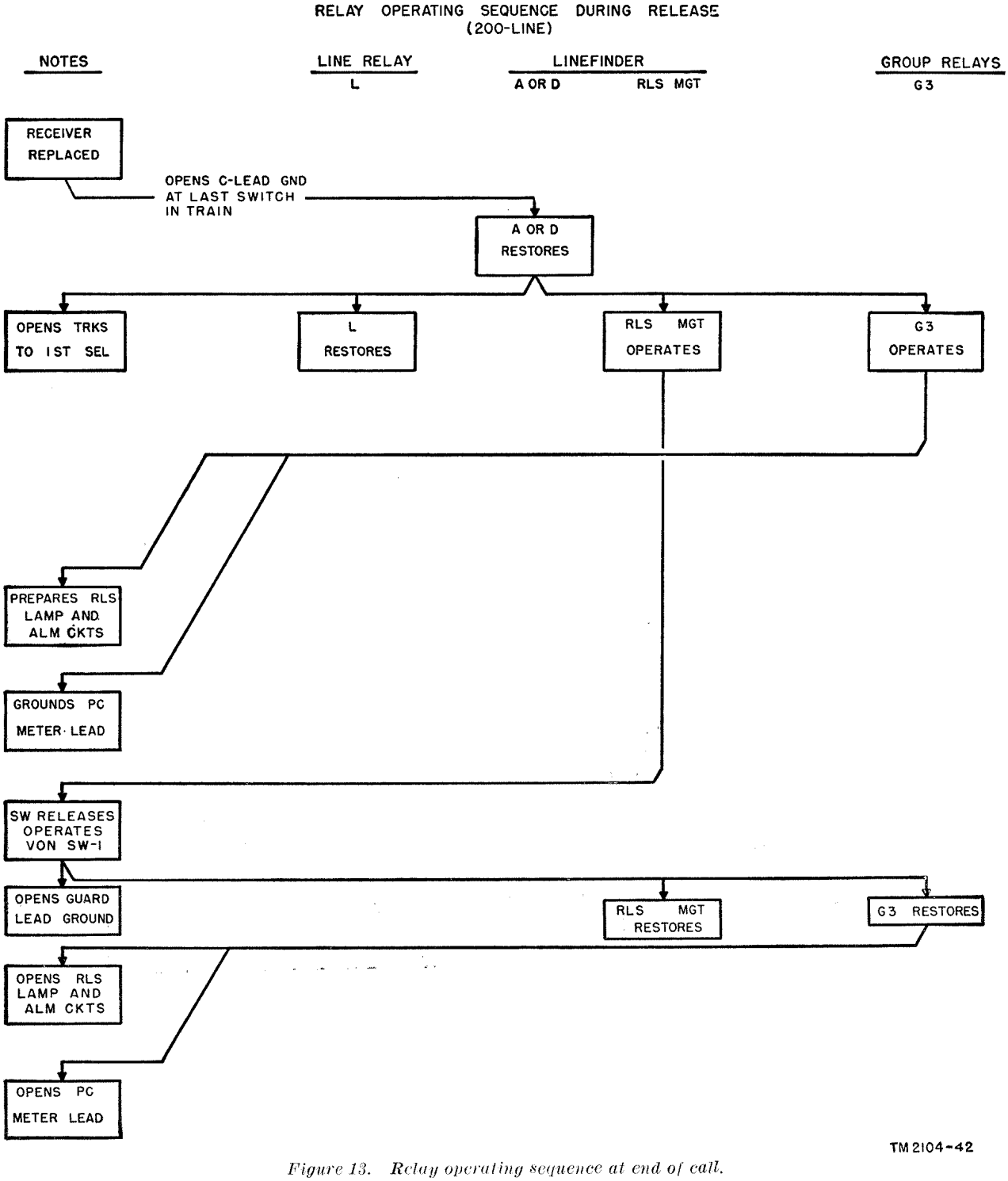

Figure 13. Relay operating sequence at end of call.

24. Failure in Vertical and Rotary Stepping

If for any reason the linefinder wipers are prevented from stepping to the marked contacts of the calling line within the period of time set by design for this action, the call will be transferred to the partner group of linefinders. The relay sequence which causes this to occur is as follows:

a. Vibrating Reed of Relay B–3 Comes to Rest. The holding circuit of relay H–3 is complete through the vibrating reed contacts of relay B–3

(par. 22*q*). As the amplitude of these vibrations diminishes, relay H–3 receives fewer pulses and is finally allowed to restore.

b. Relay H–3 Restores. (The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of relay L, and relays C–3, P–3, B, and F–3.) Relay D–3 may or may not be operated depending on whether the movement of the linefinder has been halted before or after rotary motion began. When relay H–3 restores, it opens, completes, or partially completes the following circuits:

(1) Opens one of the circuits to ground from the winding of relay P–3 through contacts 6 and 7.

(2) Opens the circuit to ground from the 1,300-ohm start winding of relay F–3, but F–3 does not restore because it is held operated by the current flowing through its 1,250-ohm winding.

(3) Opens the holding circuit of relay C–3 (par. 22*o* (1)), which passed through its contacts 10 and 11. Relay C–3 does not restore, however, because its initial operating circuit (the start circuit) has not been opened. Note that the holding circuit for relay C–3 also completes a circuit to ground from the fifth level contacts in the vertical banks of the linefinders of its own group. Whenever this fifth level contact is marked with ground, the linefinders in that group will not operate above the fifth level. This is because the test-1 lead contacts ground on the fifth level, completes the operating circuit of D–3 and starts the rotary motion (par. 22*i*).

(4) Completes the operating circuit of relay E–3, which runs from negative battery, through the 400-ohm winding of relay E–3, through contacts 1 and 2 of relay H–3 (restored), through contacts 2 and 3 of relay F–3 (operated), through contacts 4B and 5B of relay P–3 (operated) to ground.

(5) Opens the holding circuit of relay D–3 which passes through its contacts 2 and 3.

c. Relay D–3 Restores. (The following relays are operated at this point in the sequence of relay operation: *X* contacts of relay L, and relays C–3, P–3, and F–3.) If relay D–3 had been operated when relay H–3 restored, D–3 restores. When relay D–3 restores, the circuits to the RTY MGT and the test-2 lead are opened, thus preventing further current flow through the circuits affecting rotary movement.

d. Relay E–3 Operates. (The following relays are operated at this point in the sequence of relay operation: relay N–3, *X* contacts of relay L, and relays C–3, P–3, and F–3.) When relay E–3 operates, it locks itself in the operated position by completing a circuit through its 1,800-ohm winding to the ATB lead of the partner group of linefinders. This circuit runs from negative battery through the 1,800-ohm winding of relay E–3, through its contacts 5 and 6, through contacts 1 and 2 of SW–7, over the ATB lead of the partner group, through contacts 2 and 3 of *each unoperated VON switch in the linefinders of the partner group*, through contacts 1 and 2 of SW–6 of each idle linefinder in the partner group, and through contacts 3 and 4 of relay B of each idle linefinder in the partner group to ground. Note that the holding circuit of relay E–3 is completed through any idle linefinder of the partner group. Therefore, relay E–3 will not restore until all linefinders in the partner group are busy, or until the group busying switch of either group is mechanically operated by attending personnel. When relay E–3 is operated, it also completes, partially completes, or opens the following circuits:

(1) Opens the operating circuit of relay N–3 in its own group (par. 22*a*), which passes through its contacts 3 and 4 and through contacts 3 and 4 of SW–7, to the ATB lead of its own group, and opens its contacts 1 and 2 through which an alternate operating circuit of relay N–3 passes to the ATB lead of the partner group of linefinders.

(2) Completes an operating circuit of the MM. This circuit runs from negative battery, through the winding of the distributor MM, through contacts 2T and 3T of relay P–3, through contacts 7 and 8 of relay E–3, through contacts 6T and 7T of relay P–3, and through contacts 5 and 6 of relay F–3 to ground.

e. Relay N–3 Restores. When the operation of relay E–3 opens the operating circuit of relay N–3, relay N–3 restores. When relay N–3 restores, it opens, completes, or partially completes the following circuits:

(1) Opens the operating circuit of relay C–3

of its own group (par. 22*c*), which passed through contacts 4 and 5 of relay N–3, and closes a circuit through its contacts 3 and 4 to relay C–3 of the partner group (par. 15 and fig. 8). Note that when any line relay operates it marks the banks of all linefinders in both groups. Because of the arrangement of the start and level marking resistors (fig. 8), the circuit of relay C–3 is normally completed only by the operation of a line relay associated with a line which terminates in the lower five bank levels of its own group of linefinders. When relay N–3 restores, it opens the circuit between relay C–3 and the start and level resistors *of its own group* and closes a circuit between relay C–3 and the start and level resistors *of the partner group.*

(2) Opens the circuit which marks the fifth level contact in the vertical banks of the partner group, thus permitting the partner group to operate above the fifth level. This circuit is described in paragraph 22*o* (1). Note that when relay H–3 operates, it completes a circuit to ground from the fifth level contact in the vertical banks of the linefinders in its own group, but that this circuit passes through contacts 8 and 9 of relay N–3 *of the partner group.* (Note in par. 15 that the lines which appear in the lower five bank levels of the group in which the linefinder failure has occurred, appear in the upper five levels of the partner group. Therefore, when the circuit, closed by the line relay of the calling telephone, is transferred to relay C–3 of the partner group and the fifth level-marking circuit of the partner group is opened, an idle linefinder of the partner group will search above its fifth bank level for the calling telephone.)

(3) Opens an operating circuit of the MM which is normally closed through the MM interrupter contacts and the guard lead of a busy linefinder (par. 22*t* (2)). This circuit passes through contacts 6 and 7 of relay N–3 when N–3 is operated.

(4) Partially completes a circuit to the ATB meter, which registers each time relay N–3 of both groups are restored at one time.

f. Distributor MM Operates. (The following relays are operated at this point in the sequence of relay operation: *X* contacts of relay L, relays C–3, P–3, and F–3.) Note that the operation of the MM occurs concurrently with the restoration of relay N–3 as an immediate effect of the operation of relay E–3. When the MM operates it opens its interrupter contacts, thus opening the circuit between the winding of relay P–3 and negative battery. Note, however, that the circuit which causes operation of the MM in this instance is described in *d* (2) above and is not the same circuit which causes operation of the MM during the normal sequence of linefinder operation (par. 22*m* (4)).

g. Relay C–3 Restores. (The following relays are operated at this point in the sequence of relay operation: relay P–3, B, and F–3.) Although the holding circuit of relay C–3 was opened when relay H–3 restored, its initial operating circuit was still closed because the line relay is held operated by the calling party who is waiting for dial tone. The initial operating circuit of relay C–3 (par. 22*c*) passes through contacts 4 and 5 of relay N–3. When N–3 restores, it opens the initial operating circuit of C–3, and C–3 restores. When relay C–3 restores, it opens the following circuits:

(1) The circuit to the start signal lamp of its own group, which passes through contacts 1 and 2 of relay C–3.

(2) The incomplete circuit through its contacts 3 and 4. This constituted the initial operating circuit of relay P–3, but received its ground through contacts 4 and 5 of relay F–3 which is now operated. Therefore, opening contacts 3 and 4 of relay C–3 has no effect on the other components of the circuit.

h. Relay P–3 Restores. (The following relays are operated at this point in the sequence of relay operation: *X* contacts of relays L, B, F–3 and the MM.) When the MM operates, it opens the operating circuit of relay P–3 which is complete through the interrupter contacts of the MM (par. 22*r*). When relay P–3 restores, it opens the circuits described in paragraph 22*s*; however, note that some of the circuits passing through these contacts have been previously opened. The only circuits which are now completed through closed contacts of relay P–3 are the circuits of relay B of the linefinder and relay F–3, both of which pass through the operated contacts 4T and 5T of relay P–3.

i. Distributor MM Restores. (*X* contacts of

relay L are operated at this point in the sequence of relay operation.) When the distributor MM restores, it steps the wipers to the next set of distributor contacts. Note that although the interrupter contacts of the MM close when it restores, a circuit is not completed over the guard lead even if the linefinder to which the distributor wipers have stepped is busy. The circuit, which would normally cause the distributor wipers to continue stepping to an idle linefinder (par. 22*t* (2)), passed through contacts 6 and 7 of relay N–3 which has restored. The wipers of the distributor will, therefore, remain on the next set of distributor contacts until relay N–3 of the group is again operated. Note that relay N–3 will restore after relay E–3 restores as described in *d* above. When relay N–3 again operates, the MM will resume its normal function and seize the first idle linefinder which appears to the distributor wipers.

25. Linefinder Operates but Fails to Seize Marked Contact

A linefinder may fail to find the marked vertical bank contact, or it may seize the marked vertical bank contact, begin rotary motion, but fail to find the marked control bank contact. If the vertical bank of a linefinder is marked on any level below the tenth, and the linefinder fails to arrest its vertical movement upon reaching the marked contact, it will continue to step to the tenth level. The vertical bank contact on the tenth level is permanently grounded and will cause the rotary circuits to be completed even though no call has been originated in that level (par. 22*i*). If during rotary stepping on any level, the control bank wipers fail to seize a marked contact or if rotary stepping occurs across the tenth level when no line in that level is marked, the wipers will be stepped to the eleventh rotary position. When the wipers reach the eleventh rotary position, a cam mounted on the switch shaft directly under the rotary ratchet (fig. 2) operates the SW–4 (cam switch). When the cam switch operates, it closes a circuit from the guard lead to ground. This circuit may be traced from the guard lead through contacts 3 and 4 of SW–6 and through contacts 1 and 2 of SW–4 to ground. When the guard lead is grounded, the MM operates, starting a series of relay operations similar to that described in paragraphs 22*r* through *z*, and 23*a* through *c*. Note, however, that relays J–3 or K–3, and relays A or D will not have been operated because the circuits to these relays are completed only when the wipers seize the marked contact. Relays D–3, F–3, A–3, and the VERT or RTY MGT may or may not be operated, depending on the position of the wipers when the failure occurs.

26. All Linefinders Busy in a Group

Relay N–3 is held operated by having its circuit complete to ground in multiple through contacts 2 and 3 of the VON switch of each linefinder in its group (par. 22*a*). Each time relay P–3 operates, a locking ground is placed on the circuit of relay N–3 through contacts 2B and 3B of relay P–3. This locking ground is actually required only when the operating linefinder is the last of its group to operate. When the linefinder begins its verticle stepping, its VON switch operates. When the linefinder is the last of its group to operate, the operation of its VON switch removes ground potential from the ATB lead, through which the circuit of relay N–3 is normally complete. The locking ground of relay N–3 applied by relay P–3, however, holds N–3 operated until the loop has been extended to the selector and relay P–3 has restored (par. 22*s*). When relay P–3 restores, it removes the one remaining ground connection from the operating circuit of relay N–3, and relay N–3 restores. When relay N–3 restores, the start circuit is transferred to relay C–3 of the partner group (pars. 15 and 24*e* and figs. 8 and 34).

27. Linefinder-Connector Interaction for Busy and Free Lines

As soon as the loop of a calling telephone is extended to a first selector, ground from the linefinder control bank contact is applied over the CN (control normal) trunk wire and through the first selector to the connector bank contacts of that same telephone. This ground on the connector is maintained successively by each switch in the train as the loop is extended. If this calling telephone is called after its loop has been extended to a first selector, its connector, being grounded, will send a busy tone to the telephone of the party calling. If a called line is free, the cut-through relay in its connector circuits will operate and close a circuit through the CN trunk wire to the 600-ohm winding of the line relay of the called telephone. This causes the line relay to operate fully and prepares the called line for ringing.

28. Identification of a Line Using a Linefinder

When a linefinder remains connected to a line for a long period of time, it may be desired to find out whether a call is actually in progress. In this case, a hand test telephone may be plugged into the monitor jack (upper test jack) on the linefinder, and the line may be challenged. If there is no answer, the number of the telephone holding the linefinder operated may be determined as follows:

a. Short the bank test jack (lower test jack) on the linefinder with a piece of metal such as a coin or screw-driver blade. If the lower bank lamp (LB) lights, the line is in the lower bank and the line relay is one of those numbered 00 to 99; if the lamp does not light, the line is in the upper line bank and the relay is one of those numbered 100 to 199.

b. As stated in paragraph 6*c*, the numbers stamped on the line relay covers correspond to the numbers of the line bank contacts. Determine the TENS digit by noting the level on which the line bank wipers have stopped. Be sure to note whether the stalled linefinder is in group A or group B, because the TENS digit of the B group are in reverse order to the levels (par. 14). Determine the UNITS digit by noting the contact on which the wipers are stopped (count in the direction of rotation). Thus, if the wipers of a group A linefinder are on contact 4 of level 3, the line relay is number 34 if the line is in the lower line bank, or 134 if the line is in the upper line bank. If the wipers of a group B linefinder were on contact 4 of level 3, the number of the line relay would be 84 for a line in the lower line bank, or 184 for a line in the upper line bank. Level 3 of the group B linefinders contains contact numbers with TENS digit 8. The number of the line bank contact is also the number of the line relay associated with the telephone being identified.

c. Locate the number of this line relay on the proper designation card on the linefinder shelf (refer to TM 11–2103). Directly under the line relay number, the number of a connector bay is listed. The line to which this line relay is cross connected is multipled to contacts of the connectors in one shelf of the connector bay so listed. The connector terminal numbers, which also represent the telephone number, are listed beneath the connector bay number.

d. As stated in paragraph 6*c*, the digits which make up the number of a pair of linefinder contacts do not necessarily correspond to the number of the telephone associated with it. Each pair of contacts in the linefinder line banks is permanently connected to *only one* line relay bearing the corresponding number. For example, all line bank contacts numbered 11 are connected to line relay 11; each pair of contacts numbered 12 are connected to line relay 12, etc. Any line relay, however, may be cross connected through the CDF or LIDF in multiple with the connector bank contacts of any one telephone in any shelf in the central office. The line for telephone 2534 which is connected to connector terminals 34 (the last two digits of a telephone number must always agree with the digits comprising the number of the connector bank contacts (refer to TM 11–2105)) may be cross-connected to line relay 87 of any linefinder shelf in the central office. If the traffic over this line increased beyond a point thought desirable in view of the amount of traffic already handled by the linefinder shelf, a change in the cross connection would be made. The line would be cross connected to any spare line relay (perhaps 142) in any other linefinder shelf that had less traffic. The telephone number would remain unchanged because the line would still terminate on the same connector contacts.

29. Circuit Action for Restricted Service

Restricted or discriminating service means automatically denying certain lines access to interoffice trunking facilities. Restricted service circuits are provided in the linefinder shelf. The normal post cam at the top of each linefinder shaft has teeth which may be bent at an angle of 90° away from their original position (fig. 11). Each tooth bent out will then contact the roller of the normal post contact springs (SW–5) when the linefinder shaft reaches the corresponding level in its vertical operation. SW–5 operates and closes a circuit between the C lead and the EC lead to the first selector. Since the C lead was grounded, ground potential is also applied through the EC lead to the normal post contacts in the first selector, which are also actuated by the teeth of the normal post cam of the selector. The ninth selector level is usually the restricted level, although any level may be designated for this purpose, depending on the level assignments for the trunks which are to be restricted. When the calling party dials the first digit, the selector will raise its wipers to the dialed level. Rotary motion begins and the selec-

tor wipers search for an ungrounded contact. If this is a restricted level, the normal post contacts will operate and ground the C wiper, so that the wipers will automatically step to the eleventh position and send back busy tone (TM 11–2105). This feature makes it impossible for a line on restricted service to dial through to any trunk leading out of the restricted level of the first selector. Note that restricted service is possible only by levels, because it is achieved by mechanical means. Since each control bank level contains control lead contacts for 20 lines, restricting one level restricts 20 lines. Accordingly, restricted and unrestricted lines may not be assigned to the same levels. The system of reverse multipling between groups A and B of the linefinders requires that one cam tooth must be bent out for each restricted linefinder level in group A (fig. 11), and a different cam tooth bent out on the linefinders in group B (fig. 8). Restricted service does not operate unless the contacts on the normal posts of both linefinder and first selector are operated.

Section II. TROUBLE SHOOTING

30. General

The theory of operation (sec. I) indicates that relays operate in a definite sequence whenever a call starts or ends. Because of this sequence, trouble shooting the shelf involves isolating the cause of any trouble by visually locating the nonfunctioning part, and then referring to the schematic diagram (fig. 28) to determine what other unit might be causing this faulty operation.

a. Operate a busying switch to prevent the circuit from being used while testing it. If the trouble is in a linefinder, operate the busying switch for that linefinder. The other linefinders and shelf equipment will function normally and handle the traffic. If the trouble involves any other units, operate the group relay busying switch, and the calls will then be handled by the partner group.

b. When the fault is located, remove and repair the nonfunctioning unit. Return the unit to service as quickly as possible, and restore the busying switch to its OFF position.

31. Trouble-Shooting Chart

If the malfunction occurs too rapidly to locate it visually, or if the schematic diagram does not supply the necessary information, use the trouble-shooting chart below.

Symptom	Probable cause
All equipment dead	Power supply failure. Open circuit from power supply to fuse and lamp panel on regular shelf.
User cannot obtain dial tone:	
If the linefinder operates.	Dirty linefinder wipers or bank contacts. Relay A or D contacts dirty. Loose or dirty connections at PL–1, terminal 1. Open dial tone circuit (check first selector).
If the linefinders do not respond.	Nonfunctioning relays or dirty contacts of L, C–3, P–3, or B. Loose or dirty connections at PL–1, terminal 4. Level C wiper on distributor not making contact. Loose or dirty connections at PL–2, terminal 4. Open 2,000-ohm resistor. Dirty contacts 3 or 4 on relay D–3, or dirty contacts 2 or 3 on relay A–3.

Symptom	Probable cause
Linefinders cascade (all linefinders on shelf step vertically and horizontally in sequence without stopping).	Dirty contacts 1, 2, 3, 4, 9, or 10 on relay L. Open between contact 10 on on relay L and ground. Open between contact 4 on relay L and level markers on linefinders. Open circuit from contact 2 of relay L to wiper C–1 or C–2 on linefinder. Open test-1 circuit. Open test-2 circuit. Level D distributor wiper not making contact. Dirty contacts 1 or 2 on relay D–3. Dirty contacts 8–T or 9–T on relay P–3.
Release alarm sounds	If ST SIG lamp glows, a linefinder on the shelf has failed to find the calling line, or there is faulty operation in the group relay circuits. If RLS lamp glows, a linefinder on the shelf has been released but has failed to restore. There may be a trouble condition in selectors or connectors (refer to TM 11–2105).
Fuse alarm sounds	A fuse is blown on the shelf where a fuse alarm lamp glows.

Section III. ADJUSTMENTS AND REPAIRS

32. General

Most equipment faults on the linefinder shelf are corrected by adjustment. However, if parts are damaged or excessively worn, replace them. In general, new parts are better than repaired ones, since reliability of the equipment is of paramount importance. Procurement of new parts or units is made through authorized channels. Be careful when disassembling and reassembling mechanical units. Use the proper tools for the job (refer to TM 11–2103 and TM 11–2111). Secure bolts and screws, but do not overtighten them. When replacing repaired or new parts in the equipment, be sure that they are seated properly. To assure correct electrical connections, tag each conductor before removing it. When replacing conductors, use wires as short as practicable.

33. Relays

Use the current-flow test set for testing relays. Adjust the relays, if necessary, to bring them within the limits specified in figures 14 through 17. Follow the procedures outlined in TM 11–2103 and TM 11–2112. If relay failure involves a defective coil, replace the relay with another having the same manufacturer's part number. If relay failure involves mechanical trouble, correct the action if possible with the aid of armature and spring benders.

a. Line and Cut-off Relays. When working on line and cut-off relays, operate the BAT switch of the current-flow test set to its OFF position. Requirements for line and cut-off relays appear in figure 14 under relay L.

b. Linefinder Relays. If a linefinder has a defective relay, operate the busying switch, and remove the linefinder switch from the shelf (par. 34). If replacement of a relay is necessary, tag each conductor when unsoldering it, so that the new relay can be connected without consulting wiring diagrams. Requirements for linefinder relays appear in figures 16 and 17 under relays A, B, and D.

c. Group Relays. Whenever any repair is necessary within the group relays, choose a time when the central office load is light. Operate the busying switch first, and then remove the entire group relay assembly from the shelf by pulling the bottom out and away from the shelf, and then lifting the assembly to free it from the mounting hooks. Take the unit to the workbench to perform the repairs (TM 11–2103). Replace the unit on the shelf as quickly as possible, hanging it from the mounting hooks first and then carefully seating the assembly to complete all jack connections. Test its operation immediately with the test handset. Requirements for group relays appear in figures 14 through 16.

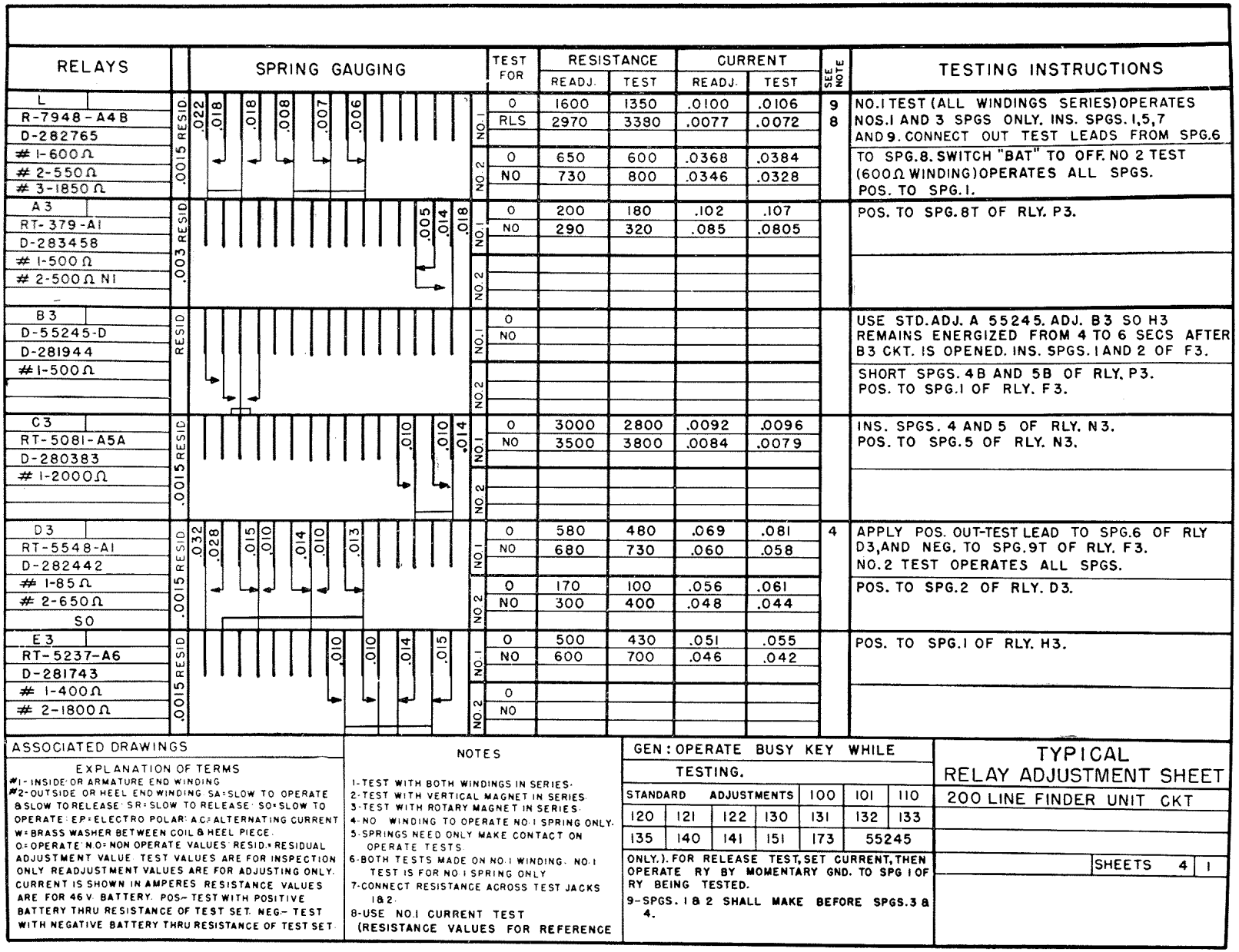

Figure 14. Relay adjustment sheet No. 1.

RELAYS	SPRING GAUGING		TEST FOR	RESISTANCE READJ.	RESISTANCE TEST	CURRENT READJ.	CURRENT TEST	SEE NOTE	TESTING INSTRUCTIONS
F3 RT-5058-B8 D-281919 #1-1300Ω #2-1250Ω	.0015 RESID.	NO.1 .015 .010 .014 .010 .010 .010 .010 NO.2	0	350	250	.0288	.031		POS. TO SPG. 12 OF RLY. F3.
			NO	750	950	.0230	.0200		
G3 RT-5165-A6 D-281426 TOT.-3.7Ω (4Ω-50Ω N1) SR	.0015 RESID.	NO.1 .010 .010 .014 NO.2	0	330	310	.138	.147		POS. TO LOWER COIL TERMINAL OF G3.
			NO	370	400	.123	.114		
H3 RT-5124-B6 D-280473 #1-1200Ω SO	.0015 RESID.	NO.1 .015 .011 .011 .011 .011 .011 NO.2	0	640	500	.031	.034		POS. TO SPG. 1 OF RLY. B3.
			NO	930	1070	.0258	.0238		
			0						
J3 RT-165-A2 D-282944 #1-200Ω #2-500Ω RES	.003 RESID.	NO.1 .010 .014 NO.2 ALLEGHENY CORE & HEEL-PC.	0	1370	1280	.0222	.0232	1	GND. LOWER COIL TERMINAL. NEG. TO COIL TERMINAL FARTHEST FROM SPGS.
			NO	1500	1600	.0209	.0200		
K3 RT-456-A2 D-282944 #1-200Ω #2-500Ω RES	.003 RESID.	NO.1 .014 .010 NO.2	0	1370	1280	.0222	.0232	1	GND. UPPER COIL TERMINAL. NEG. TO SPG. 8 OF RLY. D3.
			NO	1500	1600	.0209	.0200		
N3 RT-5025-B5 D-280832 #1-4000Ω	.0015 RESID.	NO.1 .010 .010 .010 .014 .015 NO.2	0	2500	1900	.0071	.0077		INS. SPGS. 1 AND 2 OF RLY. E3. POS. TO SPG. 2 OF RLY. E3.
			NO	3500	4300	.0061	.0055		
			0						
			NO						

ASSOCIATED DRAWINGS

EXPLANATION OF TERMS

#1- INSIDE OR ARMATURE END WINDING
#2- OUTSIDE OR HEEL END WINDING. SA=SLOW TO OPERATE & SLOW TO RELEASE: SR=SLOW TO RELEASE: SO=SLOW TO OPERATE: EP=ELECTRO POLAR: A.C.=ALTERNATING CURRENT W=BRASS WASHER BETWEEN COIL & HEEL PIECE. O=OPERATE: N.O.=NON OPERATE VALUES: RESID.=RESIDUAL ADJUSTMENT VALUE. TEST VALUES ARE FOR INSPECTION ONLY. READJUSTMENT VALUES ARE FOR ADJUSTING ONLY. CURRENT IS SHOWN IN AMPERES. RESISTANCE VALUES ARE FOR 46 V. BATTERY. POS.- TEST WITH POSITIVE BATTERY THRU RESISTANCE OF TEST SET. NEG.- TEST WITH NEGATIVE BATTERY THRU RESISTANCE OF TEST SET.

NOTES

1-TEST WITH BOTH WINDINGS IN SERIES.
2-TEST WITH VERTICAL MAGNET IN SERIES.
3-TEST WITH ROTARY MAGNET IN SERIES
4-NO.1 WINDING TO OPERATE NO.1 SPRING ONLY.
5-SPRINGS NEED ONLY MAKE CONTACT ON OPERATE TESTS.
6-BOTH TESTS MADE ON NO.1 WINDING. NO.1 TEST IS FOR NO.1 SPRING ONLY.
7-CONNECT RESISTANCE ACROSS TEST JACKS 1&2.

STANDARD ADJUSTMENTS

TYPICAL RELAY ADJUSTMENT SHEET

SHEETS 4 | 2

TM 2104-34

Figure 15. Relay adjustment sheet No. 2.

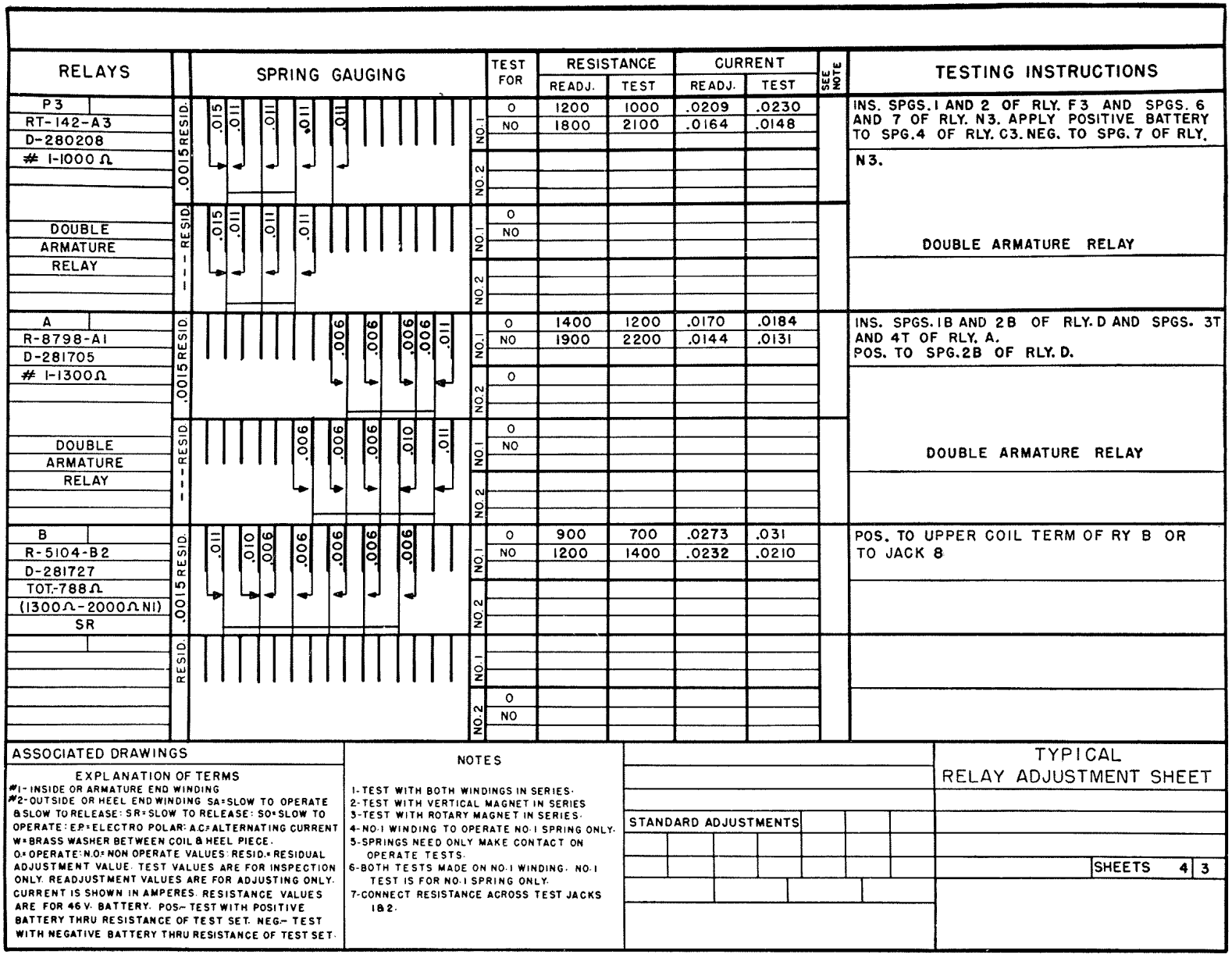

Figure 16. Relay adjustment sheet No. 3.

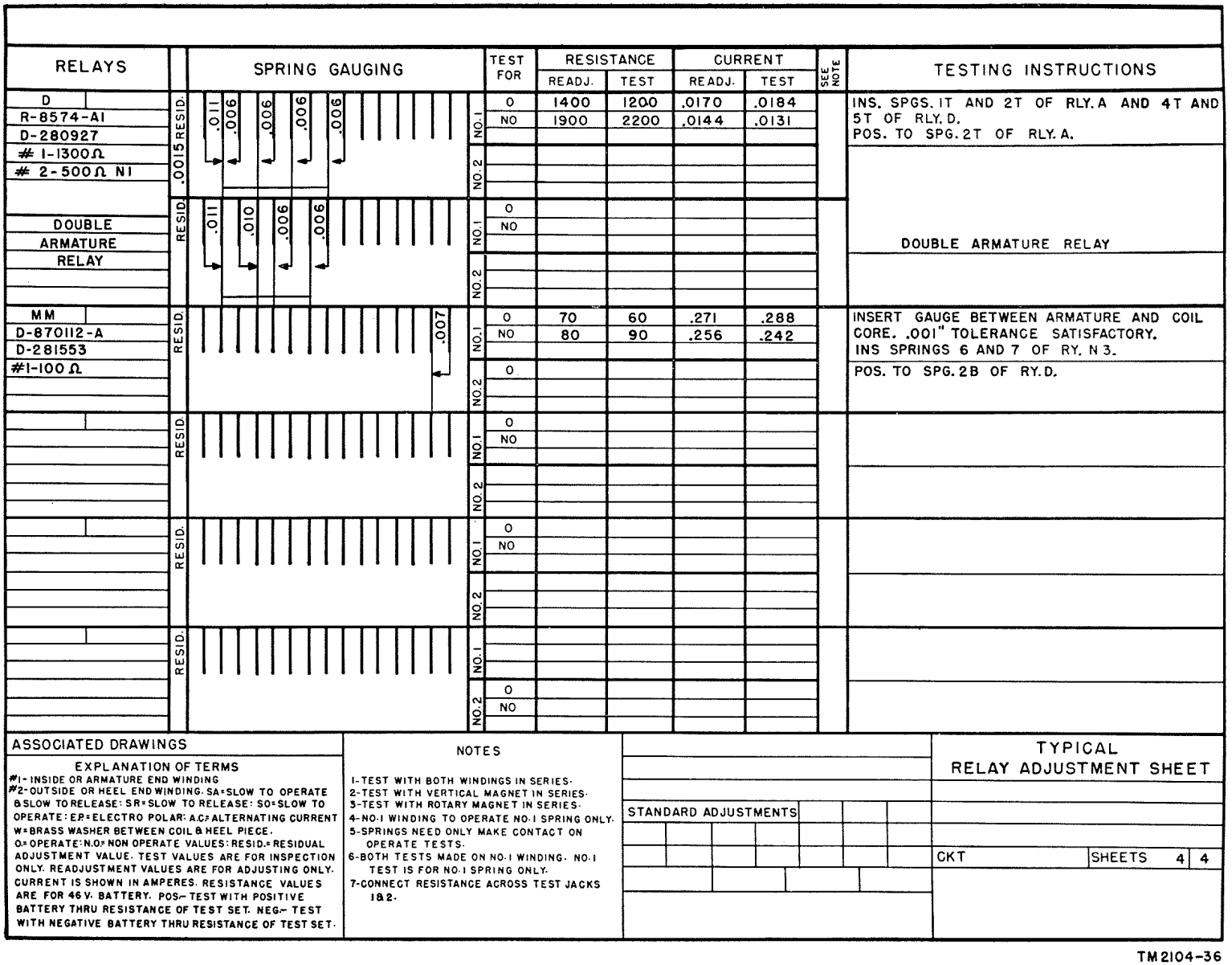

Figure 17. Relay adjustment sheet No. 4.

34. Linefinders

Operate the busying switch (SW–6, fig. 28) first. Remove a defective linefinder switch from the shelf, except when the fault is superficial and requires little attention. Remove the two holding nuts for the contact banks and slip the linefinder switch up from the bottom, then out until it is free. Take it to the workbench to perform whatever repair is necessary. Then return the linefinder switch to its place on the shelf and carefully seat the jack assembly. Replace the nuts which hold the contact banks in place and restore the busying switch. Adjust the position of the banks so that the contact wipers wipe the contacts properly (TM 11–2103). Test the operation of the linefinder immediately with the test handset.

35. Distributors

A distributor cannot be removed from the shelf without unsoldering many conductors. If repair of a distributor is necessary, operate the busying switch (SW–7, fig. 28) of the associated group relay assembly and work on the distributor, to the extent required, in its mounted position on the shelf. Do the work when the central office load is light, if possible. Requirements for the MM of the distributor appear in figure 17.

36. Miscellaneous

If lamps or resistors burn out or if capacitors short-circuit, remove and replace the defective unit with another identical unit. Be sure the wattage or voltage rating is correct, to lessen the need for further repairs. Operate busying switches only if necessary. Attach an identifying tag to each conductor as it is unsoldered, to facilitate replacement.

37. Wiring Diagrams

The wiring diagrams on the following pages represent a typical installation only. When repairing a specific equipment, use only the applicable manufacturer's drawings. The circuit and terminal designations are as they appear on the typical equipment described.

a. In figure 18 (line relay and line terminal board wiring diagram), the relay coil is shown to the left of the spring pile-up, to simplify the drawing. In reality, however, the No. 1 contact spring is nearest the core.

b. Figures 19 and 20 show the jack springs of the shelf jacks for the regular and overflow linefinders as they are actually arranged and numbered.

c. Figure 27 shows the wiring for shelf jack assembly. Note that a jack is provided for each group relay assembly.

d. For a more complete understanding of figures 22 through 24 (vertical banks and start and level-marking resistors), study them in conjunction with figure 8.

e. Figure 25 is a wiring diagram of the fuse and lamp panel mounted on the regular shelf (illustrated at the lower left-hand corner of fig. 1). Figure 26 is a wiring diagram of the smaller fuse panel mounted on the overflow shelf, for the overflow linefinders only. Observe that no separate lamps are required.

f. Figure 27 shows how the trunk terminal board on the overflow shelf is wired. It affords terminating facilities for cable run 41–B to the vertical side of the TIDF (figs. 10 and 32). Through this trunk terminal board the overflow linefinders are connected to their associated first selectors. The block provides facilities for 10 circuits, although only 5 overflow linefinders (21, 22, 23, 26, and 27) are supplied. The wiring for five additional overflow linefinders is installed. Wiring completed by the manufacturer terminates on the SHOP side of the double-ended terminals; wiring performed by the installer terminates on the INST (installer's) side. The INST side is the left side of the block when viewed from the front. The SHOP side is the right side.

g. Figure 30 shows the more complicated wiring of the trunk terminal block mounted on the regular shelf (illustrated at the upper left-hand corner of fig. 1). This block provides terminating facilities for cable run 41–A to the vertical side of the TIDF (figs. 10 and 32), to connect the 20 regular linefinders to their associated first selectors. It also provides cross-connecting facilities for the group relay assemblies, start and level-marking resistors, supervisory circuits, and facilities for connecting the six distributor levels to the overflow linefinders. Observe that the distributors receive ground from the circuit terminals for overflow linefinders 24, 25, 28, 29, and 30 (not supplied), and therefore treat them as busy. Compare this with level A in figure 30. Read the notes in figure 29 carefully.

h. Figure 31 shows the wiring diagram for the

distributors. On the actual switches the contact bank levels are arranged from F through A, left to right, looking at the front of the switch.

i. The abbreviations and color codes used in the wiring diagrams which appear in this manual are as follows:

Circuit terminal designation	Conductor	Color
1–20	+ (tip)	Slate.
	− (ring)	Slate-white.
	C (control)	Red-brown.
	EC (extra control)	Orange-slate.
21–30 (26–30 connected to terminals marked 31–35).	G (guard)	Orange-white.
	F ST (finder start)	Green-white.
	V (vertical)	Brown-white.
	T–1 (test-1)	Blue-slate, or blue-orange.
	D (relay D)	Orange-brown.
	A (relay A)	Green-brown.
GRP RYS A, B.	ATB GND (all-trunks-busy ground).	Red-slate.
	RLS BAT (release battery).	Red-orange.
	INT (interrupter)	Red-white.
	RTY (rotary)	Red-blue.
	T–2 (test-2)	Red-green.
LEV ST	V–1 (vertical bank level 1)	Blue.
	V–2	Orange.
	V–3	Green.
	V–4	Brown.
	V–5	Slate.
	V–6	Blue-white.
	V–7	Orange-white.
	V–8	Green-white.
	V–9	Brown-white.
	V–10	Slate-white.
MISC (Supervisory).	CST (class-of-service tone).	Red-brown-white.
	GND (ground)	Brown.
	ST SIG (start signal lamp).	Blue-white.
	ATB (all-trunks-busy)	Green-white.
	PC (peg count)	Red-brown.
	ST A (start A)	Red-white.
	ST SIG	Blue-slate.
	FA (fuse alarm lamp)	Orange.
	RLS (release lamp)	Green-slate.
	LB (lower bank lamp)	Blue-green.

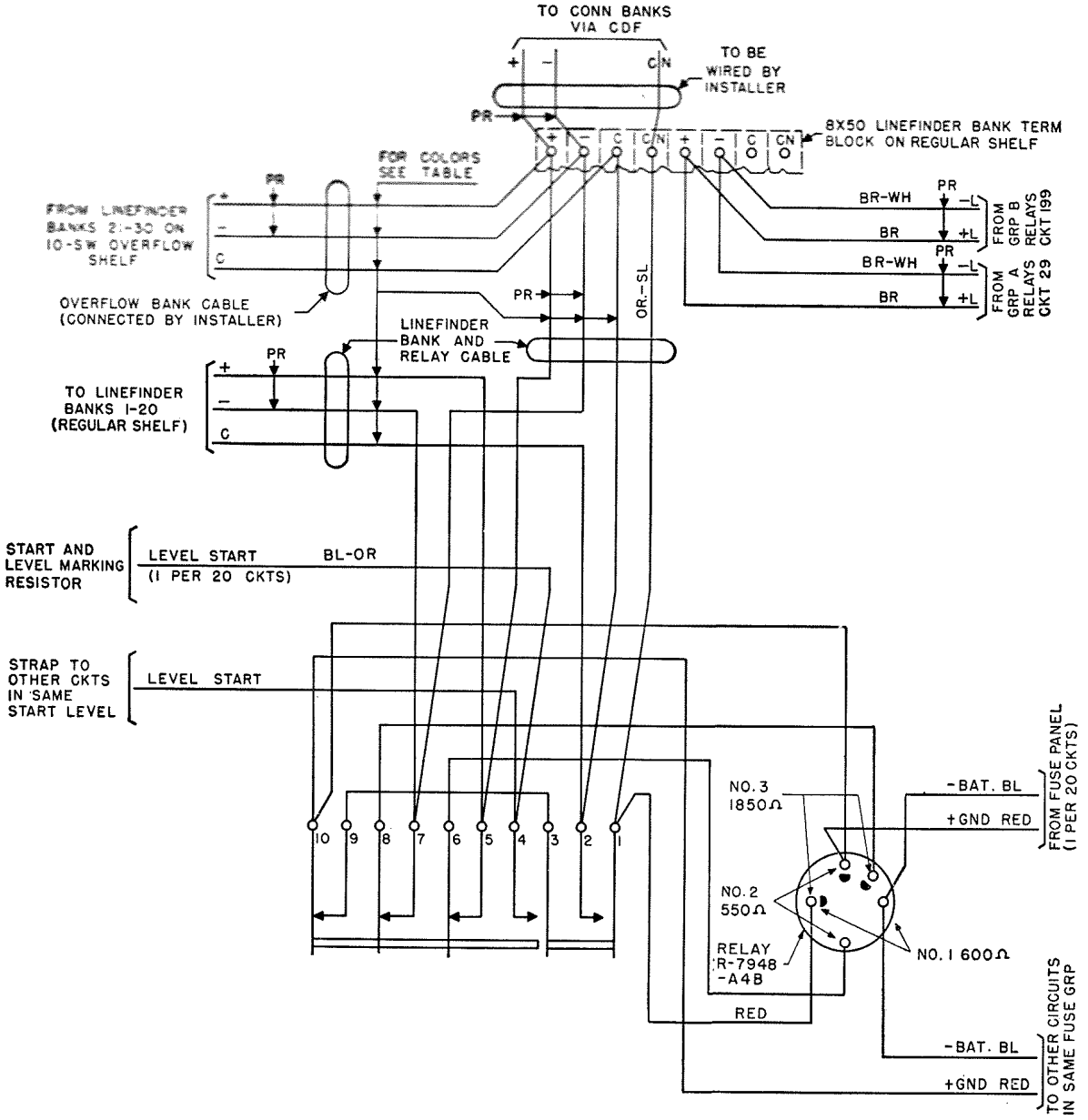

Figure 18. Line relays and line terminal block, wiring diagram.

COLOR TABLE			
CKT NOS.	+	−	C
11,21,—,—, TO 01	BL	BL-WH	BL
12,22,—,—, TO 02	OR.	OR.-WH	OR.
13,23,—,—, TO 03	GR	GR-WH	GR
14,24,—,—, TO 04	BR	BR-WH	BR
15,25,—,—, TO 05	RED	RED-WH	RED
16,26,—,—, TO 06	BL	BL-WH	BL
17,27,—,—, TO 07	OR.	OR.-WH	OR.
18,28,—,—, TO 08	GR	GR-WH	GR
19,29,—,—, TO 09	BR	BR-WH	BR
10,20,—,—, TO 00	RED	RED-WH	RED
111,121,—,—, TO 101	BL	BL-WH	BL-WH
112,122,—,—, TO 102	OR.	OR.-WH	OR.-WH
113,123,—,—, TO 103	GR	GR-WH	GR-WH
114,124,—,—, TO 104	BR	BR-WH	BR-WH
115,125,—,—, TO 105	RED	RED-WH	RED-WH
116,126,—,—, TO 106	BL	BL-WH	BL-WH+T
117,127,—,—, TO 107	OR.	OR.-WH	OR.-WH
118,128,—,—, TO 108	GR	GR-WH	GR-WH
119,129,—,—, TO 109	BR	BR-WH	BR-WH
110,120,—,—, TO 100	RED	RED-WH	RED-WH

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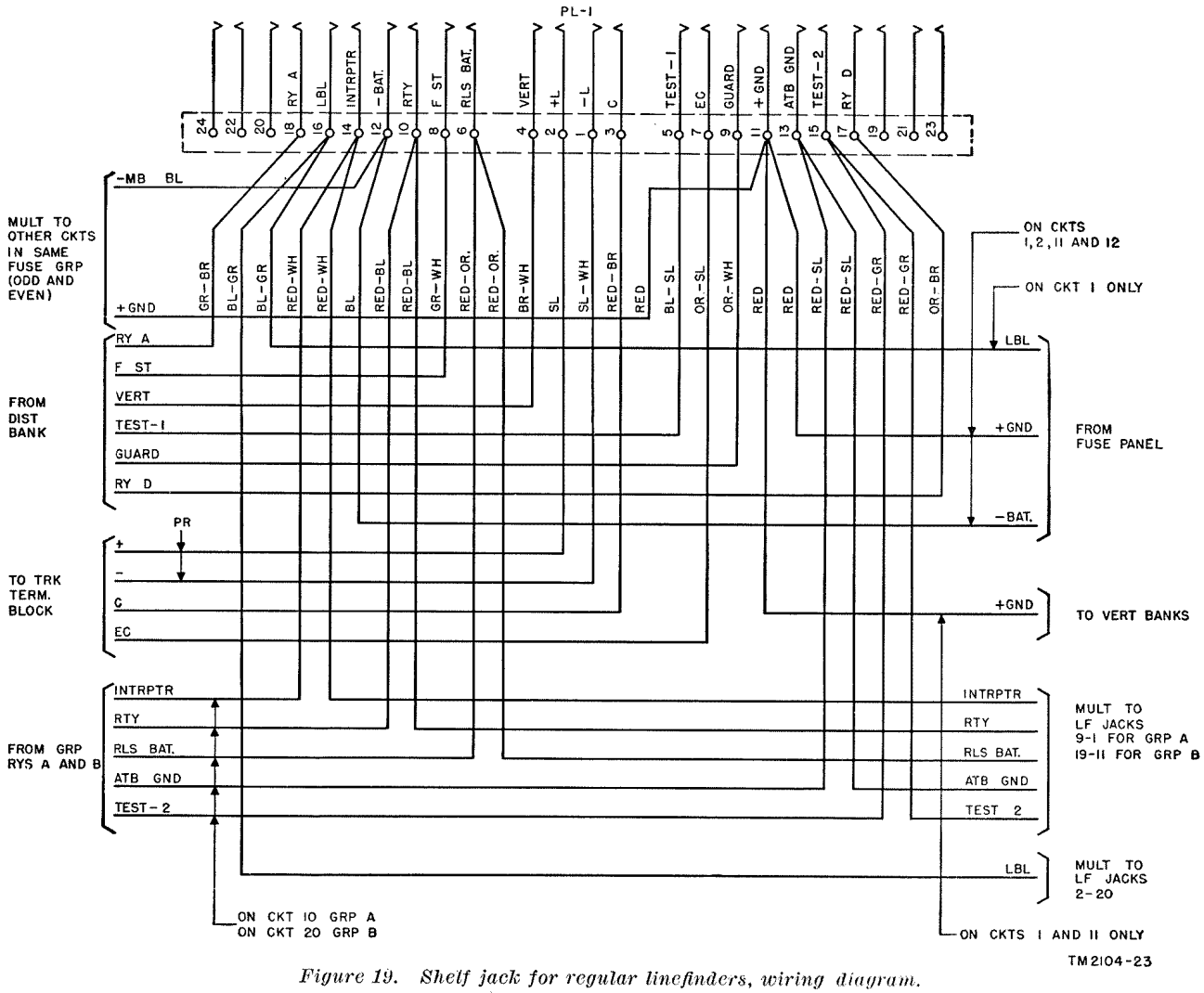

Figure 19. Shelf jack for regular linefinders, wiring diagram.

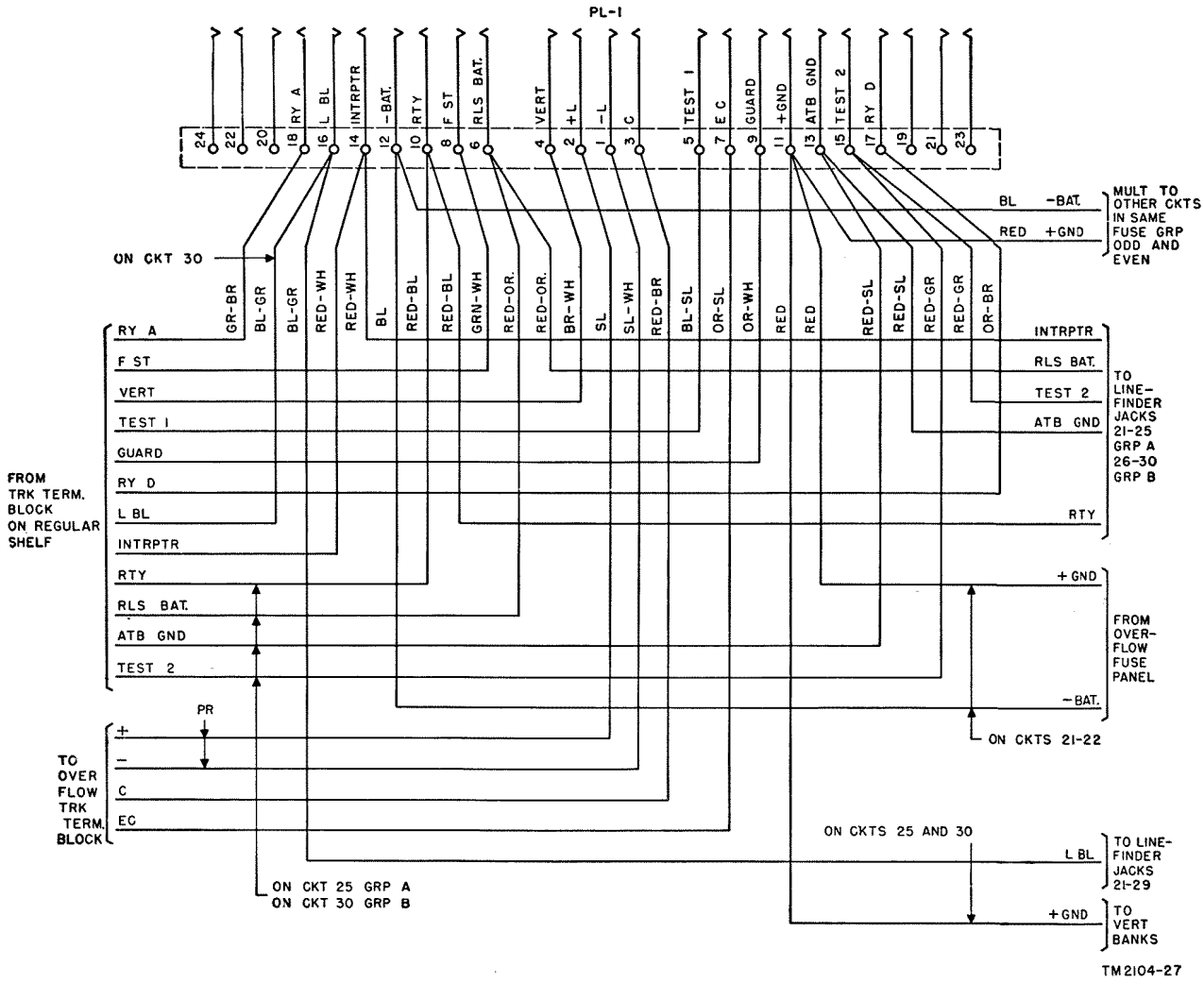

Figure 20. Shelf jack for overflow linefinders, wiring diagram.

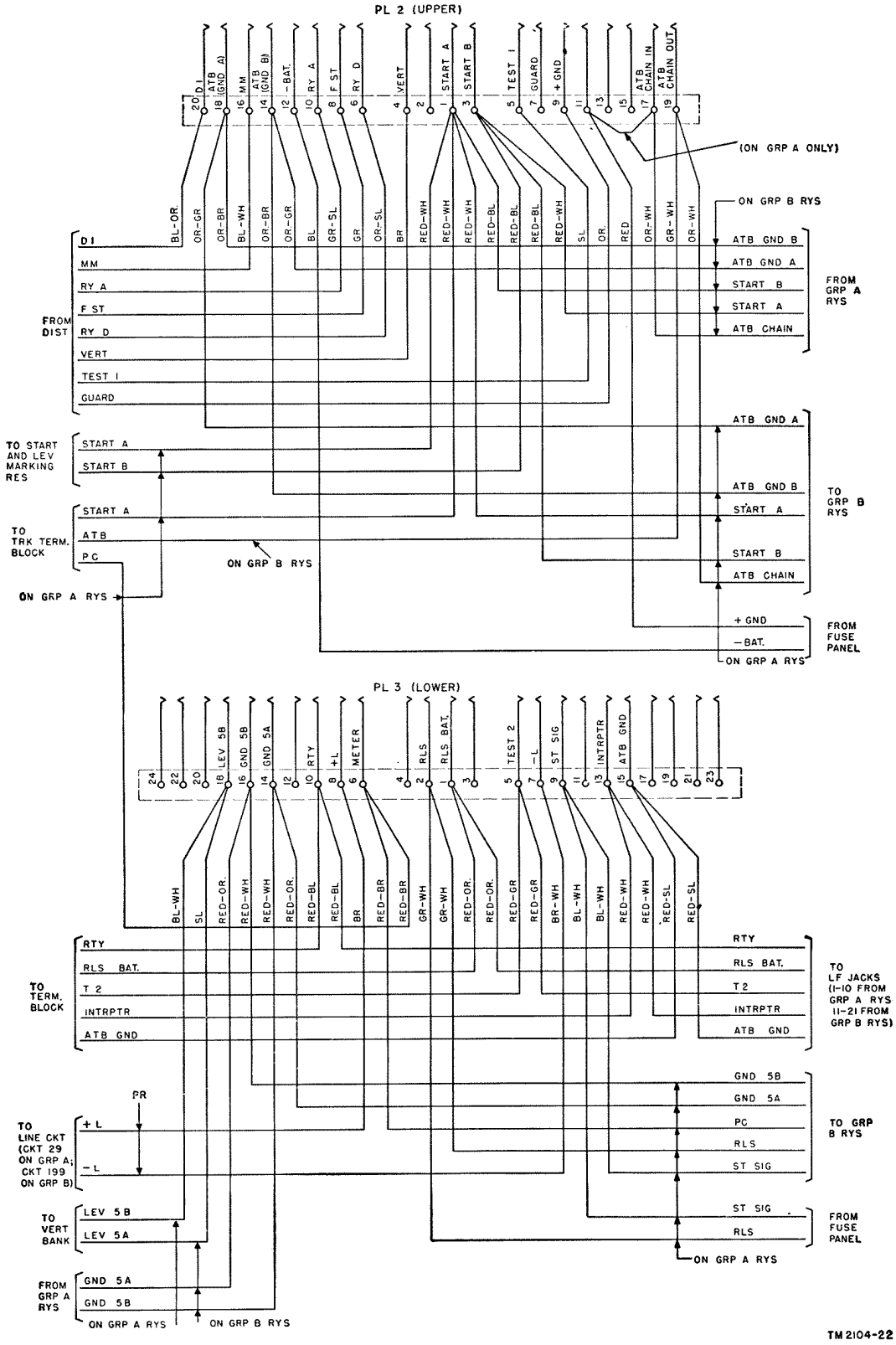

Figure 21. Shelf jack for group relay assemblies, wiring diagram.

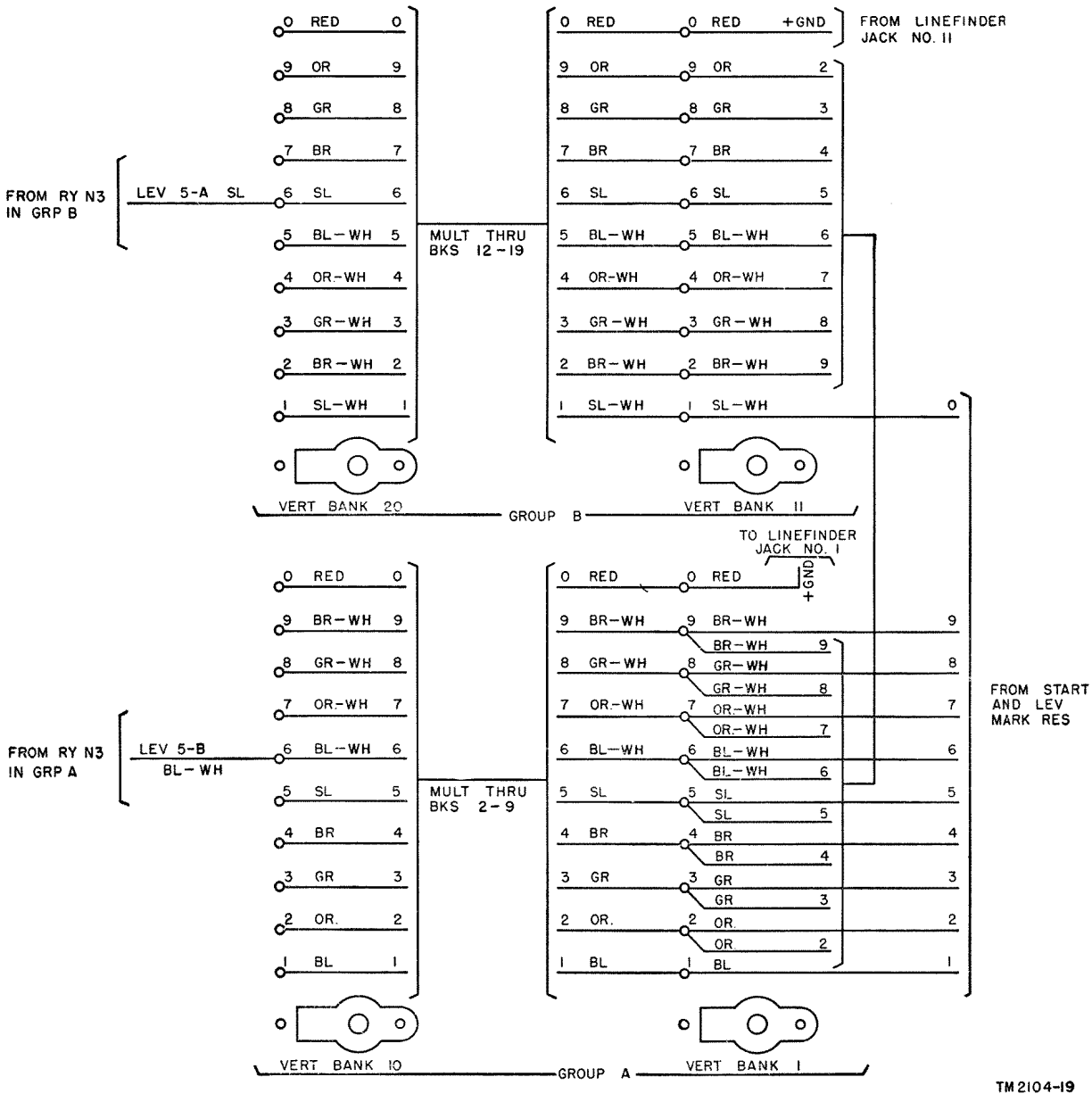

Figure 22. Vertical banks for regular linefinders, wiring diagram.

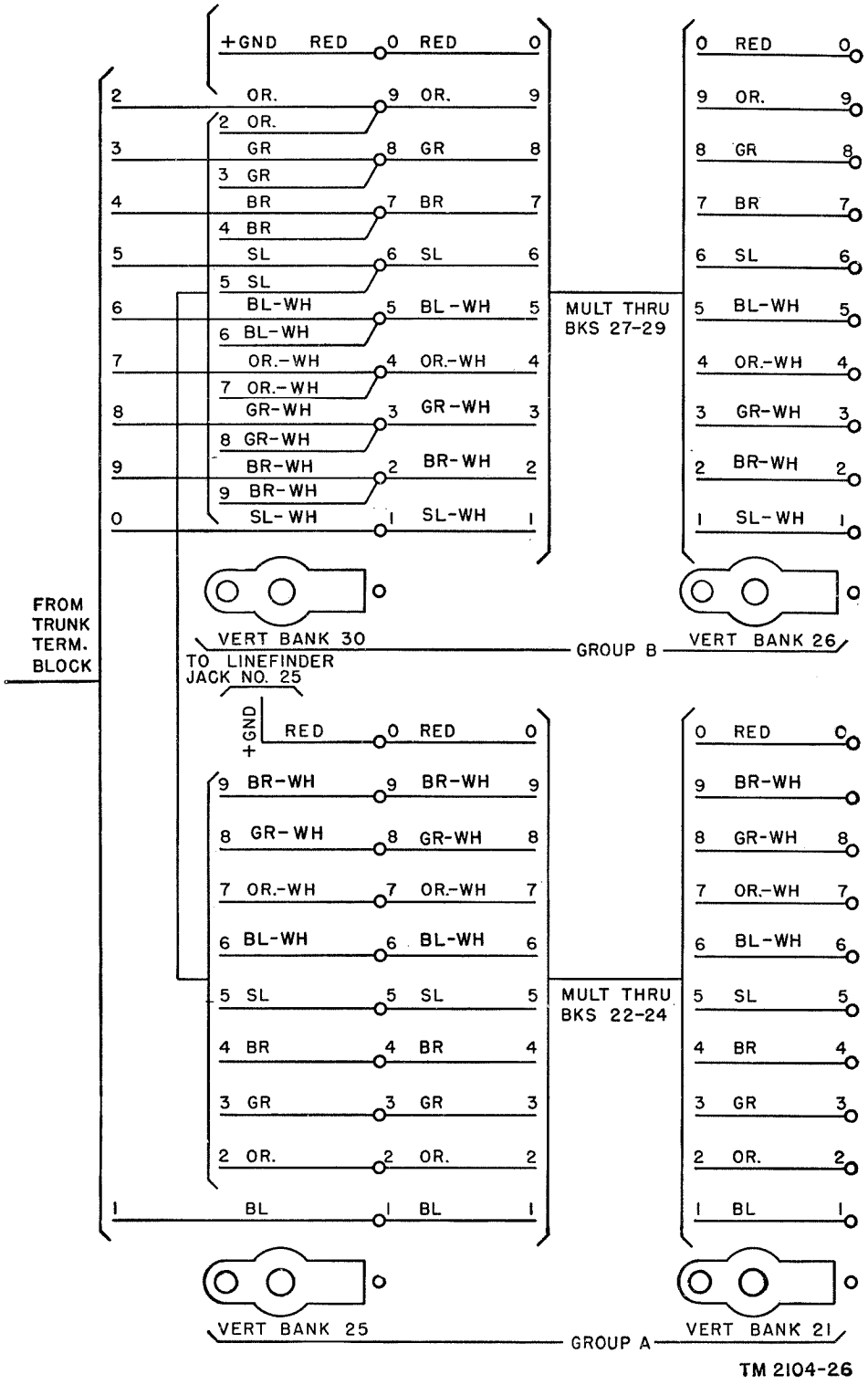

Figure 23. Vertical banks for overflow linefinders, wiring diagram.

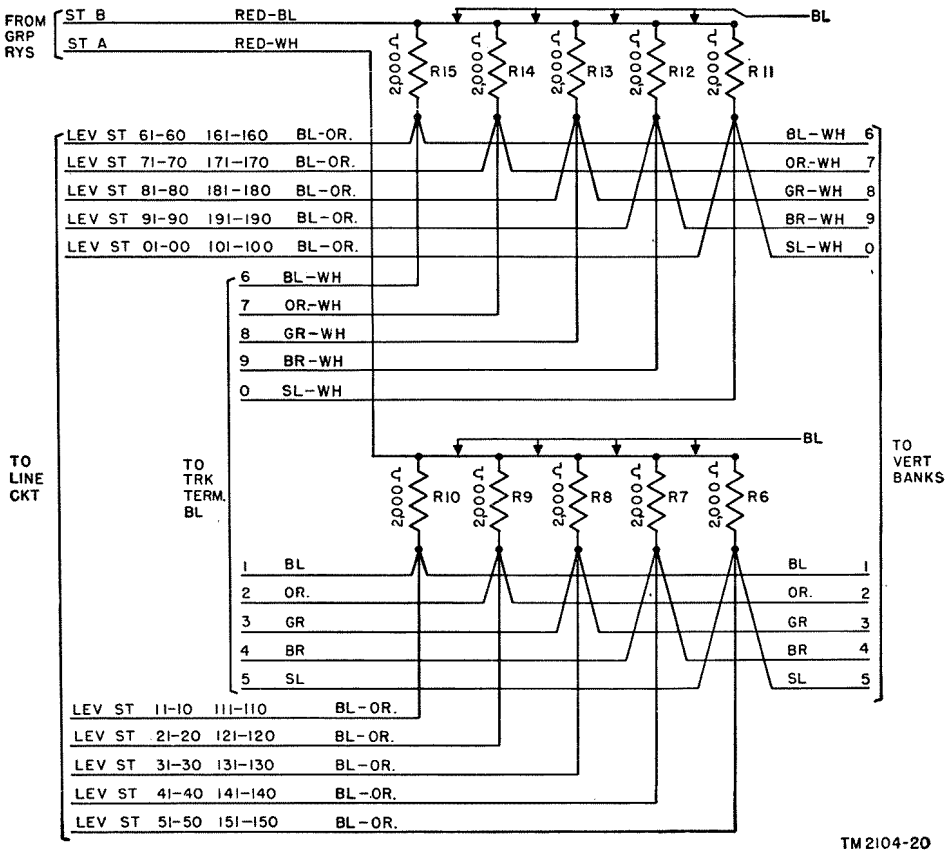

Figure 24. Start and level-marking resistors, wiring diagram.

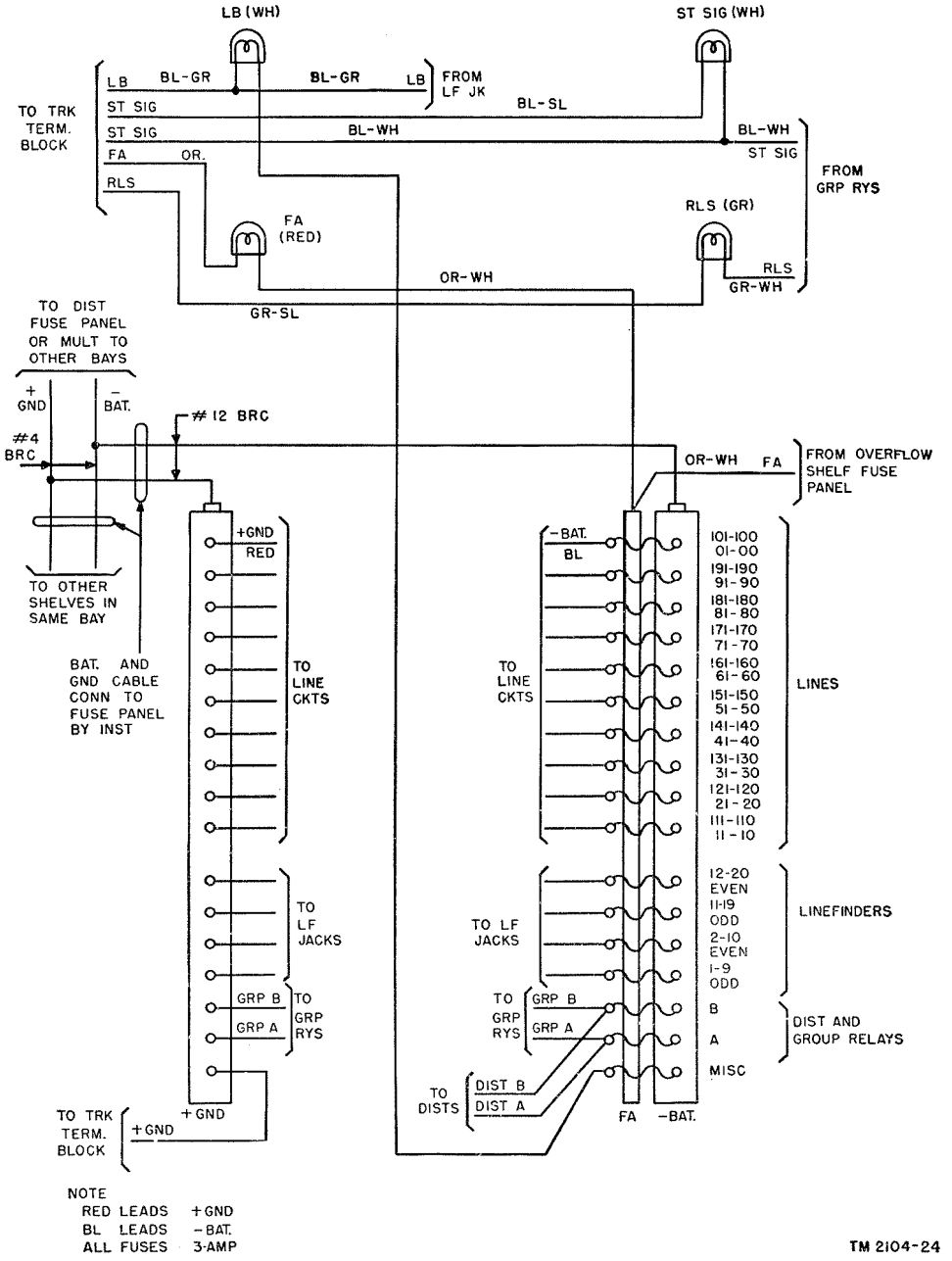

Figure 25. Fuse and lamp panel on regular shelf, wiring diagram.

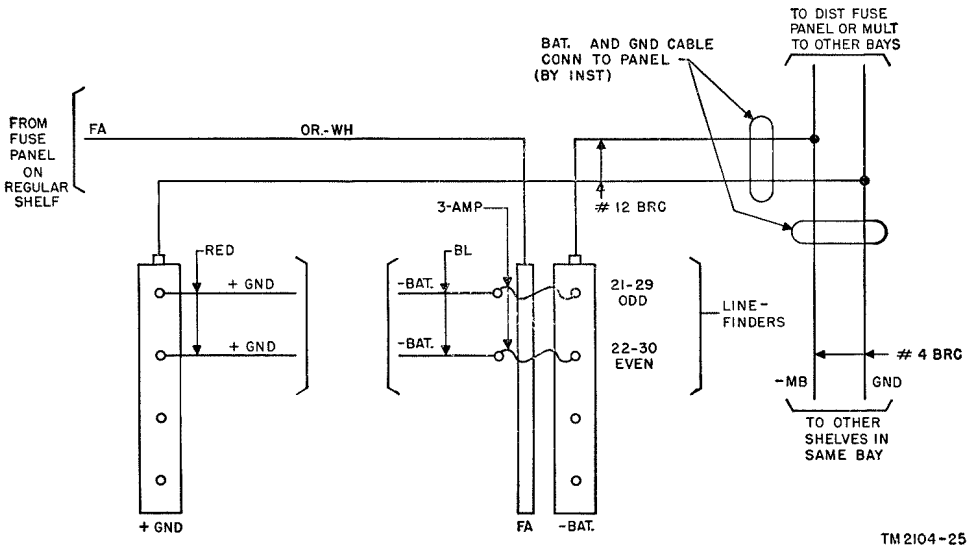

Figure 26. Fuse panel on overflow shelf, wiring diagram.

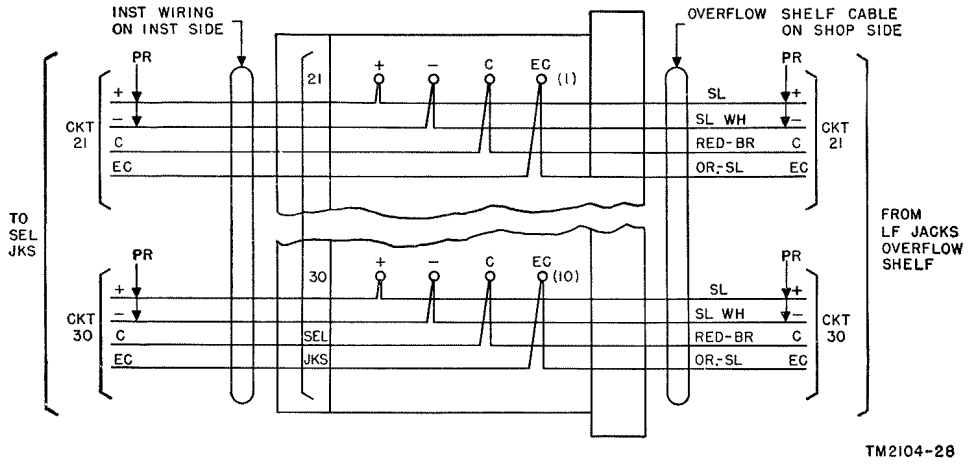

Figure 27. Trunk terminal block on overflow shelf, wiring diagram.

38. Schematic Diagram

Figure 28 is the schematic diagram for groups A and B of the linefinder shelf equipment described in this manual. The table below supplies the circuit legend to accompany figure 28.

Ref. symbol	Item
L	Line relays, one associated with each loop.
A	Linefinder relays, one set associated with each linefinder on shelf.
B	
D	
A–3	Group relays, one set associated with each shelf of linefinders.
B–3	
C–3	
D–3	
E–3	
F–3	
G–3	
H–3	
J–3	
K–3	
N–3	
P–3	
R–1	Resistor functioning as start resistor in test circuit.
R–2	Noninductive resistors across relay windings to reduce surges.
R–3	
R–4	Noise-suppression resistors.
R–5	
R–6–R–15	Start and level-marking resistors.
SW–1	Vertical off-normal contact assembly.
SW–2	Vertical magnet interrupter contacts.
SW–3	Rotary magnet interrupter contacts.
SW–4	Cam contact assembly.
SW–5	Normal post switch.
SW–6	Busying switch (linefinders).
SW–7	Busying switch (group relays).
TS–1	Test jack (linefinders).
TS–2	Test jack (group relays).
PL–1	Switch jack (linefinders).
PL–2 (Upper)	Switch jack (group relays).
PL–3 (Lower)	Switch jack (group relays).
RA–1	Rectifiers (d-c valves to block current in reverse direction).
RA–2	
C–1	Noise-suppression capacitors.
C–2	
C–3	
MM	Distributor motor magnet. Distributor contact bank.
LB	Lower bank lamp.
ST SIG	Start signal lamp.
RLS	Release lamp.
FUSE	Fuse lamp.
RLS MGT	Release magnet.
VERT MGT	Vertical magnet.
RTY MGT	Rotary magnet.

NOTES:

1. THIS ILLUSTRATION SHOWS GROUP A AND GROUP B RELAYS, ONE TYPICAL LINEFINDER OF EACH GROUP, AND THE CONNECTIONS BETWEEN A TYPICAL LINE AND CUT-OFF RELAY, LINE, AND LINEFINDER BANK.
2. RELAY DESIGNATIONS:
   LINE AND CUT-OFF RELAY..... L
   RELAYS OF TYPICAL LINEFINDER.. A, B, AND D
   GROUP RELAYS..... A-3, B-3, C-3 ETC.
3. MONITOR JACK AND BANK TEST JACK ARE ADJACENTLY MOUNTED ON LINEFINDER.

NOTES (CONTD)

4. LINE TEST JACK AND LINEFINDER TEST JACK ARE ADJACENTLY MOUNTED.
5. SW-4 OPERATES ON ELEVENTH ROTARY STEP.
6. SW-5 IS OPERATED BY NORMAL POST CAM WHEN ADJUSTED FOR RESTRICTED SERVICE.
7. CONTACTS MARKED "X" OPERATE FIRST.
8. ALL START AND LEVEL MARKING RESISTORS ARE 2K.
9. X CONTACTS OF RELAY L IN BOTH GROUPS ARE SHOWN OPERATED TO INDICATE START AND MARKING CIRCUITS.
10. WIPERS ARE SHOWN STEPPED TO MARKED VERTICAL LEVEL AND MARKED BANK CONTACT TO INDICATE LINE TO TRUNK CONNECTIONS.

TYPICAL CONNECTIONS BETWEEN LINE OF CALLING TELEPHONE, LINE AND CUT-OFF RELAY, AND GROUP A LINEFINDER BANKS

TYPICAL CONNECTIONS BETWEEN LINE OF CALLING TELEPHONE LINE AND CUT-OFF RELAY, AND GROUP B LINEFINDER BANKS

REVERSE MULTIPLING BETWEEN GROUPS

REVERSE MULTIPLING BETWEEN GROUPS

TO CONNECTOR BANK CONTACTS OF CALLING TELEPHONE

TO CONNECTOR BANK CONTACTS OF CALLING TELEPHONE

NORMAL POST SWITCH SW-5

NORMAL POST SWITCH SW-5

TO OTHER TYPICAL LINE RELAYS

TO OTHER TYPICAL LINE RELAYS

TO TYPICAL LINE RELAY

TO TYPICAL LINE RELAY

TEST 2

TEST 2

TO TRUNK TO FIRST SELECTOR

TO TRUNK TO FIRST SELECTOR

MONITOR JACK (TOP)

MONITOR JACK (TOP)

TYPICAL GROUP A LINEFINDER RELAYS AND LEADS TO DISTRIBUTOR

TYPICAL GROUP B LINEFINDER RELAYS AND LEADS TO DISTRIBUTOR

LOWER BANK LAMP

LOWER BANK LAMP

BANK TEST JACK

BANK TEST JACK

FINDER START

RELAY D

RELAY A

RELAY A

RELAY D

FINDER START

RLS

RTY

CAM SWITCH SW-4

CAM SWITCH SW-4

SW-3

SW-3

VERT.

SW-2

SW-6 BUSYING SWITCH

SW-1 VON

ATB GND

ATB GND

TEST 1

TEST 1

TEST 2

TEST 2

LINEFINDER TEST JACK

LINEFINDER TEST JACK

R-1 2K

R-1 2K

NOTE 8

GROUP A DISTRIBUTOR

GROUP B DISTRIBUTOR

LEVEL B

LEVEL E

LEVEL F

LEVEL A

LEVEL C

VERT.

ROTARY

LEVEL D

MM

LEVEL D

ROTARY

VERT.

LEVEL C

LEVEL A

LEVEL F

LEVEL E

LEVEL B

C-1 1UF

R-4 200

C-2 1UF

C-3 1UF

R-5 200

LINE TEST JACK (BOT.)

P-3

TO TEST LINE

TO ATB METER

N-3 4K

C-3 2K

G-3 5K

TO PC METER

J-3 200 500

K-3 200 500

F-3 1,250 1,300

D-3 650 50

A-3 500 500

INTERRUPTER

RA-1

RA-2

R-2 3K

B-3 200

H-3 1,200 80

R-3 3K

E-3 1,800

GROUP BUSYING SWITCH SW-7

ST SIG (WHITE)

RLS (GREEN)

FUSE (RED)

LOWER BANK (WHITE)

TO OFFICE ALARM CIRCUIT

FROM FUSE ALARM BAR

GROUP A RELAYS

GROUP B RELAYS

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Figure 28. 200-point linefinder shelf schematic diagram (see par. 38 for legend).

CHAPTER 4

DEMOLITION TO PREVENT ENEMY USE

39. General

The demolition procedures outlined in paragraphs 40 and 41 will be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished *only* upon order of the commander.

40. Methods of Destruction

a. Smash. Use sledges, axes, handaxes, pickaxes, hammers, crowbars, and heavy tools.

b. Cut. Use axes, handaxes, and machetes.

c. Burn. Use gasoline, kerosene, oil, flame throwers, and incendiary grenades.

d. Explosives. Use firearms, grenades, and TNT.

e. Other. Use anything immediately available for destruction of this equipment.

f. Disposal. Bury in slit trenches, fox holes, and other holes. Throw in streams. Scatter.

41. Destruction of Components

a. Smash frames, relays, banks, racks, terminal boards, distributors, lamps, switches, springs, etc.

b. Cut all wiring in electrical circuits.

c. Burn all instruction books, schematic diagrams, drawings, etc.

d. Bury or scatter all remaining parts of the equipment.

e. Destroy everything.

APPENDIX
REFERENCES

Note. For availability of items listed, check SR 310–20–3 for field manuals, training circulars, training aids, Army training programs, JANAP's, Tables of Organization and Equipment (T/O & E's), Tables of Allowances (T/A's), and Tables of Basic Allowances (T/BA's). Check SR 310–20–4 for technical manuals, technical bulletins, supply bulletins, modification work orders, and changes. See Department of the Army Catalog SIG 1 for available Signal supply catalogs.

1. Technical Manuals on Step-by-Step Dial Central Office Equipment

TM 11–2100, Fundamentals (Step-by-Step Dial Central Office Equipment).
TM 11–2102, Installation Instructions (Step-by-Step Dial Central Office Equipment).
TM 11–2103, Basic Maintenance Practices (Step-by-Step Dial Central Office Equipment).
TM 11–2105, Selectors and Connectors (Step-by-Step Dial Central Office Equipment).
TM 11–2106, Miscellaneous Switching Equipment (Step-by-Step Dial Central Office Equipment).
TM 11–2107, Attendant's Switchboard (Step-by-Step Dial Central Office Equipment).
TM 11–2108, Power, Ringing, and Supervisory Equipment (Step-by-Step Dial Central Office Equipment).
TM 11–2109, Distributing Frames and Line and Trunk Assignments (Step-by-Step Dial Central Office Equipment).
TM 11–2110, Test Desk Equipment and Techniques (Step-by-Step Dial Central Office Equipment).
TM 11–2111, Tools, Test Equipment and Common Supplies (Step-by-Step Dial Central Office Equipment).
TM 11–2112, Current-Flow Test Set (Step-by-Step Dial Central Office Equipment).
TM 11–2113, Connector Routine Test Set (Step-by-Step Dial Central Office Equipment).
TM 11–2114, Stepping-Switch Test Set (Step-by-Step Dial Central Office Equipment).
TM 11–2115, Crash and Conference Equipment (Step-by-Step Dial Central Office Equipment).

2. Supply Publication

SB 11–76, Signal Corps Kit and Materials for Moisture- and Fungi-Resistant Treatment.

3. Technical Manuals on Test Equipment

TM 11–346, Test Sets I–61–A, I–61–B, and I–61–C.
TM 11–2017, Test Set TS–26/TSM.
TM 11–2019, Test Set I–49.
TM 11–2036, Test Set I–181.
TM 11–2050, Test Set I–48–B.
TM 11–2057, Test Set TS–27/TSM.
TM 11–2062, Test Set I–142 and Test Set I–142–A (Telephone).
TM 11–2613, Voltohmmeter I–166.

4. Packaging and Packing Instructions

a. Joint Army-Navy Packaging Specifications.
JAN–D–169, Desiccants, Activated.
JAN–P–100, General Specification.
JAN–P–106, Boxes, Wood, Nailed.
JAN–P–116, Preservation, Methods of.
JAN–P–125, Barrier Materials, Waterproof, Flexible.
JAN–P–131, Barrier Material, Moisture-Vaporproof, Flexible.
b. U. S. Army Specifications.
100–2, Marking Shipments by Contractors (and Signal Corps Supplements thereto).
c. Signal Corps Instructions.
720–7, Standard Pack.
726–15, Interior Marking.

5. Other Publications

TB SIG 123, Preventive Maintenance Practices for Ground Signal Equipment.
TM 1–455, Electrical Fundamentals.

TM 11–372, Telephone Cable Splicing.
TM 11–486, Electrical Communication Systems Engineering.
TM 11–487, Electrical Communication Systems Equipment.
TM 11–684, Local-Battery Switchboards.
TM 11–685, Common-Battery Switchboards.
TM 11–757, Principles of Line Fault Location.
TM 11–4301, Tactical Switchboards and Long Lines Equipment — Repair Instructions, General Requirements.
TM 11–4302, Tactical Switchboards and Long Lines Equipment—Repair Instructions, Apparatus Requirements.
TM 11–4700, Electrical Indicating Instruments and Test Sets, Repair Instructions.

6. Forms

AF Form 54 (Unsatisfactory Report).
DA AGO Form 468 (Unsatifactory Equipment Report).
DD Form 6 (Report of Damaged or Improper Shipment).

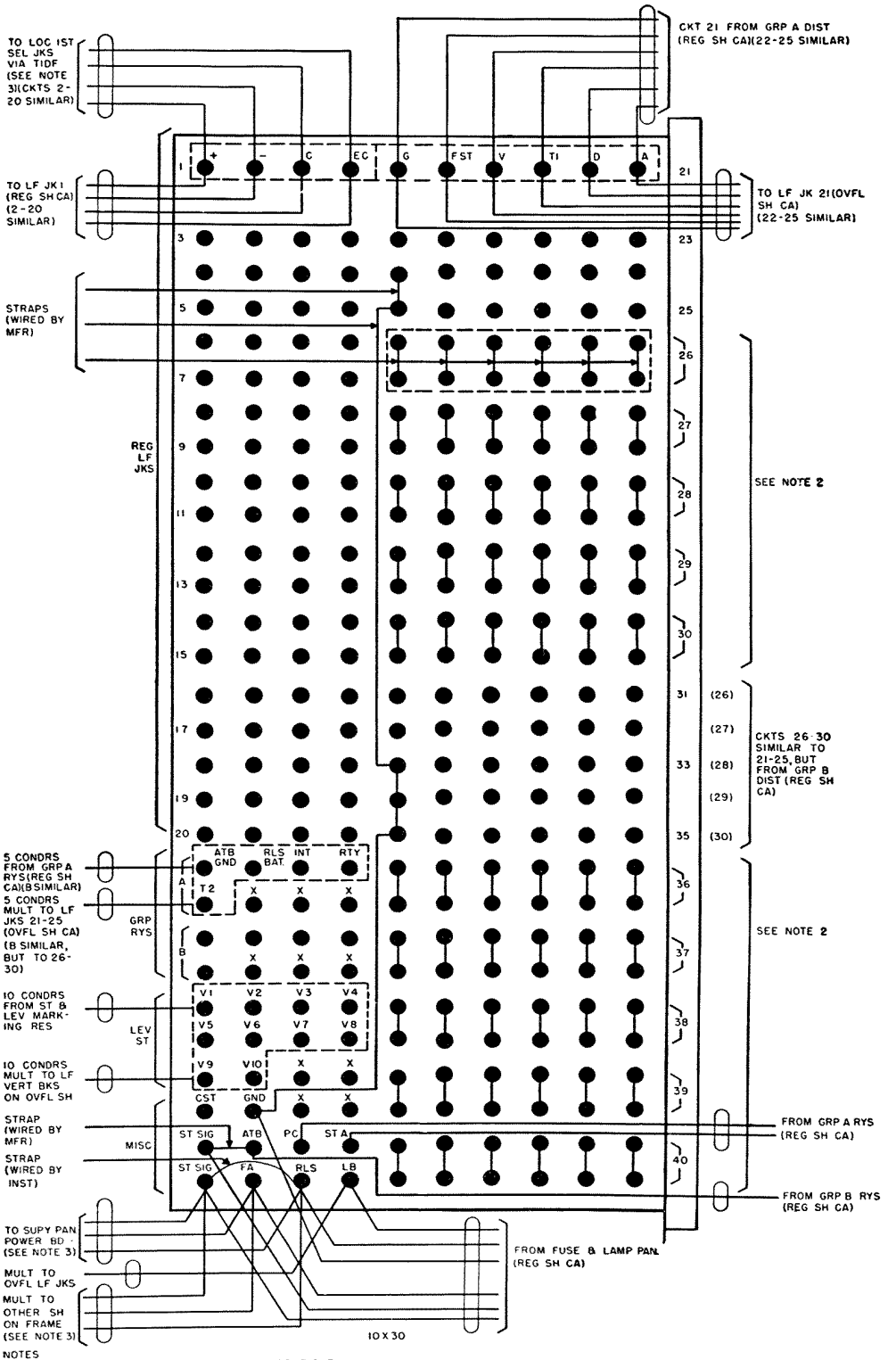

Figure 29. Trunk terminal board on regular shelf, wiring diagram.

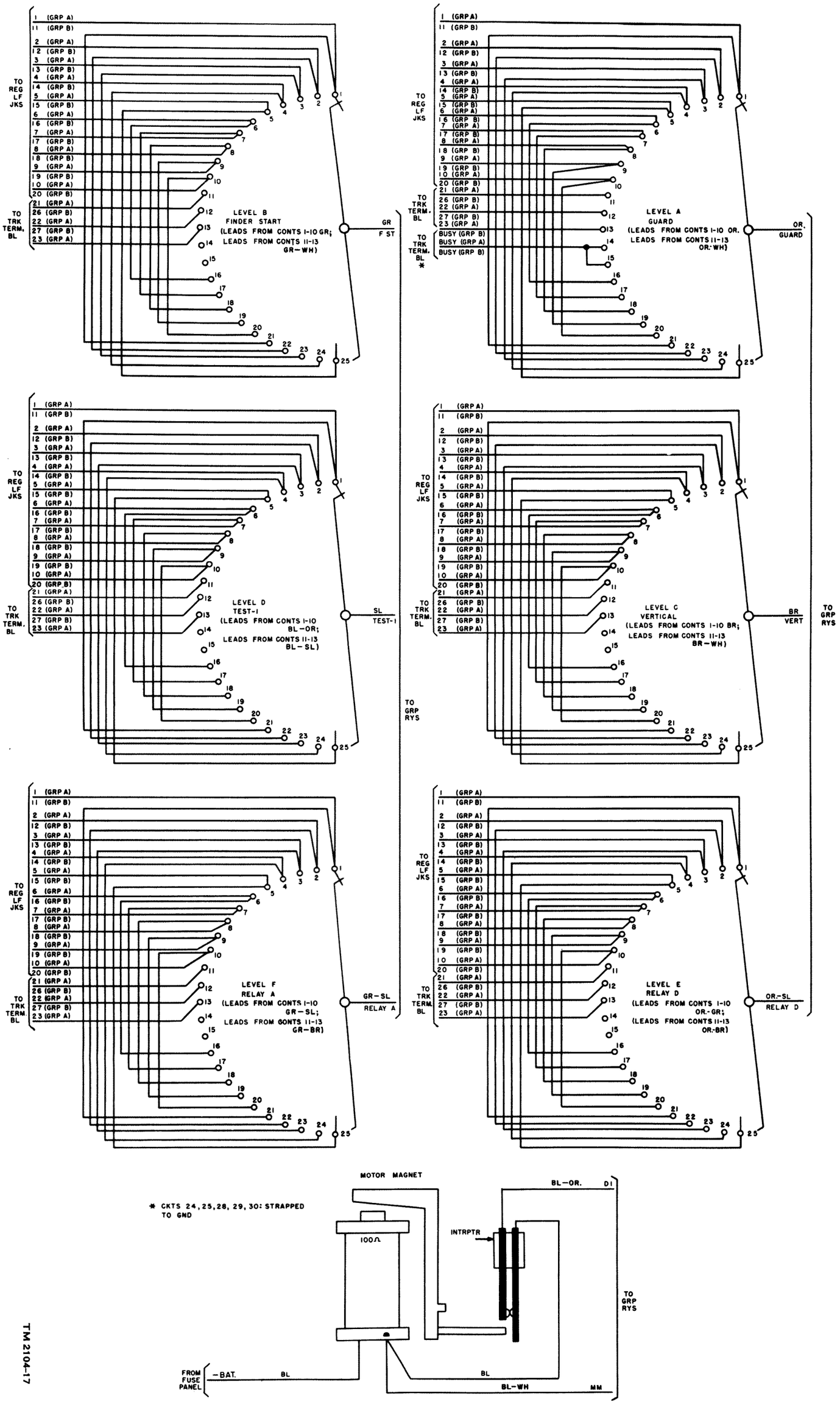

Figure 30. Distributors, wiring diagram.

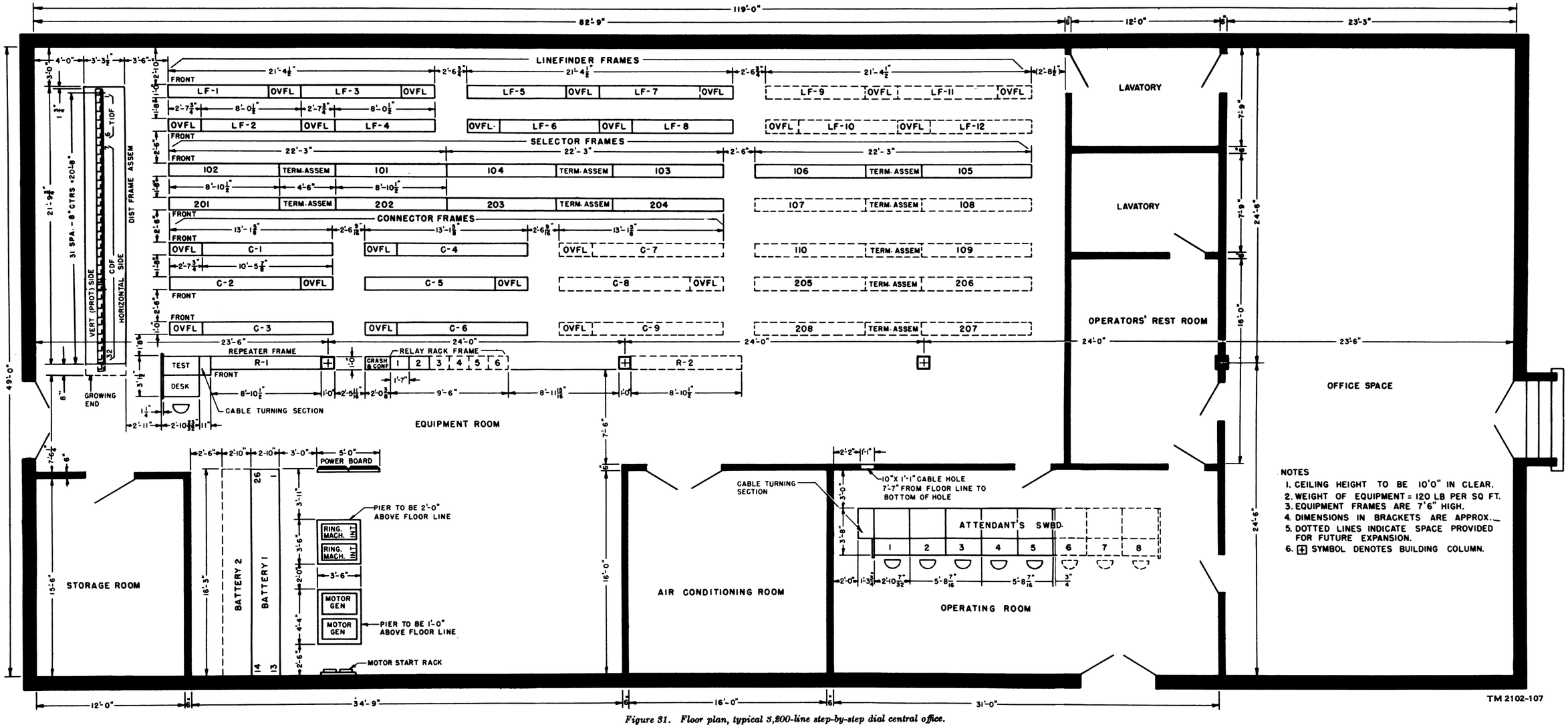

Figure 31. Floor plan, typical 3,200-line step-by-step dial central office.

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